Emergy Analysis

S. Sreeremya
Assistant Professor
Department of Biotechnology
Sree Narayana Guru College, Coimbatore, Tamil Nadu
Corresponding Author's E-mail: *sreeremyasasi@gmail.com*

Abstract

Emergy accounting avails the thermodynamic basis of all forms of energy, materials and human services, but converts them into equivalents of one form of energy. Emergy accounting is much organized as a top down approach where first a system diagram of the process is drawn to organize the evaluation and account for all inputs and outflows. Tables of the actual flows of materials, labor and energy are constructed from the diagram and all flows are evaluated. The last and final step of an emergy evaluation involves interpreting the quantitative results.

Keyword: - *Emergy, Evaluation, Analysis, Energy*

INTRODUCTION EMERGY ANALYSIS METHODOLOGY AND INDICATORS

In emergy analysis various forms of energy can be expressed as coal, oil or another given fuel, and these can be compared and assessed (Finn, 1980) . This is, somewhat impossible as regards the materials, services or labour necessary for the energy production process. Yet, each of the input quantities required in the energy production process has its own energy value, which has been typically consumed in the production or in ensuring economic resources created by the production process, and this value should be taken into account in assessing the energy production process. While availing emergy calculations, therefore mentioned input values can be calculated in comparable unit, and with their help it is possible to determine the total emergy necessary for the production process. An overall chart of the production system and the symbols used in emergy analysis are presented (Denton, 1975).

The production process uses two environmental resources:

• *R – renewable natural resources, which in turn are divided into two categories*:

- **Renewable R1**, which include solar energy, wind energy and rain;

- **Renewable R2**, which are related to local ecosystem-provided resources such as renewable energy resources (biomass), as well as water and air in process-cooling equipment. Air is also availed in combustion processes.

• **N** – non-renewable natural resources, including coal, gas, oil products or groundwater if used faster than its regeneration rate. Input F contains economy-ensured services related with the development and typical operation of the production process, services, technical equipment, remuneration, etc. Total Y emergy is attributed to the process end product (output) and is labeled Y. The production byproduct (pollutant) flow is labeled with W, and it penetrates the environment. Availing the examined flows, the following indicators are defined for each production process (company).

Emergy yield ratio (EYR).

The dialog between energy analysis (EA) and EMERGY analysis (EMA) is much embedded in the larger search for indicators to guide our lives and behaviors in environmentally desirable directions (Odum et al.,1992). Both have policy overtones as well as scientific under-pinnings. EMA is the much ambitious of the two: it has a broader purview, it is bolder in claiming a direct connection to economics and it has an internal optimizing principle. With such ambitions, EMA is more subject to criticism, and more likely to fail in its putative policy uses, but EA is hardly immune. Criticism of both came from without, especially from economists concentrating on application. Criticism of each also came from the other, often concentrating on the details of accounting and bookkeeping: how to calculate and use the quantitative results (Brown et al., 2004). The emergy approach provides policy- and decision-makers with a valuation system so that human and natural environments can be better managed and regulated. The results from this research confirm that the emergy approach attempts to provide a more comprehensive EGS value. Its ubiquitous appeal and methodology have been criticized by economists, ecologists and energy analysts. They delineate its methodology as idiosyncratic, as they claim it does not follow the principles of additivity. In addition, emergy opponents believe that its conceptual complexity will limit its uptake within the realm of policy and decision-making. Emergy proponents regulates that the emergy approach respects the principles of additivity, as it only uses balanced energy and material flows, which are converted into emergy units to assess a system's sustainability. Despite its perceived conceptual and methodological complexity, the emergy approach availing Emergy to Value Ecosystem Goods and Services continues to be applied within academia and public agencies, such as the U.S. Environmental Protection Agency (U.S. EPA) and the U.S. Forest Service, to inform policy and decision-making.

The data collected from the expert interviews and online survey all suggest that using biophysically grounded EGS-valuation methods is desirable. The use of the emergy approach in concert with economic instruments to value EGS could lead to a more complete assessment that reflects human preferences as well as the natural environment's evolutionary tendency toward energetic efficiencies (Bonati, 1993).

One makes the following recommendations for pursuing a broader investigation into and potential application of emergy and other energy-based EGS-valuation methods:

- Examine in greater detail the methods availed to derive solar transformity coefficients and various conventions used to conduct an emergy analysis.

- Apply the emergy approach along with economic instruments to a study field where an EGS assessment is underway or has been completed.

- Organize a workshop among academic experts and policy-makers to discuss energy-based approaches (including emergy) and economically based approaches to valuing EGS.

