THE WAY FORWARD

Ecosocialism or Ecocatastrophe?

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The "practical struggle" opening up a path to a socialist future is now compelled to confront the looming threat of ecocatastrophe stemming from climate change. In what follows, other interlinked features of the ecological crisis—for example, species loss, the crisis in potable water, etc.—will be placed in the background for heuristic reasons. It should be emphasized, however, that the same basic argument applies to all aspects of the generalized crisis insofar as these are driven by the basic dynamic of capital accumulation. In this context, to confront means a full recognition of the centrality of this challenge combined with a practice drawing from a truly ecosocialist theoretical foundation. The threat of ecocatastrophe is no longer a potential contingent outcome in some indefinite future of the unsustainable mode of production and consumption of global capital reproduction; it is now highly probable in the near future unless radical changes in both political and physical economies are made in time.

We face an unprecedented bifurcation in humanity's future. Never before has humankind posed such a global threat, stemming from its own technological development. Moreover, recognition of the imminence of this threat is very recent, informed by the state-of-the-art understanding of the global climate and anthropogenic greenhouse forcing.

The Prospect of Catastrophic Climate Change ("C3")

We may have only a decade left to implement a prevention program to avoid catastrophic climate change ("C3"). The onset of C3 would make the world even more dangerous and miserable than the living hell that hundreds of millions now experience. The 2006 film *Children of Men* based on the novel by P.D. James and directed by Alfonso Cuarón, provided a chilling glimpse of this future: a fascist regime confining refugees from the Global South in concentration camps. The film is set in and around London in 2027. The plot revolves around the onset of global infertility and the protection of the last pregnant woman with her ultimate delivery to a largely unseen collective, the "Human Project." While this theme is an implausible projection of the current environmental crisis (why are only humans apparently affected by this affliction?), its portrayal of a dystopian future could not be more timely. Massive emigration and chaotic social upheaval will be precisely the outcome of unchecked global warming as this devastates great swathes of the planet through the combined effects of global sea level rise and agricultural collapse. The planet is rapidly approaching numerous tipping points that will likely lead to irreversible changes in climate and loss of biodiversity, with huge negative impacts on humanity.[2]

Leading climate change scientists have made a strong case for C3 and the imperative need for its prevention. In particular, Jim Hansen, director of NASA's Goddard Institute for Space Studies in New York, now thinks his recent target of a 450 ppm ceiling in the atmospheric carbon dioxide level is likely too high to avoid ecocatastrophe, especially from sea level rise due to accelerating icecap melting. A now widely supported goal of an 80

percent reduction in carbon emissions by 2050 is likely to be insufficient. Indeed, Hansen and collaborators now argue that C3 prevention will not only require rapid reduction in greenhouse gas emissions—especially carbon dioxide from burning coal—but also, in the coming decades, carbon sequestration from the atmosphere in order to reduce the level of atmospheric carbon dioxide from its present value of 385 ppm to 350 ppm or likely lower. This is to be achieved by appropriate agricultural and forestry approaches and other known technologies, and could be increasingly powered by a rapidly expanding solar energy infrastructure discussed below. Newly invented technologies already show promise.[3]

A recent paper modeling the climate response to carbon emissions concludes:

> In the absence of human intervention to actively remove CO_2 from the atmosphere, each unit of CO_2 emissions must be viewed as leading to quantifiable and essentially permanent climate change on centennial timescales. …This means that avoiding future human-induced climate warming may require policies that seek not only to decrease CO_2 emissions, but to eliminate them entirely.[4]

To avoid C3 requires the end of oil and fossil fuel addiction, giving up the nuclear option, and a rapid conversion to a high efficiency solar energy infrastructure. Further, since the major obstacle to this path is the nuclear military industrial fossil fuel complex ("MIC" for short), especially its U.S. component, this complex and its imperial agenda must be confronted, isolated, and finally eliminated as the biggest threat to human survival. Thus C3 now joins the continuing threat of nuclear war (even a small regional nuclear conflict may have devastating climatic consequences for all humanity).[5] More precisely, MIC's material infrastructure should be solarized and its huge legacy of chemical and nuclear waste contained. A solarized and demilitarized world—a formidable challenge to say the least!

The Nuclear Military Industrial Fossil Fuel Complex ("MIC")

MIC is likely the biggest single obstacle to preventing C3, first, because of its own consumption levels of fossil fuel and other resources, but most critically because the Pentagon is a "global oil-protection service" for the U.S. imperial agenda,[6] and even for the transnational capital class itself.[7]

Recent estimates put Pentagon oil consumption levels at about 0.4 percent of annual global oil consumption, with the Pentagon's total primary energy consumption being roughly 1 percent of the U.S. total in FY 2006.[8] A recent estimate for the minimum total carbon dioxide equivalent emissions for the Iraq War corresponds to less than 0.1 percent of the total global carbon dioxide emissions from burning fossils fuels for the same five-year period.[9] More research is needed to evaluate not only the Pentagon's direct consumption, but the much higher levels derived from MIC as a whole, given the level of its expenditures. The huge role of MIC in the U.S. and global economy is illustrated by the military expenditure of over $1.2 trillion in 2006, with the U.S. responsible for 46 percent of the total.[10] But even this total may be underestimated. According to the War Resisters League, the U.S. 2009 Fiscal Year military budget is actually $1.449 trillion (the U.S. GNP in 2006 was $11.5 trillion).[11] The projected $3 trillion for the Iraq War and occupation[12] is close to the estimated renewable energy investment of $2.89 trillion needed by 2030 to insure a 50 percent reduction in carbon dioxide emissions by 2050.[13] Barring some near future

revolutionary breakthrough in the development of very inexpensive high efficiency thin film photovoltaics or a similar technology, the necessary funds for rapid conversion to a solar energy infrastructure will likely be on the order of several trillion dollars. Where will this funding and material resources come from if not from the demilitarization of the U.S. and global economy—a process which, needless to add, would create a much more just, peaceful and sustainable society for our children and grandchildren?[14]

