8th Biennial Conference

Emergy & Environmental Accounting

Theories, Applications and Methodologies

January 16 - 18, 2014
Ballroom A ~ J. Wayne Reitz Union

Sponsored by:
Center for Environmental Policy ~ University of Florida

CONFERENCE SCHEDULE

Thursday, January 16, 2014 – Ballroom A

7:30 **Registration**

8:20 – 8:30 **Opening Remarks: Mark Brown Introduction & Kirk Hatfield,** Director of the Engineering School for Sustainable Infrastructure & Environment (ESSIE)

8:30 - 10:10 **Session 1 ~ Methodological & Conceptual Approaches**

Systems Ecology: Where are the boundaries?
Brian Fath

Transformity dynamics and maximum empower in pulsing systems
David Tilley

Emergy and co-emergy
Stephen Tennenbaum

Open issues in Emergy Methodology
Enrique Ortega, Simone Bastianoni

10:10 - 10:35 **Break**

10:35 - 12:15 **Session 2 ~ National and Regional Analysis**

Sustainability of tourism in the Alps: the role of hotels
Dina Rizio, Geremia Gios

Study of the environmental sustainability of ABC Paulista using emergy synthesis
Fábio Sevegnani, C.M.V.B. Almeida, B.F. Giannetti, S.H. Bonilla, F. Agostinho

On the meaning of the emergy indices in nested systems
Fabiana Morandi, Dan Campbell, Federico M. Pulselli, Simone Bastianoni

World economy in a cube
Federico Pulselli, Luca Coscieme, Simone Bastianoni

12:15 - 1:15 **Lunch**

1:15 - 2:30 Session 3 ~ Technological Systems: Fuel Production

Influence of cellulase enzyme production on emergy efficiency of lignocellulosic ethanol
Feni Agostinho, Ana B.B. Bertaglia

Emergy evaluation of a partial substitution of gasoline with 2nd generation ethanol: theoretical aspects and practical consequences
Simone Bastianoni, Nicoletta Patrizi, Fabiana Morandi, Federico M. Pulselli

Emergy analysis of emerging methods of fossil fuel production
Elliott Campbell

2:30 – 2:55 Break

2:55 – 5:00 Session 4 ~ Built Environments

A review of integrated environmental assessment methodologies in the built environment using a case study building
Ravi Srinivasan, Wes Ingwersen, Christian Trucco, Robert Ries, Daniel Campbell

Environmental building design: Hierarchies of production and use in buildings
William Braham

Environmental Value Engineering: An environmental life cycle assessment methodology for comparing built environment alternatives
Wilfred H. Roudebush

Evaluating the impacts of built environments on ecosystem goods and services using University of Florida Campus as a case study: Maintenance of soil quality and drainage services
Christian Trucco, Ravi Srinivasan, Cynnamon Dobbs

A case study in emergy based building retrofits
Hwang Yi, William Braham

5:45 – 9:00 Poster Session & Reception at *Ustler Hall*, hosted by the Center for Environmental Policy
(maps at end of program and on the website)

POSTERS

Emergy analysis of an English school located in the south of Minas Gerais Brazil
S. H. Bonilla, Daniel Lupinacci

Emergy assessment of integrated swine-crops-eucalyptus systems with manure anaerobic biodigestion, greenhouse gases management and energy recycling
Luz Buller, Enrique Ortega, Ivan Bergier, Maria L. A Benini

Digital photography – there is more to it than "point and click"
Robin Burgess, (**Dan Campbell** representing)

The real wealth purchased in a New England fish dinner
Dan Campbell, C. Wigand, N.B. Schuetz

The United States of Abraham: A path toward peace in the Middle East?
Dan Campbell, David M. Scienceman, Elliott T. Campbell

Dynamic planetary emergy baseline applied to crustal minerals
Chris De Vilbiss

Computing the Unit Emergy Value of computers – a first attempt
André L.A. Di Salvo, **Feni Agostinho**

SCASE: web application for calculation and analysis of environmental sustainability in emergy
Wellington L.M.França, F.J.C.Demetrio, B.F.Giannetti, C.M.V.B. Almeida