- Expand this study to assess and analyse the potential of other energy-based EGS-valuation methods, such as net energy accounting, ecological footprint and net primary production.

- Examine the potential use of energy-based valuation methods (including the emergy approach) to assess and analyse supporting ecosystem services that cannot be adequately evaluated using economic approaches.

- Identify the decision-making metrics used by government departments to better understand how EGS-valuation information derived from economically and energetically based methods can be much informative for these agencies and compatible with their needs.

In accordance with the saying “we can only manage what we measure,” adequately valuing EGS requires a combination of biophysical and economic methods (Bastianoni, 2005). The emergy approach typically provides a way to objectively and comprehensively assess goods and services from the environment, society and the economy availing solar energy as a common unit of measure that allows for the assessment of a system’s sustainability. Additional research on the emergy methodology is needed to determine whether it should be applied more vastly to valuing EGS. Emergy analysis comprehensively measures the sustainability of human and natural systems. Specifically, it can be availed to account for estimating the work required to deliver ecosystem services, environmental flows of energy and storage of energy in the form of natural capital (Brown, 1991).

According to Hau and Bakshi the emergy analysis offers a number of advantages, as it:

- Provides a way to bridge economic and ecological systems.
- Provides an objective means by which to quantify and value non-market inputs into a typical system.
- Shares the rigour of thermodynamics and is scientifically sound.
- Provides a common unit that allows for a comparison of all resources.
- Provides a more holistic alternative to many existing methods of decision-making.

Emergy comprehensively measures value as it considers all contributions to the formation of a particular good or service. Odum has gone as far as suggesting that since emergy is a more complete measure of wealth, it could substitute for money (Odum,1987). Although the emergy approach has a typical ubiquitous appeal, it has drawbacks, like many other environmental accounting methods

Emergy critics generally complain that the method:

Using Emergy to Value Ecosystem Goods and Services

- Lacks formal links with related concepts in other disciplines.
- Lacks adequate details on the underlying methods.
- Is computationally and data intensive.
- Is based on sweeping generalizations that remain unproven.

Using emergy to value goods and services has been criticized for ignoring one of the fundamental tenets of economics, which centres on human preference and demand(Brown et al.,1997).

For example, the value of fuels will be linked to physical scarcity, capacity to do useful work, storage amenability, safety, cost of conversion and so on. Consumers will spend more or less resources to appropriate particular goods or services depending on the attributes they find much attractive (Buranakarn, 1998). Emergy analysis consists of converting all goods and services into a common unit of measure so they can be aggregated to evaluate a system's sustainability. Transformity values availed to convert energy and material stocks and flows into emergy values may provide some insight into the energetic quality of a particular good or service, but they do not capture those attributes that are linked to economic utility. This criticism stems from the fact that economics places an anthropocentric value on the goods and services that are generated from natural and human systems (Brown eta l., 1996). Emergy, on the other hand, provides an eco-centric value by focusing on the major supply side of the system (Simoncini, 2006). In essence, emergy values goods and services by focusing on what goes into them rather than what someone may be willing to pay for them. It does so by catering a systems view of our dependence on ecosystems, which is a direct and indirect expression of our reliance on the sun. Emergy practitioners have tried and implemented to communicate the important insights provided by their analysis method by converting emergy units into emdollars. This is accomplished by multiplying an emergy value by a conversion factor, which is the ratio of a particular economy's GDP divided by the total emergy that supports it. This technique has been met with much skepticism from economists who claim that it introduces double counting. In addition, expressing emergy values in emdollars conflicts with the argument that money is an incomplete measure of wealth—an argument that is availed to bolster the use of emergy analysis. Nevertheless, this conversion provides a means for communicating the importance of emergy flows to policy-makers, who base their decisions on monetary measurements (Odum, 1996).

About 30–40% of the total natural resources that are used industrialized countries are exploited by the building industry. Almost 55% of this energy flow is used for weather conditioning (heating and cooling) in buildings. Almost 42%of the world's consumption of materials converts to the built environment, and about 30% of energy use is due to housing. For example, in the US, a rate of 36–60% of the national energy budget is used to maintain buildings. Since 76% of the electrical supply in the US is thermoelectricity, a large amount of CO_2emissions also depend on housing, in addition to the emissions due to building materials production (Wang et al., 2013). In the E.U., the energy consumption for housing and services was 371.46Mtoe (million tons of oil equivalent) in 2000, which is higher than other sectors such as transport and industry. An environmental policy for the building industry would aim to maintain a high quality of the built environment while optimizing the use of resources. Since energy consumption, energy wasting, emissions and environmental impacts due to housing are expected to increase in the next few years, an accurate monitoring and management of the building industry is quiet urgently required. Buildings could theoretically be conceived as thermodynamic engines that use energy to provide specific services, and that maintain their performances constant in time with respect to variable context conditions such as climate, temperature, humidity, sun irradiation, and air motion. Building management therefore refers to the energy exchanges between buildings and their living context made by human beings and the surrounding environment (Dong et al., 2013).