Solar Communism, an Achievable Utopia

In 1992 I proposed "solar communism" as the name for a future global society that will realize a contemporary version of Marx's guiding principle for his vision of communism, namely: "From each according to her ability, to each according to her needs," where "her" refers to humans and nature (considered as the integral of all ecosystems).[15] I urged the rethinking of the scientific utopian vision of communism, cleansed of the stain of Stalinism and Maoism, fully acknowledging the crimes committed in its name and freed of the dogmas that froze it into ideologies like state-sponsored "Marxism Leninism." We should hearken to how the governor of Puglia, Italy, Nichi Vendola, a gay Catholic Refoundation Communist, responded to the question "So what can communism mean in this day and age?" He replied:

> The word is redolent of light and dark. The dark was the gulags, the tragi-comic dictatorships. But we have to return to the roots and aim for true globalization: not that of the market but of human rights and the globalization of human happiness.[16]

But why communism and not simply socialism? Following the Leninist tradition, I define socialism as the first phase (stage) of communist society,[17] hence the *transition* from capitalism to communism. This transition will surely be hybrid, a process of nonlinear emergence, likely protracted but in itself now an imperative for C3 prevention. In this respect I find the equation of socialism (whether "Eco" or not) and communism[18] unhelpful, because it points away from the necessity of addressing a theory and practice of *transition*, the project of emancipative transformation.[19]

The positing of two likely yet radically different scenarios within the first few decades into the future of the 21st century is informed by an understanding of the cutting edge of climate science and the political economy of the present. I contend that even as soon as 2020, the world will not look like an extrapolation of the present. Rather, it will either be much worse or much better with respect to the quality of human life according to the success of ecosocialist practice and theory.

The Iraq War and occupation has left the U.S. imperial project severely damaged—the only positive outcome of this horrific intervention. A multipolar world replacing the U.S. hyperpower is necessary but far from sufficient to open up an ecosocialist path for humanity. Thus an ecosocialist "international" has yet to emerge with the necessary power to prevent a plunge into a world of ever magnified destructive power to both humans and nature.

The fulfillment of ecosocialism is critically contingent on the development of a robust theory that goes beyond the familiar binary aspects of "red" and "green" practice. One challenge is to achieve a deep understanding of the dialectics of social governance of

production and consumption from the global to the local level. Expanding the commons in all spheres of social life is imperative, as is self-management at all levels from global to local. However, even in a radically democratized world, local autonomy must be limited by the character of its global impacts.[20] Another critical challenge is the theorization of the necessary conditions for creation of a transnational ecosocialist movement and its interrelationships with local and national struggles. However, the focus of the present contribution is on the materiality of technological basis for that "other world that is possible."

I submit that socialist theory has long lacked a full conceptualization of the technological basis of an ecosocialist transition to a future global society.[21] An historical materialist theorization of this transition and a vision of this future global society should encompass its full materiality, in both the technological and social senses of that term. Socialist or Marxist political economy cannot theorize this transition by itself. The natural, physical and informational sciences—in particular, climatology, ecology, biogeochemistry, and thermodynamics—must be fully engaged. These sciences will inform the technologies of renewable energy, green production, and agroecologies, whose infrastructure are to replace the present unsustainable mode.

Marx and Engels had prophetic insights into the ecological impacts of capitalist society.[22] But there has been little socialist engagement with the physical and natural sciences necessary for a sustainable economy in the late 20th century. The environmental crisis contributed to the collapse of "real existing socialism," with the notable exception of Cuba, which, significantly, is now a leader in agroecology.[23] The near absence of ecosocialist theory and practice has left a space for the penetration of Neo-Malthusian and "end of growth" ideologies into the contemporary green movement. We are treated to continual invocations of fallacious visions of entropic apocalypse, leading to the die-off of civilization. Instead of scientific utopias, we more frequently confront dystopian visions of hell on earth, depicting the only alternative to be a return to a primitive and unmediated relationship with nature. Harvey Wasserman's "Solartopia!" is a rare and refreshing exception.[24]

So I urge that we proceed in the spirit of Bloch's "warm stream of Marxism," with its rescue of utopia through the revelation of the process by which utopia is possible,[25] using its "cold stream," materialist analysis and the cutting edge of science and knowledge of the technology of the possible. We should "unashamedly embrace utopia"[26] not, however, in the sky, but a concrete utopia in its full materiality, recognizing that its contours will be fleshed out by struggle and dialogue. Martinez-Alier put it this way:

> Some tendencies in Marxism have always insisted on the strict separation of "utopian socialism" from "scientific socialism." However, it is quite possible that "scientific utopias" make a more accurate guess at the future. … The function of "scientific utopian" writing should be not only to suggest new and desirable social relations based on the old moral values of equality and freedom, but also to specify feasible and viable productive bases for such societies, and for the whole world. … Some energy and material accounting *in natura* is an essential ingredient of "ecological utopianism."[27]

The Misuse of Entropy in Social Prognostication, and Why the Ecosocialist Project Should Rest on Robust Thermodynamic Theory

I will begin with a short summary of standard thermodynamics and its three traditional laws, along with the "zeroth law," which grounds the concept of temperature. The first law asserts the conservation of energy (after Einstein, this needs to be read as mass and energy). The second captures the fundamental asymmetry of the universe, in which the distribution of energy changes in an irreversible manner. This irreversibility is measured by the production of entropy. There are several different ways of expressing the second law. One is that work can be totally converted into heat, but the reverse is impossible. Entropy is defined as the heat supplied to a system divided by its absolute temperature (e.g., 0° Celsius, the freezing point of water, equals 273° Kelvin on the absolute temperature scale). Temperature is a measure of the intensity of thermal vibrations in any material system, its kinetic energy, i.e., active as opposed to potential 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 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). The third law applies to matter at very low temperatures, forbidding it to reach absolute zero in a finite number of steps.