Emergy synthesis as a tool to assess soil quality change
Fernando Guerra, Marcio Roberto Soares, José Carlos Casagrande, Takashi Muraoka, Thiago Libório Romanelli

Emergy analysis of the cover crop of the banana tree pseudo stem, an applied study in Pedralva south of Minas Gerais Brazil
Daniel Lupinacci, R. M. Silva, C.C. Silva, J.H. Oliveira

Carrying capacity by emergy evaluation and ecological foot print
Sayoko Nakajima, Enrique Ortega

Assessing alternative developments for milk production in the southern region of Minas Gerais State, Brazil: an emergy perspective
Max Wilson Oliveira, **Feni Agostinho**

Emergy accounting of the distance teaching version of a technical course on management by IFSULDEMINAS: a case study
José Hugo de Oliveira, C. M. V. B. Almeida (**C.C. Silva** presenting)

It is needed a rational system that can interpret emergy indicators
Enrique Ortega

Impacts of fuel collecting radius on biomass direct-fired power system: insights from the emergy analysis of a case plant in China
Yueming Pang, Lixiao Zhang, Changbo Wang

Emergy Evaluation of mass and energy flows in semi deciduous forest in Brazil
Thiago Roncon, Enrique Ortega, Paulo Y. Kageyama

Urban metabolism of cities: the case of Uppsala, Sweden
Tommaso Russo and Pier Paolo Franzese (**Sergio Ulgiati** representing)

Modeling and simulation of the Billings Reservoir resilience - São Paulo, Brazil
Marlei Scariot

Emergy account for production of fuel ethanol from ardent spirits
Adrielle Frimaio, Carlos Cezar de Silva

An assessment of Maryland and West Virginia's urban ecosystem health state using Emergy Synthesis
Caroline Stanley, Brian Fath

Emergy accounting of a specialized Danish pig production – Potential allocation of resource use
Christina Wright, **Hanne Østergård**

Emergy evaluation of the forest ecosystems in Jigongshan Mountain Natural Reserve of China: A case study for ecosystems valuation and environmental decision making
Maochao Yan, Sergio Ulgiati, Xiaobin Dong, Wangsheng Gao, **Yuqin Wu**

Ecological network analysis of emergy flows: a quantitative characterization of ecosystem structure and function
Lucía Zarbá, Mark Brown

Using emergy network evaluating the ecosystem services for the payment of a watershed-scale wetland restoration project
Yiran Zhang, Renqing Wang, Jian Liu

Friday, January 17, 2014

8:30 - 10:10 Session 5 ~ Technological Systems: Pollution, Waste and Recycling *(Ballroom A**)***

Emergy evaluation of the urban solid waste metabolism in Liaoning Province
Gengyuan Liu, Zhifeng Yang, Bin Chen, Yan Zhang, Meirong Su, Lixiao Zhang

Emergy based model for recycling processes accounting for material losses
Kevin Ruben Deutz, Nadia Jamali-Zghal, Olivier Le Corre, Bruno Lacarrière

Relationships among energy import and consumption, economic growth and air emissions in Japan after the World War II
Hongfang Lu, Bin-le Lin, Masayuki Sagisaka, Daniel E. Campbell

Emergy assessment of local environmental sustainability of energy use - the case of Shanwei, Guangdong, China
Bo Lou, Yonghai Qiu, **Sergio Ulgiati**

8:30 - 10:10 Session 6 ~ Production Systems: Methodology and Conceptual Frameworks *(Ballroom E**)***

Renewability and emergy footprint
Hanne Østergård, Christina Wright, Andreas Kamp

Opportunities and limitations of emergy analysis in the evaluation and optimization of agricultural production systems: The case of the Slovenian dairy sector
Tina Jaklič , Luka Juvančič, Marko Debeljak

Effect of time scale on renewable emergy accounting: a case study of forest ecosystems in south China
Linjun Li, Hongfang Lu, David R. Tilley, Hai Ren, Guoyu Qiu

Emergy synthesis of the effects of paddy rice landscape changes on agro-ecosystem services in Taiwan
Ying-Chieh Lee

10:10 - 10:35 Break

10:35 - 12:15 Session 7 ~ Spatial Approaches in Urban & Regional Systems *(Ballroom A**)***

