

The Emergy Baseline for the Earth: Is it Arbitrary?

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The emergy baseline for the Earth is used in determining the transformities of the products of all planetary processes and through these relationships it influences all emergy evaluations. Estimates of the emergy baseline made in the past have changed depending on the number of independent sources of available energy that were considered and the interaction of these sources to drive the primary processes of the Earth, e.g., the interaction of solar energy and geological deep heat to run the planetary cycle of crustal uplift and subsidence. The central problem in establishing a planetary baseline is to determine the equivalence between solar radiation, which is taken as the base energy type, and the two other independent inputs to the Earth, the deep heat from radioactive decay and residual heat of formation, and the gravitational attraction of the sun and moon. This can be accomplished by evaluating a production process to which solar radiation and one or more of the other inputs contribute. The baseline obtained depends on the degree to which the three independent inputs interact in producing a product. For example, if all three inputs interact to produce the sedimentary cycle of the Earth and the geopotential energy of the world oceans, the $15.83 \text{ E}24 \text{ sej/y}$ baseline is the result of the equivalences determined. In contrast, if solar energy and the Earth's deep heat interact to produce the sedimentary cycle, and gravitational attraction and solar energy interact to produce the geopotential energy of the world oceans, the $9.26 \text{ E}24 \text{ sej/y}$ baseline results. As long as all transformities in a study are calculated relative to the same baseline, the results of the study should be the same. In addition, any baseline can be converted into another by multiplication by the appropriate factor. The question then arises, "Is the choice of baseline arbitrary?" We present several lines of evidence to show that it is not an arbitrary choice. The main difference between the baselines is the relative importance attributed to processes driven by solar emergy (e.g., photosynthesis) in the overall organization of structure and function on Earth. The higher the baseline the lower is the role of solar energy in supporting organization compared to that of the Earth's deep heat and the tidal forces. One obvious test of any theory is that the results that are derived from it must lead to conclusions that are consistent with observations. We argue that the 9.26 baseline is preferable to the 15.83 baseline because the relative scaling of the efficacy with which solar, tidal, and deep heat produce order and organization on Earth more closely matches qualitative observations using the 9.26 baseline ($\text{solar} \cong \text{deep heat} > \text{tidal forces}$) than that obtained using the 15.83 baseline ($\text{solar} \cong \text{tidal forces} < \text{deep heat}$). In addition, an earlier analysis of petroleum formation at optimum conditions in the past led to the realization that the thermodynamic scaling of primary production on the Earth also makes the 9.26 baseline more plausible.

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