The thermodynamic concept of entropy is commonly misunderstood and/or distorted in many discussions of sustainability and energy use.[28] Enthusiasts of Peak Oil, apocalyptic thinkers, and neo-Malthusians commonly draw from the thermodynamic theories of Nicholas Georgescu-Roegen, a founder of ecological economics.[29] The typical argument is that global energy use must be drastically reduced as the existing mode is replaced or runs out; this claim is justified with the argument that there are entropy limitations blocking the possibility of a global high-efficiency solarized economy. In particular, Georgescu-Roegen's fourth law of thermodynamics is commonly cited as the basis of such arguments. However, there is a major fallacy in this so-called fourth law resulting from his conflation of isolated and closed systems. He claimed: "A closed system (i.e., a system that cannot exchange matter with the environment) cannot perform work indefinitely at a constant rate."[30] This proposition is of course true if the system is also isolated to incoming high-quality energy (a low entropy flux), and indeed, becomes a mere restatement of the second law of thermodynamics. Hence for an economy run on energy derived from fossil fuel, or even the fission of uranium or thorium—all being finite (i.e., non-renewable) reserves in the earth's crust—such an economy will eventually run down, since the energy to do work is not renewable., That is, you can neither reuse waste heat *ad infinitum* (this is true of waste heat from using solar energy as well), nor can you regenerate the low-entropy energy reserve—a service afforded by the sun with solar energy.

However, the critical point is this: while the biosphere is essentially closed to transfer of matter, it is not isolated with respect to energy flux, in particular, solar radiation. Presently the global energy flux from all technological activity, in the form of waste heat, is equal to 0.03 percent of the solar flux to land. An equivalent statement is that one hour of solar flux to the earth supplies the same amount of energy as that consumed globally by society in one year. Hence there is no inherent reason for bowing before the second law in this case. Indeed. tapping the solar flux has huge potential as the energy basis of future civilization, and with much smaller impacts on global ecology than now, for the simple reason that any such conversion to useful work results in essentially no added waste heat to the environment above the natural flux.[31]

The following selection from an earlier paper of mine should help clarify this point:

> 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.[32]

Georgescu-Roegen's conflation of the thermodynamic concepts of closed with isolated systems seems to have been at the root of his contention that solar energy would always be parasitic on a fossil fuel base. This pessimism has continued to inspire many neo-Malthusians and even ecosocialists.[33]

Several prominent and influential Marxist scholars have recently drawn from Georgescu-Roegen's theory of entropy. Joel Kovel's appropriation[34] in *The Enemy of Nature* was critiqued—although he has since rejected this view for the reasons advanced here.[35] More recently, Paul Burkett supported Georgescu-Roegen's theory of entropy in an apparent attempt to seek convergence of Marxist theory with ecological economics.[36] The very shaky foundations of Georgescu-Roegen's thermodynamic theory, however, undermine this attempt.[37] Likewise, Elmar Altvater makes a similar reference to Georgescu-Roegen's theory of entropy, quoting him with approval: "it is not the sun's finite stock of energy that sets a limit to how long the human species may survive. Instead, it is the meager stock of the earth's resources that constitutes the crucial scarcity."[38] However, this contention is inaccurate, because recycling and recovery of metals and other matter derived from these resources can continue in the far future utilizing the incoming solar flux, once the global economy is solarized.[39] Altvater does conclude with a positive argument for a solar revolution with the potential of ending the dependence on fossil fuels, unlike Georgescu-Roegen who argued that solar energy generation would never escape being a parasite on depletable energy resources.

Is Solarization Viable? Why its Energy Return on Energy Invested is Critical to an Answer

Altvater once supported Georgescu-Roegen's position that the technology of the direct collection of solar radiation, while feasible, is not viable—i.e., it is impossible to construct and operate except by continuing to rely on fossil fuel energy inputs. In 1993 Altvater argued:

> 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.[40]

These views are somewhat 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, even such a prominent ecosocialist as Saral Sarkar, following Georgescu-Roegen's lead, has continued to argue that modern solar technologies such as wind turbines and photovoltaics do not presently demonstrate viability in Georgescu-Roegen's sense.

> Suppose we accept the claim of some enthusiasts that the energy payback time of photovoltaic technology is seven to ten years. Will that—after meeting all or a part of our other energy needs—leave us with enough surplus energy for running all the industries necessary to reproduce the photovoltaic power plants every twenty years? We doubt very much that it will. The expected technological breakthroughs may or may not come. In any case, we cannot place our hopes at present on an elaborate vision of "a solar world economy" (Scheer, 1999) on the basis of that expectation.… it seems safe to predict that in a future sustainable economy neither energy nor raw materials will be as cheap as today, nor will their availability be as great as the sum total of all the non-renewable and renewable resources available today. The need to reduce resource consumption drastically will be compelling, not only for protecting the environment but also because there simply will not be enough to maintain today's average standard of living for a world population of 8-10 billion, the figure forecast for the year 2050. The world economy as a whole must therefore shrink. Resource consumption of the advanced industrial countries must, as Schmidt-Bleek (1993) demands, go down by a factor of ten if the people of the whole world are to get a chance to satisfy their basic needs.[41]

This is a typical die-off argument, with Neo-Malthusian premises.[42] Its underlying concept is EROEI (energy return on energy invested). In other words, EROEI = Quantity of energy supplied by a given technology for its lifetime of operation divided by the Quantity of energy used in creating and maintaining the same technology.[43]

Sarkar and Kern cite EROEI estimates of Howard T. Odum published in 1996 and indicating solar [photo]voltaic cell electricity with a value less than 1, meaning more energy is invested in this technology than is returned for the lifetime of its use.[44] According to Odum, "wind electro-power" has an EROEI of only 2 with an uncertain estimate of possibly higher values indicated. Interestingly, Sarkar and Kern note that Heinberg cites the same figures.[45] While we can possibly forgive Georgescu-Roegen for his pessimism with respect to potential future solar viability in the 1980s, it is puzzling why in 2008 Sarkar and Kern base their argument on such old data. Solar technology is rapidly advancing, and both wind power and photovoltaic production are exponentially increasing.[46]

