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The "energetic" dogma refers to the view that only energy matters, and the energy crisis of the 1970s has revived this view. This paper argues it is not only energy that is important, but that "matter matters, too."

THE ENERGETIC DOGMA

There are different justifications for the energetic dogma. Fred Cottrell[1] (1953) argues that net energy is all that mankind needs. Following Cottrell, H.T. Odum[2] (1973) defines efficiency in terms of net energy extraction: the greater the net energy extracted, the more efficient the process. However, the question should be extended to ask why efficiency should not be related to net matter as well? For example, copper is used in the production of copper, resulting in a positive amount of net copper. Moreover, copper mining results in negative net energy, while energy production results in negative net matter. The bias of energetics is in looking only at positive net energy as a criteria of efficiency.

Another justification for the energetics view is made in the 1957 book The Next Hundred Years, by Harrison Brown, James Bonner and John Weir. They claim that any material can be obtained by increasing the energy inflows to a system. This view has been extended by a number of writers who argue that, with adequate energy, the complete recycling of matter is possible.

The energetic view of the economic process in relation to the environment can be represented by a multi-process matrix of flows and funds. This economic process can be divided into five parts:

1) producing "controlled" energy from *in situ* energy;
2) producing capital goods;
3) producing consumer goods;
4) recycling material wastes from all processes into recycled matter;
5) supporting the population.

To test the energetic dogma, a stationary state must be considered in which the only inflow to the economic process from the environment is energy, i.e., there is no inflow of matter. The only outflow from the economic process into the environment is dissipated (unavailable) energy. The system reproduces itself, including the material funds that are a part of it: capital, people and land. The energetic model of the economic process must therefore be a closed system, since only a closed system can exchange only energy with its surroundings. The energetic view suggests that the economic system can provide internal *mechanical* work at a constant rate as long as there is a constant inflow of energy. However, this is impossible as a result of the inevitable degradation of matter over time (a principle that may be regarded as the Fourth Law of Thermodynamics).

The energetic view does not take into account that matter also continuously degrades into unavailable forms. For example, friction leads to the dissipation of both matter and energy. The energetic dogma instead claims that the dissipation of matter can be reversed completely given enough available energy.

MATTER MATTERS, TOO

Since complete recycling is impossible even in a steady state, there must be an input of available matter into the economic process from the environment to compensate for matter that dissipates and becomes unavailable. For example, if all of the iron produced in the United States between 1870 and 1950 were still in use in 1950, there would have been 13.5 tons per capita in use. However, in fact there was only half of this amount, the rest having been dissipated due to oxidation, corrosion and general wear. This dissipation occurs for all forms of matter, and the flow of dissipated matter increases with the size of the material stock.

Two separate accounts must therefore be maintained in accounting for environmental transactions: one for matter and the other for energy. The relationship between the economic process and the environment described earlier must then be modified to include:

1) an additional process that transforms matter *in situ* into controlled matter;
2) a new set of flows to account for dissipated matter that will be passed into the environment; and
3) a set of flows to account for "refuse" that flows into the environment.

ENERGY ANALYSIS AND ECONOMICS

The entropy law is the reason for economic scarcity; all commodities that have any usefulness must consist of low entropy. However, low entropy is only a necessary and not a sufficient condition for a commodity to be useful. In spite of the role that entropy plays in the economic process, it is wrong to think of this process as a set of thermodynamic equations. There is no quantitative law that links the amount of pleasure to the amount of low entropy consumed.

A number of writers have argued in favor of an energy theory of value. This is surprising, as there is no consensus on how to measure energy values. An examination of either net energy or gross energy methods of economic valuation shows that "in *absolutely* no situation is it possible for the energy equivalents to represent economic valuations." (1048)

GLOBAL ANALYSIS AND ECONOMIC CHOICE

The delivery of goods to the consumer requires both energy *in situ* and matter *in situ*, so we must pay attention to the depletion of available matter. Given our present industrial system, in the long run matter will become a greater constraint than energy. Furthermore, natural resource economic choices cannot be reduced to physico-chemical reactions, since matter and energy cannot be transformed from one to the other. All economic choices should therefore not be based on energy calculations alone. For example, if there are two technologies, one that results in more net energy, and the other in more net matter, then the appropriate choice is an economic, not a technical, problem. If both the technologies result in the same net energy, then the technology that results in more net matter should prevail.

GLOBAL ANALYSIS AND TECHNOLOGY ASSESSMENT

Solar energy is considered "free," and this point is used to argue for technologies based on this source. However, one must be careful before accepting such a claim. There is a difference between feasible technologies and viable technologies. At present, solar energy is feasible, but not viable, due to the material and energy requirements of producing solar collectors. Clearly attempts must be made to find viable solar energy techniques, but solar energy should not be viewed as a panacea that can overcome the problems of resource limitations.

Notes

1. Fred Cotrell, *Energy and Society* (New York, McGraw-Hill, 1953).
2. Howard T. Odum, “Energy, Ecology, and Economics” in *Ambio* 6, 220-227 (1973).