EMERGY ANALYSIS

Emergy is the total energy that the production of material, energy or service is needed directly and indirectly. It is expressed in a same unit as solar emjoules (sej). The emergy production analysis can take all material flow and energy flow into consideration, so it can break the gap between social economic and ecological environment. As it considers the consumption of environmental resources, it can express the pressure of urban development on surrounding area. Renewable resources (R) include solar emergy, rain geo potential emergy, rain chemical emergy, wind emergy and so on. To avoid double counting one only take the largest emergy to calculate for R, instead of the sum of renewable resource emergy.

Nonrenewable resources (N) refer to the dispersed resources such as soil, and resources used for construction process. We divided imports and outside resources into four part, including material, energy, goods, and services and labor. Exports emergy majorly includes items which are agricultural, raw material, fertilizer and pesticides, processed material, machinery and transportation, services (Boix et al.,2015).

CONCLUSION

Emergy, it is the amount of energy that was consumed in direct and indirect transformations to make a product or service. Emergy is a measure of quality differences between different forms of energy. Emergy is an expression of all the energy veiled in the work processes that generate a product or service in units of one type of energy. Emergy accounts for different forms of energy and resources (e.g. sunlight, water, fossil fuels, minerals, etc).

REFERNCES

I. Boix, M., Montastruc, L., AzzaroPantel, C., Domenech, S., 2015, Optimization methods applied to the design of ecoindustrial parks: a literature review. Journal of Cleaner Production 87, 303-317.

II. Dong, H., Geng, Y., Xi, F., Fujita, T., 2013, Carbon footprint evaluation at industrial park level: A hybrid life cycle assessment approach. Energ Policy 57, 298-307.

III. Wang, H., Lei, Y., Wang, H., Liu, M., Yang, J., Bi, J., 2013, Carbon reduction potentials of China's industrial parks: A casestudy of Suzhou Industry Park. Energy 55, 668-675.

IV. Odum, H.T., 1996, Environmental accounting, Wiley. Brown, M.T., McClanahan, T.R., 1996, EMergy analysis perspectives of Thailand and Mekong River dam proposals. Ecol Model 91, 105-130.

V. Brown, M.T., Ulgiati, S., 1997, Emergybased indices and ratios to evaluate sustainability: monitoring economies and technology toward environmentally sound innovation. EcolEng 9, 51-69

VI. Buranakarn, Evaluation of recycling and reuse of building materialsusing the emergy analysis method, University of Florida, Ph.D. Thesis,1998.

VII. Simoncini, Analisiemergetica di un edificio: effetti ambientalidi materiali e tecnichedella bioarchitettura, Degree Thesis, available at:Dept. of Chemical and Biosystems Sciences, University of Siena, Italy,2006.

VIII. Odum, E.C. Odum, R. King, R. Richardson, Ecology and Economy:‘‘Emergy’’ Analysis and Public Policy in Texas. Energy System in TexasandThe United States, Policy Research Project Report Number 78, TheBoard of Regents, University of Texas, TX, 1987.

IX. Brown, J.E. Arding, Transformity Working Paper, CenterforWetlands, University of Florida, FL, 1991.

X. Bastianoni, D. Campbell, L. Susani, E. Tiezzi, The solar transformityofoil and petroleum natural gas, Ecological Modelling 186 (2) (2005) 212–220.

XI. L.Bonati, U. Cosentino, M. Lasagni, G. Moro, D. Pitea, A. ad Schiraldi(Eds.), Proceedings of the second International Workshop—Trends inEcological Physical Chemistry, Elsevier, Amsterdam, The Netherlands,1993, pp. 187–215.

XII. Brown, H.T. Odum, S.E. Jorgensen, Energy hierarchy and transformity in the universe, Ecological Modelling 178 (2004) 17–28.

XIII. Odum, Emergy and Public Policy, Part I–II, Environmental Engineering Sciences, University of Florida, Gainsville, FL, 1992.

XIV. Denton, R.V., 1975. The energy costs of goods and services inthe Federal Republic of Germany. Energy Policy 3, 279–284.

XV. Finn, J.T., 1980. Flow analysis of models of the Hubbard Brookecosystem. Ecology 6, 562–571.