Up-to-date compilations of EROEI values for solar technologies are significantly higher, e.g., wind averaging at 20, photovoltaics at 8, and solar thermal at 4, compared to nuclear and coal at 6-8.[47] Smil gives similar values.[48] Promising new solar technologies such as plastic thin-film photovoltaics may have even greater EROEI values, with prospects for a cheap energy revolution. Further, a simple comparison of the EROEI of fossil fuels with solar technologies such as wind power neglects taking into account the huge

negative externalities of past and continued fossil fuel use their ecological footprint. This point is argued well on solar energy entrepeneur Ron Swenson's website.[49]

Are existing fossil fuel reserves sufficient to effect a solar transition? Yes, these reserves are more than adequate if used for solarization rather than simply exhausted as fuel. One scenario, taking this issue into account is found in Kharecha and Hansen's recent paper.[50] They emphasize that conventional oil reserves should be stretched out with energy conservation and efficiency, avoiding the use of liquid fuels from coal or unconventional fossil fuels such as tar sands.

High-efficiency solar technologies (excluding highly problematic corn-based ethanol production and other low-efficiency biomass-based fuels) are already viable. With sufficient political leverage, these can be made fully capable of replacing our unsustainable fossil fuel and nuclear-based energy infrastructure.

The counterargument that Peak Oil—the near-future decline in oil productionwill make this transition impossible is misleading for several reasons. First of all, fossil fuel reserves are quite sufficient for such a project. Reserves of heavy oil and tar sands are likely to be at least as large as the proven reserves of ordinary crude (e.g., Venezuela alone may have a heavy oil reserve roughly equal to the less viscous global crude reserve). Further, global extractable coal reserves can supply the world with energy at the present consumption levels for 600 years, with the U.S.'s proven reserves comprising some 25 percent of the global. Considering *only* energy reserves, once the production of ordinary oil peaks, there is plenty to replace it, especially since coal can be converted by the process of liquefaction to oil, in spite of its amplified carbon emission. The point is not inadequacy of reserves, but the fact that *the world cannot afford this energy transition within a fossil fuel regime.* Thus, the peak in fossil fuel production and consumption must come as soon as possible, driven by a rapid conversion to renewable energy and more efficient use of energy, rather than the reserves still in the ground. This conversion is imperative because of the imminent prospect of C3.

Other Uses of "Entropy"

Entropy has been commonly used as an equivalent to the level of disorder and loss of complexity and structure in a system. Self-organizing systems, such as living organisms and the Earth's biosphere maintain or even increase their degree of order as opposed to being dissolved into a state of chaos, or maximum entropy. The ecological crisis with all its impacts that generate pollution and decrease biodiversity can be seen as increasing disorder, hence producing entropy in the biosphere.[51] A related concept is "social entropy," which is widely used in analysis of complexity in social organization, e.g., applied to spatial distribution of residents in a city.[52]

Thus, as Kovel has argued, industrial capitalism, especially in its preparation for and practice of war, has been a prodigious generator of entropy, manifest in the destruction of formerly self-organized societies and ecosystems. This becomes increasingly pronounced in the 21st century, as anthropogenic impacts on the global biosphere have created huge threats to both civilization and biodiversity.[53] In this sense, the usage of entropy as metaphor indicates the path we must take to restore both human and natural communities by eliminating the Great Entropy Generator—capitalism in general and its creation MIC, the

Moloch of Mass Murder. However, the appropriate technological path to a world of peace and justice needs to be illuminated by a rigorous definition of entropy in relation to the closed but not isolated biosphere in which humanity lives.

Which Fossil Fuels to Solar? Carbon Emissions and the Political Economy of Choice

A transition to solar-powered civilization will require using fossil fuel, the dominant energy source now available, for the creation of an alternative infrastructure. Moreover, it will be necessary to tap into fossil fuels as a continuing energy source until full solarization is achieved, even with the very significant reductions of energy use possible in industrialized countries with aggressive conservation strategies, especially for buildings and transportation (e.g., mass transit replacing cars). Carbon emissions contributing to global warming must be minimized during this transition. As it comes on line, the potential energy from a global solarized civilization can significantly exceed the present energy consumption level without most if not all of its negative impacts.

The major fossil fuels now in use are coal and petroleum (refined liquid hydrocarbons and natural gas), with alternatives such as tar sands and oil shale thankfully still marginal given their even greater negative environmental and health impacts from their extraction. Which fossil fuel is the best choice for this minimization? An emission ratio of CO_2 emitted to released energy tells us just how much CO_2 emission will occur using a specific fossil fuel for energy. According to Smil, the typical emission ratios of coal to refined oil to natural gas (including methane) is 25 to 19 to 14.[54] Thus natural gas is the best choice for the solar transition, releasing for the same energy produced only 56 percent the CO_2 compared to coal, with liquid hydrocarbon fuel at 76 percent. However, there is one important caveat. Methane is a much more potent greenhouse gas than carbon dioxide, molecule per molecule. Significant amounts of methane have already leaked to the atmosphere during the extraction and transportation of natural gas.[55] If natural gas use increases, then such leakage must be reduced to achieve the desired reduction in greenhouse effect derived from the emission ratios given above.

I will now compare the recommendations of four leading advocates of a rapid renewable energy transition and discuss the political economic implications of their prescriptions of choice. The four are Jim Hansen, Michael Klare, Arjun Makhijani, and Hermann Scheer.

