EMERGY SYNTHESIS 4

Theory and Applications of the Emergy Methodology
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Acknowledgments

This being the fourth conference, I wish to thank all those who have made it possible. The organizing committee members - Daniel Campbell, Shu-Li Huang, Enrique Ortega, Torbjörn Rydberg, David Tilley, and Sergio Ulgiati – were helpful in all aspects of the conference and helping to organize the proceedings. In addition, they were an invaluable source of ideas and assistance throughout the months proceeding and following the conference. Students in the System Ecology Program at the University of Florida were, once again, involved in welcoming participants to our campus and providing support during the registration period. Carol Binello again provided invaluable coordination of conference logistics, receptions and food. Betty Odum hosted the first open house to welcome all participants. Leah Cohen was invaluable in assisting with editing the proceedings and setting high standards for this publication. Probably most important, as with past conferences, the invaluable and most capable assistance of Eliana Bardi, is most gratefully acknowledged…the conference and publication of these proceedings resulted from her hard work and dedication. Ely, thank you for everything.

I would also like to thank the conference participants, who traveled far to join us in this most important endeavor by contributing to the information exchange that is so vital to the growth, maturity, and application of the emergy theory.

The manuscripts in these proceedings have benefited from the following reviewers, who gave generously of their time to provide constructive criticism, ideas, and challenges to authors, which certainly increased the quality of each of the papers in this volume.

Tom Abel, Tzu-Chi University, Hualien, Taiwan
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Finally, it is most apparent that the community of emergy practitioners is growing as our conferences increase in number of attendees and presentations. The growth of our community is important if we are to have an impact on the future. During these times of social and political unrest, increasing globalization of commerce, and peak oil, our work is ever more important. I would like to acknowledge the global emergy community and the contributions they are making to further our understanding of the biosphere and humanity’s place within it. Further, I would like to challenge everyone to use their science in the search for peace, justice, and rational patterns of material wealth that not only acknowledge our utter dependence on a healthy biosphere, but that protect it for this and succeeding generations. I urge you to speak loudly in favor of a prosperous way down.

Mark T. Brown
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Introduction

Emergy Synthesis

In this volume, 39 papers are presented that resulted from the Fourth Biennial Emergy Conference held in Gainesville, Florida in January 2006. Because of the large numbers of papers, we have organized them into “Themes” or sections, spanning from theory, applications and comparisons of the emergy methodology, to a more in depth analysis of environmental accounting and issues regarding sustainability and carrying capacity, and ending with a series of case studies in which the emergy methodology is applied. A quick scan through the Table of Contents demonstrates the varied applicability of the emergy methodology, with papers addressing alternative fuels, sustainable development, water resource allocation, environmental welfare, information, agroforestry, agricultural and industrial production systems, national time-scale analysis, and many other subjects.

Held every two years in Gainesville on the University of Florida campus, the “Emergy Conference” has grown steadily from about 35 participants in 1999 to over 120 participants in the January 2006 conference. The proceedings of the conference, published by the Center for Environmental Policy at the University of Florida has increased in size from a book of 26 papers resulting from the 1999 conference to 39 papers from the 2006 conference. The Conference is truly international, bringing together scientists representing over 20 countries from the continents of Asia, Australia, Europe, and North and South America.

General Introduction: Concepts and Principles

To simplify the tasks of all the authors whose papers appear in this proceedings, we provide introductory material that defines many of the terms and concepts used in the emergy field. We begin with clarifying the title of this series of conference proceedings:

**Synthesis** is the act of combining elements into coherent wholes. Emergy synthesis is a “top-down” approach to quantitative policy decision making and evaluation. Rather than dissect and break apart systems and build understanding from the pieces upward, emergy synthesis strives for understanding by grasping the wholeness of systems. We have named this series of conference proceedings “Emergy Synthesis” to reflect our commitment to building understanding rather than dissection of knowledge.