GIS use of empower density for environmental protection
John Richardson, Neil Burns, Robyn Polinsky

A spatial comparative analysis of urban metabolic efficiencies in the Yangtze River Delta
Yuqin Wu, Guicai Li

Regional differences of solarshare in Taiwan food consumption
Ying-Chen Lin

An emergy approach for urban vulnerability assessment: A case study of Taiwan's western coastal plain
Li-fang Chang, Shu-Li Huang

10:35 - 12:15 Session 8 ~ Production Systems: Agricultural Case Studies *(Ballroom E**)***

Food and biogas production in a Ghanaian village - Results and modelling issues
Andreas Kamp, Hanne Østergård

Emergy evaluation of grazing cattle in a Mediterranean agro-silvo-pastoral system
Ana Margarida P. Fonseca, Daniel E. Campbell

Environmental sustainability of Chinese agriculture: an overview of case analysis of farming systems using emergy synthesis
Lixiao Zhang, Yueming Pang, Zhifeng Yang, Bin Chen, Gengyuan Liu

Changes in the values of Emergy Sustainability Indices for agricultural holdings in Pomerania after accession of Poland to the European Union
Anna Lewandowska-Czarnecka, Andrzej Nienartowicz, Adam J. Czarnecki

12:15 - 1:30 Lunch *(sessions after lunch in Ballroom A**)***

1:30 – 3:10 Session 9 ~ Ecosystem Services

Emergy analysis for quantifying nutrient regulating ecosystem services of subtidal oyster reefs
Brittany Blomberg, Paul Montagna, Jennifer Beseres Pollack, David Yoskowitz

Dynamic evaluation of ecological assets and human well-being - A case study of Zhifanggou valley in Shanxi province, China
Xiaobin Dong, Baohua Yu, Guangshuo Dai, Sergio Ulgiati

Emergy accounting of ecosystem services in a green economy
Torbjörn Rydberg

The emerging exits of grazing livestock
Bo Falk

3:10 – 3:35 Break

3:35 – 5:15 Session 10 ~ Theory and Conceptual Frameworks

Odum and the Vicious Circle Principle
Craig Dilworth

Emergy/Symplexity
Dennis Collins

Convergence and divergence in the production of energy transformation hierarchies
Tom Abel

6:30 Open House hosted by Mary Logan, at H.T. and Betty Odum's former house *(map in back and on website)*

Saturday, January 18, 2014 (! Room NEB 202 !)

8:30 – 9:20 Session 11 ~ Emergy and LCA

Progress and questions: The emergy method in LCA
Chris De Vilbiss, Mark T. Brown, Wesley Ingwerson, Cissy Ma

Dealing with waste management in emergy and LCA: overview and synergies
Maddalena Ripa, Marco Raugei, Alba Bala Gala, Sergio Ulgiati

9:20 – 10:20 Emergy and LCA Panel
Chair: Marco Raugei

10:20 – 10:40 Break

10:40 – 11:30 Session 12 ~ Emergy Baseline

Emergy, transformity, the emergy unit and the emergy baseline
Daniel Campbell

An emergy baseline derived from the Global Tripartite
Mark T. Brown, Sergio Ulgiati

11:30 – 12:30 Emergy Baseline Panel
Chair: Chen Bin

12:30 – 2:30 Working lunch / Meeting of the International Society for the Advancement of Emergy Research (ISAER)
Lunch provided by ISAER

7:00pm – Party at Mark Brown and Carol Binello's House
See map in at end of Program or on the website

ABSTRACTS

Thursday, January 16, 2014

8:30 - 10:10 Session 1 ~ Assessing the Global Emergy Baseline

The solar equivalence issue and the effects on the baseline

Brian D. Fath

Advanced Systems Analysis Program, International Institute for Applied System Analysis, Laxenburg, Austria

Systems theorist Gilberto Gallopin once remarked that the concept of environment is a paradox because one could always enlarge the system boundary effectively subsuming the environment into the system. However, we know that the identification of a system boundary is the first, critical decision of any systems analysis. In this presentation, I review the concept of boundary in relation to its environment, with a particular focus on systems ecology approaches such as ecological network analysis, eco-exergy, and emergy synthesis. In the case of emergy synthesis, the extent of the global boundary is clear, due to the fact that all flows lead ultimately to solar radiation, but the choice of a local boundary can greatly affect the results and subsequent interpretations. It is my intention that these remarks will stimulate further discussion regarding the emergy baseline and the importance of boundary definition.