Jim Hansen: "We need a moratorium on the construction of traditional coal-fired power plants by 2010 and a phaseout by 2030."[56] Hansen leaves an opening for continued coal use, if carbon capture technology is employed during its combustion. This possibility looks more remote than ever, especially given the decade or two left to begin rapid reduction in carbon emissions. Recently federal funding was cut under the Bush administration for this pilot technology.[57] Its future under Obama is unknown as of this writing. Hansen argues that carbon sequestration from the atmosphere can be accomplished using appropriate agricultural and forestry practices. It should be stressed that the creation of a solar infrastructure will also permit direct CO_2 removal from the atmosphere, without concomitant release of greenhouse gases.[58] Thus the fossil fuel of choice for Hansen is petroleum, both as liquid and natural gas. He argues that even moderate estimates of

remaining reserves are sufficient to implement his scenario of C3 prevention.[59]

Michael Klare has well documented the growing threat of resource wars especially over depletable energy supplies such as petroleum.[60] He now fully recognizes the challenge of global warming in this discourse[61] correcting the neglect of this factor in his previous writings.[62] Klare emphasizes our dependence on oil and ties militarism to the protection and control of its supply, through the political power of the transnational energy corporations. He calls the Pentagon the "petroleum protection service" of MIC. Klare has previously stated "it is apparent that the world faces a profound shift in the global availability of energy, as we move from a situation of relative abundance to one of relative scarcity."[63] But there is certainly no prospect of real scarcity of energy when the sun supplies in one hour the entire world's energy consumption in one year. Noting the huge role of coal in China's energy production, Klare argues that U.S., China, Russia and India should collaborate in reducing dependence on petroleum, shifting instead to alternatives including biofuel ethanol (a very bad choice), "climate-friendly coal" (i.e., with carbon sequestration) as well solar. He claims that a "lessening in international friction and conflict over contested sources of energy would also permit a gradual reduction in global military expenditures and thereby free up substantial funds for systematic efforts to tackle the threat of global warming."[64] How "gradual" the reduction is the real issue: will it occur in time to prevent C3?

Arjun Makhijani has outlined a clear and detailed plan for U.S. solarization.[65] Makhijani proposes that natural gas combined with carbon sequestration be the last fossil fuel source as the renewable transition is completed by mid-century.

In a brilliant outline of this transition, Hermann Scheer, the architect of Germany's rapid growth of renewables, proposes the establishment of an International Renewable Energy Agency.[66] We should strongly endorse this idea, and leave the International Atomic Energy Agency with the task of coordinating the final decommissioning of the last nuclear power plant on the planet. While several countries in Europe are rapidly solarizing, with Portugal in the lead,[67] transnational capital centered on the energy conglomerates is still strongly committed to expanded fossil fuel exploration and extraction and to nuclear power expansion. Scheer identifies "the perversion of energy security by securing resources through military means" as a critical "blockade to action" that is, in the transition to a global regime of renewable energy.[68]

Because of its significantly lower carbon emission ratio to energy released, the fossil fuel of choice for a solar transition is petroleum, in particular natural gas if leakage to the atmosphere can be effectively contained. Similarly, increasing U.S. energy self-sufficiency by utilizing domestic natural gas supplies is far preferable to depending on the sizable reserves of domestic coal, since carbon capture coupled with coal combustion is far too problematic to be a viable option, not to mention the well-known negative environmental and health impacts of coal extraction. Ending fossil fuel "addiction" should translate into policies that favor rapid solar transition accompanied by significant energy conservation and decreasing use of fossil fuels, starting with coal. This path is essential for preventing catastrophic global warming. The creation of an equitable new international energy regime will require significant and rapid demilitarization, starting with Imperial U.S.A.

We can be guardedly optimistic about Obama's energy-related nominations to his cabinet and advisory council. Steven Chu for Energy Secretary, John Holdren for scientific advisor and Jane Lubchenco for head of the U.S. oceanic research body (NOAA) all have records of taking climate change very seriously. Judging from his record, Chu will likely focus on developing new solar technologies, energy conservation, and a better electric transmission infrastructure facilitating the expansion of wind power. However, he also favors carbon capture from coal combustion, while joining Hansen in calling for the phaseout of coal utilities without sequestration. Further, Chu is on record as endorsing the expansion of nuclear power.[69] The most worrisome of the group is Tom Vilsack for Secretary of Agriculture. Vilsack has vigorously supported corn-based ethanol production, fossil fuel-intensive industrial agriculture and the development of genetically modified organisms (GMOs).

With peak oil on the horizon, oil-exporting countries in the Global South—particularly those moving away from neoliberal policies such as Venezuela—should seriously consider investing their new found revenues into renewable energy infrastructures. Likewise, the oil-rich states in the Mid and Near East should invest in solar technology especially given their high solar fluxes.

Another challenge will continue to confront global society after the transition: Will liquid and gaseous fuels still be in sufficient supply to power air travel and other uses that are not compatible with a stored electricity supply?[70] In this case the answer may also lie in new technologies, since viable alternatives are already being devised, for example, hydrogen-powered air travel using fuel derived from solar powered water electrolysis.[71] Another possibility is chemical synthesis of hydrocarbon fuels using atmospheric carbon dioxide and water with appropriate catalysts or possibly highly efficient storage of electricity in superconductors. Such alternatives may also be viable in a future solarized economy without contributing to greenhouse gas emissions.

A radical transformation of U.S. political economy is a pre- and co-condition for the transformation of the global physical economy into a solar-based infrastructure. Demilitarization is imperative as Klare and Makhijani explicitly recognize. Perhaps we are even near a political tipping point with respect to the necessity of demilitarization. Even neoliberal mainstream figures such as Jeffrey Sachs have recently spoken out in support of cuts in the military budget.[72] Peace and justice activists have in the last two years organized around the theme of "No War, No Warming!"[73] We are now witnessing an early yet very hopeful convergence of peace, justice, and environmental movements. Many obstacles remain, including the fact that several very influential environmentalists who recognize the real danger of C3 and the need for solarization still largely avoid confronting the huge obstacle of military spending in their writing.[74] It is highly implausible to expect that "one company at a time going green" will occur at a fast enough pace to avoid the dreaded climatic tipping points facing all humanity. Likewise, a "green" Pentagon, reducing its fossil fuel consumption while continuing to serve as a "petroleum protection service" for MIC, will be at best a smokescreen for a plunge into the abyss of climate catastrophe.