The emergy concept and the maximum empower principle constitute powerful concepts, definitions and tools for investigation of systems at all scales, framing a system’s behavior and sustainability within the biosphere’s driving forces and evolutionary pattern. By expanding the scope of energy studies to the biosphere’s space and time scales, the emergy method is able to:

a) Investigate systems that are outside of human activities (ecosystems, global biosphere processes).

b) Focus on the role of the environment in support of human dominated processes, both on the resource supply side and on the sink side (dilution or uptake of pollutants).

c) Perform a donor-side quality assessment as a complement of generally used user-side assessments. This provides a measure of how much the system relies on the biosphere for support.

d) Evaluate processes that are directly based on small flows of physical carriers, but supported by huge indirect flows of resources, such as the creation and processing of information.

e) Expand the time scale of the evaluation, to include the memory of resource flows converging to the system.
f) Assess the renewability of resources based on both space and time convergence required to make them. The transformity quantifies this renewability in a continuous form, with higher values corresponding to higher convergence of environmental work and therefore lower renewability.

g) Evaluate in a quantitative way the (donor-) quality of those resources flows and storages that have no market (such as fresh water, biodiversity, fertile topsoil) and cannot be evaluated in monetary terms.

h) Assess the environmental impact of processes based on matching of high quality and low quality resources.

i) Include in the evaluation the emergy supporting human labor and services.

All of these properties provide a powerful and comprehensive tool for the investigation of systems on the larger scales of the biosphere, and, finally, help with understanding the dynamic interaction between human dominated processes and resources and services provided for free by nature.

Following are brief definitions of the emergy concepts. For a more complete introduction to the emergy methodology please refer to H.T. Odum’s Environmental Accounting (1996) text.

Definitions

Energy is sometimes referred to as the ability to do work. Energy is a property of all things which can be turned into heat, and is measured in heat units (BTUs, calories, or joules)

Emergy is the availability of energy (exergy) of one kind that is used up in transformations directly and indirectly to make a product or service. The unit of emergy is the emjoule (see below), a unit referring to the available energy of one kind consumed in transformations. For example, sunlight, fuel, electricity, and human service can be put on a common basis by expressing them all in the emjoules of solar energy that is required to produce each. In this case the value is a unit of solar energy expressed in solar emjoules (abbreviated sej). Although other units have been used, such as coal emjoules or electrical emjoules, in most cases all emergy data are given in solar emjoules.

Emdollar is a measure of the money that circulates in an economy as the result of some process; abbreviated as “em$” or ”em$”. In practice, to obtain the emdollar value of an emergy flow or storage, the emergy is multiplied by the ratio of total emergy to Gross National Product for the national economy.

Emjoule is the unit of measure of emergy, the term is short for emergy joule. An emjoule is an expression of the units of energy previously used to generate a product; for instance the solar emergy of wood is expressed as joules of solar energy that were required to produce the wood. Solar emjoules is abbreviated "sej."

Empower is a flow of emergy (ie emergy per time). Emergy flows are usually expressed in units of solar empower (solar emjoules per time).

Unit Emergy Values (UEV) are based on the emergy required to produce something. UEVs are calculated by dividing the sum of all emergy required by the units of product output. There are three types of unit emergy values appropriate for this chapter as follows:

Transformity is defined as the emergy per unit of available energy(exergy). For example, if 4000 solar emjoules are required to generate a joule of wood, then the solar transformity of that wood is 4000 solar emjoules per joule (abbreviated sej/J). Solar energy is the largest but
most dispersed energy input to the earth. The solar transformativity of the sunlight absorbed by the earth is 1.0 by definition.

Specific emergy is the unit emergy value of matter defined as the emergy per mass, usually expressed as solar emergy per gram (sej/g). Solids may be evaluated best with data on emergy per unit mass for its concentration. Because energy is required to concentrate materials, the unit emergy value of any substance increases with concentration. Elements and compounds not abundant in nature therefore have higher emergy/mass ratios when found in concentrated form since more work was required to concentrate them, both spatially and chemically.

Emergy per unit money is a unit emergy value used to convert money payments into emergy units. The amount of resources that money buys depends on the amount of emergy supporting the economy and the amount of money circulating. An average emergy/money ratio in solar emjoules/$ can be calculated by dividing the total emergy use of a state or nation by its gross economic product. It varies by country and has been shown to decrease each year. This emergy/money ratio is useful for evaluating service inputs given in money units where an average wage rate is appropriate.

Emergy accompanying a flow of something (energy, matter, information, etc.) is calculated using a unit emergy value. The flow expressed in its usual units is multiplied by the emergy per unit of that energy or material. For example, the flow of a fuel input to a process, in joules per time, can be multiplied by the transformativity of that fuel (emergy per unit energy in solar emjoules/joule), or the mass of a material input can be multiplied by its specific emergy (emergy per unit mass in solar emjoules/gram). The emergy of a storage is calculated by multiplying the storage quantity in its usual units by its unit emergy value.

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