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# Clark's Crow: A design plugin to support emergy analysis decision making towards sustainable urban ecologies

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ABSTRACT

Architects working with city planners and developers in the shaping of urban environments typically consider multiple factors in isolation, from urban design and socio-economic relationships to data analyses. Analyses regarding urban life cycle scenarios are exemplar of this trend, with considerations made in isolation at the later stages of the design-development process when the scope for decisions which could ultimately affect the sustainability of an urban environment is much more limited. This paper defines our effort to introduce a new tool, named "Clark's Crow", which aims to address this shortcoming by promoting awareness of the impact of different design options through a biophysically based ecological accounting method in the early stages of urban design-development. The tool is used within existing architectural design environments with an aim to offer a socio-ecological analysis during the design decision-making process. Clark's Crow is underpinned by the emergy analysis method, which aims to consider both the energy, material, and information flows of a system, such as an urban ecology, and to understand both the work of the techno-sphere in constructing our urban environments and that of the geo-biosphere in sustaining such development. Clark's Crow facilitates emergy analysis in the early stages of urban design, thereby allowing queries regarding material and energy flows to be addressed in conjunction with design choices at this initial stage. In this paper, we demonstrate the effectiveness and features of Clark's Crow through a case study of development using next generation systems in Manhattan, New York, depicting how an emergy analysis approach can lead to an understanding of the value and impact of speculative buildings towards sustainable design-development.


## 1. Introduction

The development of urban environments from a socio-economic perspective is greatly influenced by the health of our urban ecosystem and surrounding natural environment. Buildings and the built environment play a major role in urban ecosystems. In the U.S. alone, the building sector accounted for 41% of primary energy consumption and 30% of material use in 2010 (DOE, 2012). As illustrated in Fig. 1, the materials and energy vectors that are directly used by the building sector are part of the so-called techno-sphere (which comprises our economies and societies), but they are ultimately reliant on the availability of ecological goods and services in the geo-biosphere (including the provision of primary energies and materials, as well as the dilution and recycling of emissions). Urban systems place a burden on the geo-biosphere through the indirect exploitation of these ecological goods and services, as well as through the release of unintentional emissions which, unless diluted through biological processes, may ultimately lead to environmental overloading. How we process, recover, restore and regenerate both the technical "nutrients" of the techno-sphere and the biological nutrients of the geo-biosphere within urban ecosystems is thus a crucial question when considering sustainable urban development.

Urban systems are often treated as linear processes, focusing solely on the operational stage of buildings in terms of their direct use of energy and waste management. Over the last four decades, however, a number of material and energy accounting methods have been developed in order to speculate and give a quantitative estimate of the relationship between the resources of the geo-biosphere and the material and energy flows within the techno-sphere, such as Embodied Energy Analysis (Costanza, 1980), Life Cycle Assessment (LCA) (ISO, 2006), and Emergy Analysis (Odum, 1988; Odum, 2007; Odum and Odum, 2000). Through the introduction of the concept of "embodied energy" and other life-

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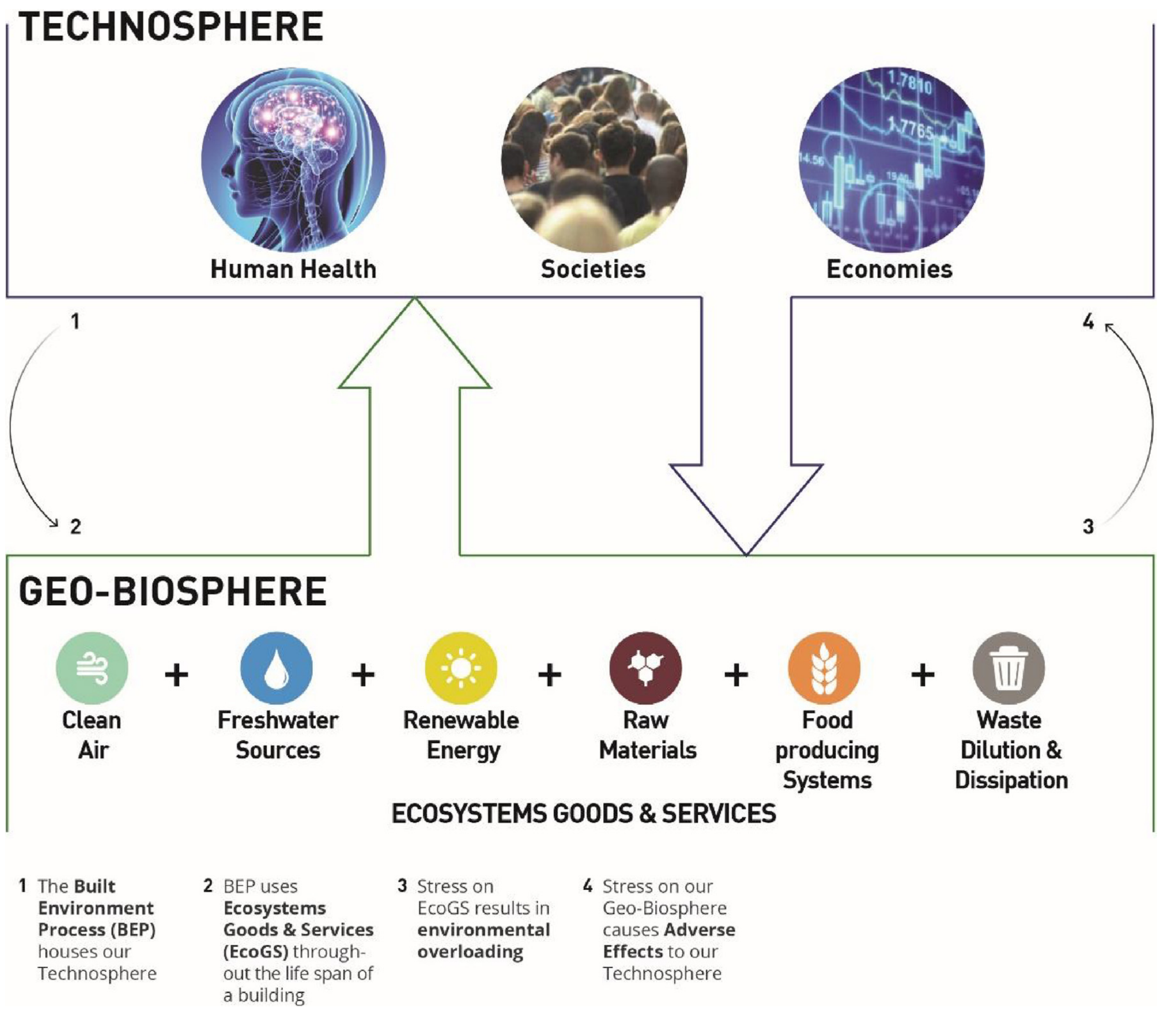