Global financial and economic crisis now converges with the threat of C3. However, there is still insufficient recognition—even by leading Marxist economists—that these converging economic and ecological crises must be solved by an ecosocialist approach. For

example, at the plenary of the Fifth Historical Materialism Annual Conference held in London in early November, 2008, four prominent Marxist economists, Robert Brenner, Gerard Dumenil, David McNally and Costas Lapavitsas, discussed the financial crisis. The challenge of global warming and the need to confront MIC as an obstacle to the resolution of both crises was not mentioned and was only raised in questions from the audience.

It is a tragic irony that the great increase in the global misery index, resulting from the current and likely prolonged economic depression may actually generate more time to create the infrastructure necessary for C3 prevention. Already carbon emissions have begun to decline, just as we saw in Russia in the 1990s.[75] This crisis is potentially a huge opportunity to promote green energy job creation as a partial solution, as Obama has offered, without any commitment as yet demonstrated to significantly reduce MIC. However, the decline in oil prices is likely to make clean energy investment less attractive, unless governments subsidize these investments. If imperial power is unchecked, we may witness a new version of military Keynesianism as a way out of economic decline.

We must put prevention of C3 at the nexus of our social movements, starting with the global peace and anti-imperialist network. A demilitarized world is necessary for magnifying the cooperation needed to manage existing fossil fuel supplies in a rapid and effective transition to full solarization.

Is "Ecocatastrophism" an Obstacle to Ecosocialist Politics?

I was a coauthor on a collective review of Kovel's *The Enemy of Nature*. We wrote: "But we do not see the fear of an apocalypse as either ecologically likely or politically helpful in building this [ecosocialist] movement."[76] I personally had some reservations about this argument at the time we submitted our paper. While ecocatastrophe seemed remote nearly a decade ago, I felt that such a possibility should be taken seriously. As it turned out, in just a few years Kovel's anticipation of ecocatastrophe—the destruction of civilization as we know it—became much more plausible as a near-future result of the acceleration of global warming. While there are still uncertainties in climate models, the scientific consensus takes this possibility more seriously than even a few years ago.[77]

Nevertheless, I believe that simply making this threat widely known will not create a social movement broad and deep enough to prevent C3 and open up a path for the end of the rule of capital. The best science should inform our politics, but a political strategy and practice must energize a movement sufficient to overcome obstacles that stand in the way of preventing C3.

Leo Panitch has similar reservations: "I am dubious about ecocatastrophism because it tends to throw up politics that are reformist in a particular naïve way; for example by encouraging new kinds of popular front-style coalitions with any bourgeois forces that recognize ecological problems or by endorsing policies that further commodify our lives as a way of dealing with them." Further, "While I disagree strongly with those who are dismissive of the problem of global warming, the argument needs to be taken seriously that we must avoid drawing hard and fast conclusions based on the form of scientism which simply extrapolates current trends." He goes on to argue that we likely have enough time to build a movement for democratic planning of the economy.[78] However, the timescale left to us is

growing short, if we take the worst case scenario seriously. We should apply the precautionary principle with political determination, rather than rejecting the worse case scenarios because of remaining uncertainties in climate forecasting. If eco-catastrophe is on the horizon in a decade or two if we fail to take appropriate and radical action, then let this truth inform our politics, including making coalitions with sectors of capital that are committed to a rapid solar transition.

Further, making known the real threat of ecocatastrophe must be coupled with winning the very agenda that will prevent C3 and deliver real and immediate benefits to working people: so-called green collar jobs building a solar economy, locally grown organic food, clean air and water, a reduced work week, income security, and, of course, a hopeful future for all children. Urban air pollution driving the childhood asthma epidemic has the same source as the carbon emissions driving global warming—traffic congestion and fossil-fuel burning power plants. Childhood asthma is an immediate impact while global warming is now more in the headlines than in perceived reality. A sharp reduction in air pollution will only come with sharp reductions in carbon emissions. This connection should inform ecosocialist practice.[79]

Must Capitalism Grow or Die?

In our critique of Kovel's *The Enemy of Nature*, we argued that the economic growth entailed with the reproduction of capital could be *potentially* sustainable with a focus of exchange-value linked to dematerialized production (e.g., software—of course recognizing that the present production of new software is linked to runaway obsolescent computer production). Whether this mode of production replaces the unsustainable mode is contingent on class struggle creating a new environmental regime for capital reproduction. However, in his reply to our critique, Kovel emphasized that the scale of capital reproduction inherently generalized "ecological disintegration." Further, Kovel prophetically argued that "transnational financial manipulation may involve dematerialized commodities, but by creating debt, sets the whole world system on an eco-destructive course."[80] This is a powerful insight. It is indeed ironic that the current financial meltdown may actually give us precious more time to prevent C3.

Kovel's central argument is that endless economic growth is inherent in the capitalist mode of production and consumption ("Grow or Die"). But the quality of this growth and its contingent relationships are critical with respect to issues of sustainability. Yes, we can construct computer models of sustainable reproduction of capital in a globally dematerialized solar capitalism. However, the historical legacy of real capitalist development makes its realization virtually impossible. And most significantly, MIC, as the core of unsustainable capital reproduction, is the biggest obstacle standing in the way of an ecosocialist transition. A global "solar capitalism" is an illusionary prospect, because the level of red and green struggle required to solarize global capitalism will itself likely result in ecosocialist transition. While individual capitalist economies may solarize, the dominant role of the military industrial complex in global capitalist reproduction makes its termination both an essential requirement for and likely a direct path to ecosocialist transition on a global scale.[81]

Many greens now argue for an end to economic growth as a societal goal.[82] But the qualitative aspects of economic growth should be more closely examined, even within a capitalist economy. There have been other indices proposed as alternatives to the GNP, which better capture the relative sustainability and environmental impact of economic activity.[83]

The uncritical call for an end to economic growth in green agendas tends to isolate greens from the global working class. Rather, I argue that red greens should advocate a program of sustainable economic growth. This would entail the immense task of solarization, demilitarization, ecosystem repair, and even carbon sequestration along with desalination powered by solar energy. Urban space would be converted to green cities by retrofitting solar technologies and creating agroecologies. Such a program would greatly reduce unemployment and would be an integral part of an ecosocialist transition.