Transformity dynamics and maximum empower in pulsing systems

David Tilley

Dept. of Environmental Science & Technology, University of Maryland, MD, USA

The solar transformity of an energy is the property that defines, among other characteristics, how far removed it is from solar radiation. Due to the multitude of processes available for transforming a feedstock energy from one form to another, it is reasonable to expect that solar transformities for the same form of energy will have different solar transformities. For example, there are over 40 estimates of the solar transformity of electricity in the literature, which include various feedstocks such as coal, biomass, biosolids, hydrodams, natural gas, nuclear, peat and wind, and several operational configurations, such as anaerobic digestion, steam turbines, combined heat and power, fuel cells, gas turbines, and internal combustion engines. These estimates ranged from 18,000 solar-energy-joules per joule-electric (sej/Je) for a wind turbine to a high of 7.5 million sej/Je for an ethanol by-production plant with a mean of 572,000 sej/Je and a median of 286,000 sej/Je. In one of his earliest definitions of transformity, Odum (1988) wrote "…we defined a new quantity, the transformity, which is the amount of energy of one type required

to generate a unit of energy of another type (in real competitive conditions of optimum loading for maximum power)." What is often overlooked in this definition by emergy scientists is the latter part in parentheses about maximum power. Here I used Odum-styled simulated mini-models to explore the dynamics of solar transformity in pulsing and non-pulsing systems to understand the relationship between solar transformity and maximum power. Fundamental understanding of transformity dynamics can improve the fidelity of emergy analyses.

Emergy and co-emergy

Stephen Tennenbaum

The George Washington Univ., Dept. of Mathematics, Washington, DC, USA

Emergy is the total energy inputs to a system required to support the activities or production of some associated subsystem. These energy inputs are traced back to their origins as solar inputs to the earth or are put on some commensurate bases to solar inputs by comparisons of transformations to a common energy form (e.g. petroleum to electricity compared to solar to wood to electricity). The sum of these congruous energy inputs is *emergy*. Another definition of emergy also comes from its originator, H. T. Odum who states "Emergy is the available energy of one kind previously used up directly and indirectly to make a service or product" (Odum 1996). Although these two definitions appear on the surface to be of trifling difference, they are on closer reflection quite different. And although the definition is usually given in the latter form, the former is the one employed almost universally in calculations. We introduce a method of calculating emergy from both definitions using the concept of co-emergy. The utility of the co-emergy method is that it requires only ordinary algebra without any reliance on special rules to account for co-production and byproducts.

Open issues in Emergy Methodology

Enrique Ortega[1] and Simone Bastianoni [2]

[1] *Ecological Engineering Laboratory, State Univ. of Campinas, São Paulo, Brazil*

[2] *Ecodynamics Group, University of Siena, Siena, Italy*

In order to attend the demands of new actors of global society in relation with systemic scientific knowledge, Emergy Methodology deserves to be critically revised in order to build interfaces between with other scientific and philosophical approaches. It is important to discuss the different points of view concerning the emergy methodology that appear between emergy scientists. The main points to discuss are:

[01] To review the baseline considerations (ideas and proposals from various researchers);

[02] To consider renewability of inflows and modification of emergy indices;

[03] To consider environmental services as products in agricultural projects;

[04] To include negative externalities (social and environmental impacts);
[05] To discuss services inflows (as added work) in national and agricultural systems;
[06] To consider social indicators in emergy terms;
[07] To make critical discussion of certain emergy indices (EYR, ESI);
[08] To include economic subsidies as inflows;
[09] To develop emergy indices for ideological, military, and cultural inflows and stocks
[10] To describe administrative, financial, military, faith and citizen powers;
[11] To develop emergy indices able to evaluate climate change impacts;
[12] To develop emergy indices to evaluate climate change mitigation;
[13] To develop emergy indices for ecological and social resilience;
[14] To develop emergy indices for internal stocks;
[15] To include the issues of environmental and ethical debts in Emergy Synthesis.
These ideas and specific proposals are presented in this paper.