**Fig. 1.** The relationship between the Techno-sphere and the Geo-biosphere. Urban environments house the work of the techno-sphere from socio-economic activity to human health and well-being. In order to function, they rely on ecosystem resources of the geo-biosphere.

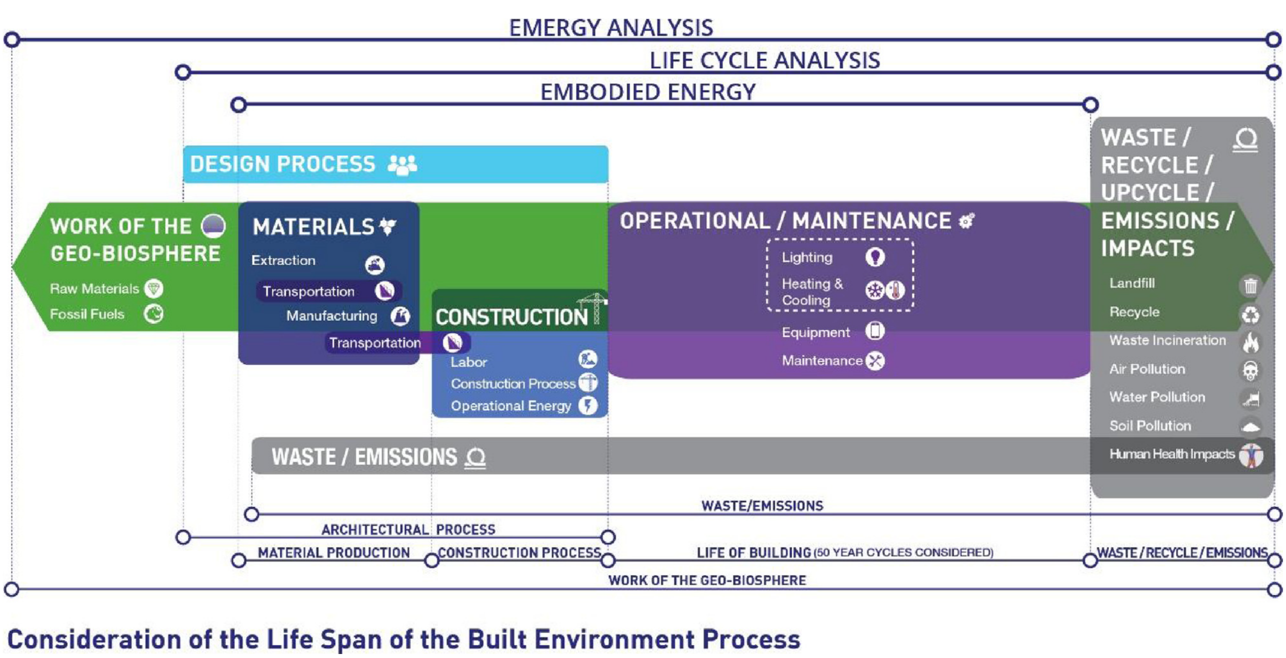


**Fig. 2.** Consideration of the Life Span of the Built Environment Process (BEP). Different assessment methods focus on various scopes of a system's "life cycle". In terms of buildings, the scope of analysis may include any segment of the following: extraction of raw materials, manufacturing of materials, the construction process, the operational and maintenance phase and/or the end of life design.