As sustainable economic growth entails energy conservation in homes, transportation and industry, along with a sharp reduction in the production of wasteful commodities, it would also free up the use of human creativity and clean energy for the creation of the material infrastructure of the new society. Don Fitz has written:

> The greatest barrier to coping with climate change, peak oil, toxins and habitat destruction is the total mass of production. This mass is increasing; its increase vastly outpaces any real or imagined increase in consumption; and its increase is made worse by peddling green gadgets as some sort of solution.[84]

To be sure, the huge pileup of discarded commodities and unrecycled waste is evidence of runaway commodity production. If capitalist production continues, during times of economic recession or depression, this will only be partially reduced.

Thus, the ecological footprint of our technosphere must be radically reduced. I have argued that environmental policy should include application of both the containment and precautionary principles. While the precautionary principle is better known, the containment principle is its radical application to the goal of preserving the ecosphere for future generations. This principle emphasizes that the production of substances and genetic information not naturally present should be avoided (e.g., CFCs, chlorinated hydrocarbons, genetically engineered organisms). Further, fluxes of naturally present substances (e.g., nitrates) and radiative energies above trivial levels compared to those in the ecosphere should not pass through the porous boundary of human habitation (the "technosphere"). This will require the use of non-toxic closed cycle technologies, i.e., industrial ecology, green industrial chemistry.[85]

Further, an ecosocialist transition out of capitalism may even entail a higher physical throughput than now, considering the immense tasks involved in creating a new physical infrastructure for energy, agroecology, repair, andcleanup of the mess capitalism has left humanity.

Sustainable economic growth in both the physical and social economies therefore presuppose a transition into global solar communism. Then and only then will the goal of a steady-state economy be plausible as population size and sustainable consumption stabilizes

within the context of a globally solarized economy.

Ecosocialism into Solar Utopia

In addition to a global high-efficiency solar energy infrastructure to replace fossil fuels and nuclear energy, essential features of an ecosocialist transition include:

1) Application of the containment and precautionary principles to environmental policy (including industrial ecology and organic agriculture centered around and in green cities);
2) Progressive dematerialization of technology and global availability of state-of-the-art information technology; and
3) Increase of human population density centered in green cities with elimination of sprawl, leaving extensive biospheric reserves that are managed to preserve biodiversity.

Radical political and economic changes are, of course, necessary to realize these material prerequisites,[86] a challenge that is now a focus of intense investigation and debate by scholars and activists globally. Further, the actual creation of sustainable infrastructures must always be contingent on a process that organically includes participation of both the exploited and oppressed so that the social management and impacts of these technologies are emancipatory.

Joel Kovel's argument for ecosocialism makes an eloquent case for ending the rule of global capital.[87] In the fall of 2007, an historic meeting in Paris created the embryo of an ecosocialist international.[88]

Is ecosocialist transition to "solar utopia" an achievable goal in the 21st century, or is this simply wishful thinking? Aside from the formidable political challenges, we need to ask whether the material prerequisites are realizable, in particular, the creation of a solar-based energy infrastructure and agroecologies sufficient to support the global human population while significantly reducing the negative environmental and ecological impacts that characterize fossil-fuel intensive industrial agriculture.

A considerable body of recent work has established the feasibility and practicality of solar technology—including wind and solar thermal power as well as photovoltaics.[89] At the same time, it is now convincingly demonstrated that the expansion of nuclear energy, specifically a reincarnation of fission-powered reactors with new technology, will not significantly mitigate global warming.[90] Nor will it plausibly avoid the well-known negative environmental and health impacts of this energy source.[91] Similarly, development of biofuels represents a continuing threat to sustainable food production and biodiversity, while actually contributing to global warming by releasing soil carbon and nitrous oxide to the atmosphere, with the possible exception of restoring and harvesting prairie ecosystems on degraded land and perhaps a few other polycultures.[92]

The energy and material requirements for this transition in energetic infrastructure are considerable but not limited by the available fossil fuel reserves; nor are the negative impacts from this necessary parasitism on the existing energy base significant, relative to the

continued reliance on a fossil fuel base. One example is a current plan to create a concentrated solar power (CSP) infrastructure in the Sahara, which would meet the entire present demand for electricity in Europe and simultaneously provide a large increase in power availability for North Africa, with a radical reduction in carbon emissions by 2050 at a lower cost per kwh than present market costs for electricity production.[93]

Demilitarization will free up vast human and material resources necessary for this transition. If this prospect is unthinkable on the time frame necessary to avoid the likely catastrophes of global warming impacts, then so is any meaningful progress for humanity in this century. Of course a truly equitable implementation of solarization must entail democratic governance as well as an elimination of North/South disparities. Decentralization of power production (allowing cogeneration of heating) will result in reductions in carbon emissions and improvement of quality of life.[94] The creation and maintenance of this solarized infrastructure in progressively greener cities would create 21st Century employment for oppressed minorities and unemployed around the globe.

And as for the second big challenge, whether the global population can be fed without the concomitant negative impacts of industrial agriculture the following may be ventured: "Overpopulation" is a reality, but only in the context of the carrying capacity of the present political economy in this world of extreme inequalities. It is not so in relation to the carrying capacity of the biosphere. Mike Davis eloquently describes the overpopulated cities of the South, bursting with poor residents driven from rural areas,[95] because of the social impacts of the so-called green revolution,[96] as well as structural adjustment programs imposed by the IMF. But other regions are actually now under populated, such as rural areas in countries of sub-Saharan Africa, devastated by AIDS, in which population levels are arguably too low to restore and maintain sustainable agricultural production.

