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An ecological understanding of net zero energy building: Evaluation of sustainability based on emergy theory

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Abstract

This study evaluates the sustainability of NZEB in terms of ecosystems development at the global environmental scale, presenting ecological indices and metrics. Employing Howard Odum's ecosystems theory and emergy (spelled with an "m"), authors attempt to associate building energy consumption with a thermodynamic networking of energy quality transformation. All upstream impacts of energy use are evaluated with emergy-based sustainability indicators. A test building, a LEED-platinum-credited NZEB was chosen and a previous study was revisited to set a baseline (non-NZEB) with refined data for comparative analyses. Findings showed that NZEB uses greater nonrenewable emergy to seek a zero-emergy budget despite its greater emergy sustainability index (ESI). It was identified that production of renewable energy and the intensification of a climate-modifying function (insulation) required an increase of environmental inputs (construction materials, economic services, and labor) with upgraded energy quality. Spatial hierarchies of building emergy flows characterize the empower distribution within NZEB. This work demonstrates that building sustainability depends on increasing power, not efficiency, and also justifies maximum empower principle in environmental building research.

Keywords: *Net zero energy building, Emergy analysis, Maximum empower principle, Emergy sustainability index*

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