Emergy Baseline for the Earth: A Historical Review of the Science and a New Calculation

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ABSTRACT

Quantifying the emergy baseline of the Earth is a practical necessity for emergy evaluations, because it serves as a unified basis for determining transformities of the available energy storages and flows of the geobiosphere. The current debate over the value and significance of the planetary baseline has been in progress since 1998, when the author first brought new data on geopotential energy formation in the world oceans to H.T. Odum’s attention. In this paper, past studies of the baseline were reviewed and errors in data translation and model formulation were found to be sufficient to justify a new calculation. A fundamental epistemological obstacle to establishing a unified planetary baseline (i.e., the production functions for deep Earth heat and tide as a function of solar radiation are unknown) is overcome by using the transitive property of equalities to estimate equivalences between solar radiation and Earth’s deep heat exergy flows (4200 solar equivalent joules per joule, seJ J⁻¹) and between the exergy of solar radiation and the tidal exergy dissipated in the oceans (35,400 seJ J⁻¹). At present, the planetary baseline for the Earth with its ice-covered, polar oceans is approximately $1.16 \times 10^{25}$ seJ y⁻¹ and the distribution of the emergy or the organizing power of the inputs is: 1/3 solar radiation, 1/3 deep Earth heat and 1/3 tidal geopotential energy. In addition, the planetary baseline has been remarkably stable over the past 555,000,000 y ($1.00 \times 10^{25} \pm 1.13 \times 10^{24}$ seJ y⁻¹ or within ±11%). The tidal exergy dissipated in the world oceans over this time varies from 31% to 155% of its present value largely due to the changing efficiency of the Earth as a “machine” for generating tidal exergy. Close correspondence of the value and properties of this new baseline with the principles of Energy Systems Theory indicates that it should be preferred over prior determinations.

Citation

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