"Overpopulation" is not the fundamental driver of global inequalities and widespread misery; it is, rather, a symptom of the unsustainability of a world economy in which capital reproduction takes priority over the needs of humanity and nature. Even now there is still enough food produced globally, both in calories and nutritional content, to potentially feed everyone,[97] although this mode of production has huge negative impacts on people and nature. Hunger and malnutrition are the results of existing political economy and not any real shortage of food. But can agroecology still feed the world's population without the well-known negative impacts of industrial agriculture? There is a very good case that it can, particularly if it is carried out along with the processes of solarization.[98]

The End of Value in the 21st Century?

Will solar utopia realize the "End of Value," i.e., the end of capital reproduction? A passage from Jim Davis is illuminating:

> New technologies express the fulfillment of Marx's writings in his "Fragment on Machines"—a production system without human labor, where the productivity of technology so overwhelms the production process that "labor time ceases to be the measure" of wealth and "production based upon exchange value collapses." Such a production system is antithetical to a system based on the expropriation of surplus labor, and by definition cancels it. However, production has not collapsed; rather than work disappearing, or at least lightening, more people than ever are engaged in

> wage labor; and each new high-tech production zone seems to be matched by a new Dickensian production zone. Can these two positions be reconciled? Qualitatively new technologies are labor-replacing technologies, and lay the basis for Value-less production. …The new technological climate does not in itself destroy the Value system, or capitalism, but it does create the conditions for Capital's destruction and the construction of a communist society. The end of Value is not automatic, but a conscious act by class forces born out of the new conditions…This is how Value will end—as a political act, the exercise of class power [i.e., class struggle].[99]

We need to add that such an exercise of class power is a prerequisite for the possibility of ecosocialist transition, which can only be carried out with the historic dissolution of MIC, coupled with increasing social ownership and governance of the means of production as well as the modes of consumption—the entirety culminating in the creation of global solar communism.

A critical material prerequisite for the end of value is the availability of virtually "free" energy derived from a global infrastructure based on high-efficiency solar energy. This infrastructure will create the supply and quality of energy necessary to radically reduce negative environmental impacts—indeed to also restore and repair the biosphere—within the limits of the irreversible damage that has already occurred (e.g., biodiversity loss). In contrast, continued reliance on the present unsustainable energy supply not only contributes to well-known negative environmental, ecological, and health impacts, but it also reduces labor productivity while externalizing the costs of these negative impacts.

I have stated that existing technologies can accommodate the transition to the solar economy. But there are plausibly imminent breakthroughs of revolutionary proportions in high-efficiency thin-film photovoltaics, solar-driven hydrogen generation by water-splitting, as well as highly efficient wind-driven electricity production.[100] It is conceivable that high-efficiency thin-film photovoltaic technology might be ready for wide global use in less than a decade. Such a development would make possible a more rapid and much less expensive transformation of the global energy infrastructure than current solar technologies such as wind power and concentrated solar power, and this in turn would increase the chances of solarization taking place in time to prevent C3. This possibility could translate into rapid demilitarization, by undercutting the *raison d'etre* of MIC—its dependence on fossil fuels and nuclear power and its imperial project. Needless to add, this will not happen automatically but only in the course of inspired and dedicated political struggle. We are in the realm of speculation here. It is not, however, an idle speculation, but the imagining of really existing radical alternatives—for example, the subversive use of the global internet may be repeated in the near future by a global grassroots movement promoting a high-efficiency solar energy base. The end of the rule of capital and value may then be on the agenda, far sooner than we can now anticipate, provided the ecosocialist movement is of sufficient force. On the other hand, if such technologies are not ready in the next few decades, then the obstacle of MIC must still be overcome to prevent C3, using already existing solar technologies with a much greater cost for global implementation.

Each stage of history has been energy-parasitic on the previous: pre-industrial (low-efficiency solar, i.e., photosynthesis), then industrial (fossil fuels, nuclear fission); and now in the 21st century, the challenge of transition to post-industrial high-efficiency solar feeding off the remaining reserves of fossil fuel energy.

Another challenge to ecosocialist theory is to develop dynamic models that demonstrate the practicability of solar utopia, arising out of our present unsustainable mode of production and consumption. Such models would help us think through the contingencies and possibilities lying in wait in the path to its realization, revealing unexpected places in global political economy where ecosocialist movements might have the most leverage to move the monstrous boulder of capital down the slope to its well-deserved sedimentary cemetery of prehistory on a path that minimizes the destruction of nature and humans.

To move this to the level of actualization, we need models of the transformation of industrial/genetically modified agriculture to global agroecologies, as well as the creation of green cities and industrial ecologies in a world committed to rapid and progressive demilitarization and solarization—models that begin to demonstrate that another world is indeed not only possible but realizable in the 21st century.

Conclusion

Solar utopia is that "other possible world," when every child born on Earth has the right to a full life of creative fulfillment, to an environment free of hatred and pollution, and to a world with what is left of our planet's complement of biodiversity intact. For this we need to bring to an end the present global regime prioritizing capital reproduction over human and nature's needs.

This optimistic, yes, frankly utopian, vision of a global civilization will likely be achievable only if we can prevent climate change catastrophe by a timely transition to a global solarized economy. To be something of a "Leninist" now in our political practice is essential, first, to recognize the potentiality of the moment and act, else we lose the chance to change the future;[101] and second, to utilize every division in the ruling class to gain the necessary political momentum to prevent catastrophic climate change. But the vision itself and its realization cannot be a result of "expert" dictation. Rather, it can only come about as a product informed by the dialogue between a committed scientific/technological intelligentsia and communities of struggle, as embryos of the future are created within the womb of globalized capitalism, as global class struggle unfolds to achieve its full reality.