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Exergy and the economic process

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The Second Law of Thermodynamics (2nd Law) dictates that the introduction of physical work in a system requires the existence of a heat gradient, according to the universal notion of Carnot Heat Engine. This is the corner stone for the notion of exergy as well, as exergy is actually the potential of physical work generation across the process of equilibration of a number of unified systems with different thermodynamic states. However, although energy concerns the abstract ability of work generation, exergy concerns the specific ability of work generation, due to the requirement for specifying an environment of reference, in relation to which the thermodynamic equilibration takes place; also determining heat engine efficiencies. Consequently, while energy is always conserved, exergy –deriving from heat gradient equilibration- is always consumed. According to this perspective, the availability of heat gradients is what fundamentally drives the evolution of econosystems, via enhancing –or even substituting- human labor (Boulding 1978; Chen 2005; Ayres and Warr 2009). In addition, exergy consumption is irreversible, via the gradual transformation of useful physical work to entropy; hence reducing its future economic availability. By extending Roegen's relative approach (1971), it could be postulated that this irreversible exhaustion of exergy comprises the fundamental cause of economic scarcity, which is the corner stone for the development of economic science. Conclusively, scarcity consists in: (a) the difficulty of allocating -in the Earth System- very high heat gradients that would make humanity's heat engines very efficient and (b) the irreversible depletion of existent heat gradients due to entropy production. In addition, the concept of exergy could be used to study natural resource degradation and pollution at the biogeochemical level and understand why heat gradient scarcity in the Earth System was eventually inevitable. All of these issues are analyzed both theoretically and quantitatively.

Keywords: 2nd Law, physical work, heat gradient, Carnot Heat Engine, exergy, energy, reference environment, econosystems, irreversibility, entropy, scarcity, resource degradation, pollution

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