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The attempt by the Ukrainian socialist Sergei Podolinsky to use the laws of thermodynamics to analyze agricultural and industrial energy flows was rejected by Marx and Engels, leading later Marxists to disregard biophysical analyses of production. This paper suggests that both ecological economists and Marxists can benefit from a reconciliation of physical analyses of production with theories of valuation and distribution.

The Marxist labor theory of value accords no inherent value to natural resources. Biophysical or ecological economists, on the other hand, see the capture of low entropy as the fundamental requirement for production, although they do not emphasize theories of value. Many Marxists share with neoclassical economists a vision of unlimited resource abundance without physical constraints on production. Nevertheless, the fundamental requirement for growth in production is net or surplus energy, rather than labor. This is consistent with Marx's analysis of the crucial role of the steam engine and the use of coal in the development of modern capitalism.

Natural Resources and Surplus Value

The Marxist focus on extraction of surplus value from labor needs to be complemented by an understanding of the essential role of the environment in economic production. Both the concentrated nature of natural resources and the capture of low entropy by biological systems are essential for mobilizing surplus. Much more energy must be expended to recover low-grade resources compared to high-grade ones. The environment therefore affects the organization of production. At the same time, the organization of production affects the environment. Capital accumulation makes much more rapid exploitation of natural resources possible. This modification of the Marxist dialectic also creates a contradiction overlooked by Marxists, because by depleting high-quality resources, advanced industrial production undercuts its own productivity. Energy supply conditions also affect class relations. An abundant energy supply in the US prior to the early 1970s allowed both rising real wages and increasing surplus. Stagnant energy input from the early 70s to the mid-80s was associated with declining real wages and increasing class conflict.

Managing Socialist Economies

Marxists have asserted that socialist economies should not degrade their resource base because they are free of the contradictions of capitalism. This is false, as empirical evidence from communist economies amply demonstrates. Both capitalist and socialist economies are constrained by the same physical laws.

Dialectic of Resource Quality

Biophysical economists might benefit from a less reductionist, more dialectical approach to the relationship between technology and resources. New technologies make more effective resource recovery possible, but they simultaneously speed up resource depletion. This depletion in turn drives the development of technology.

Social Forces and Biophysical Economics

A consideration of social forces - central components of Marxist theory - needs to be added to the biophysical analysis of energy flows, as these flows are mediated by social relations. Similarly, economic relations cannot be reduced to physical interactions. For example, the technical availability of more concentrated sources of energy in the 20th century (e.g., petroleum and nuclear energy) has had a mediating effect on class conflict; the shift to these new energy sources was readily implemented for this reason. This technical strategy has become less effective during the last two decades, as energy returns to investment have declined for petroleum, and nuclear power has proved to have a lower energy return on investment than hydropower. The result has been a reduction in the amount of energy consumed by wage earners, which is consistent with Marxist analysis.