10:35 - 12:15 Session 2 ~ National and Regional Analysis

Sustainability of tourism in the Alps: the role of hotels

Dina Rizio and Geremia Gios
University of Trento, Trento, Italy

Sustainable development of tourism in the Alps is crucial from different points of view. For a large part of local communities, tourism is the first and sometimes the only source of income. However, transport and hospitality are generally recognized as the most energy-intensive components of tourism industry. The growing trend of tourist flows makes necessary to approach long run paths for sustainable development especially in such sensitive areas. The Alps are characterized by a strong tourist vocation. Tourism is mostly based on experience the alpine landscape and the local natural resources. In addition to that, man-made facilities have also a key role. Among others, hotels are important for tourists even though these facilities are responsible for the consumption of large quantities of energy, water and extra efforts in waste management. Both the natural (the alpine landscape) and the man-made (hotels) components contribute to compose the tourist supply of this destination. This research is at its initial stage. It analyses two hospitality systems in this context by the emergy synthesis methodology. The aim is to assess the sustainability of two hotels located within the same alpine valley (in the east part of the Alps). The selection of the hotels is performed in order to get two representative case studies of alternatives energy use patterns and

energy management plans. This approach allows assessment of the sustainability level of both hotel typologies, to perform an analysis of these components of tourist supply, and to address local policies for the management of this destination.

Study of the environmental sustainability of ABC Paulista using emergy synthesis

Fábio Sevegnani, C.M.V.B. Almeida, B.F. Giannetti, S.H. Bonilla, F. Agostinho
Paulista University – UNIP, São Paulo, Brazil

Cities are the focal point of several activities, being them commercial, industrial, social, economic or politics. The urban population growth generates several changes in life style, land use, energy demand and consequent environmental pressure. In this way, studies related to environmental sustainability of urban systems and the availability of natural resources are of major importance. Emergy is a powerful tool to environmental accounting and measures both natural and human resources to generate products and services. The evaluation through emergy synthesis of cities, states, nations and its base resources provides large scale perspective to the evaluation of urban areas and can help selection of policies for public benefit. This work applies the emergy synthesis methodology to evaluate the environmental sustainability of the municipalities that form ABC Paulista, through an approach capable to gather economic and environmental aspects. ABC Paulista is a group of three municipalities: Santo André (SA), São Bernardo do Campo (SBC) and São Caetano do Sul (SCS), which is part of Greater São Paulo. ABC Paulista is an important industrial, technological and housing area that gives support to Greater São Paulo. Automotive and chemical industries are the leading economic activity in this urban system. Despite being neighbor municipalities, some environmental and economic differences are observed between them. Results show that ABC Paulista, as well as the three municipalities separately, are highly dependent on imported resources from outside its boundaries, being them not sustainable in the long term.

On the meaning of the emergy indices in nested systems

Fabiana Morandi[1], Dan Campbell[2], Federico M. Pulselli[1], Simone Bastianoni[1]
[1]*Ecodynamics Group, Dept. of Earth, Environment and Physical Sciences, University of Siena, Siena, Italy*
[2] *US Environmental Protection Agency, Narragansett, RI, USA*

Emergy indices can be calculated to describe the degree of sustainability of the system under study. In this work the main emergy indices for the evaluation of a system's sustainability are considered as applied to the case of hierarchically nested systems. In particular, three territorial systems nested within each other

have been considered and, for each level, the emergy indices are calculated and compared. To do this, the emergy transfers between levels of system organization are defined using set theory and then applied to a real nested territorial system, that is the case of the European Union – Italy - Tuscany. We highlight the fact that cross-scale comparison is possible only if we want to understand the role of the inner system with respect to the outer one. In particular, the cross boundary imported flows (F) play an important role in the calculation of indices and their composition changes at different levels of organization (while the renewable, R, and non-renewable, N, flows do not change when the system is considered as a part of the larger system that contains it). In this paper, we demonstrate that emergy indices calculated for different levels of organization in a nested system are best used to compare systems only at the same level of organization. In fact, if we compare the same indices from a system and its subsystems or a system and the larger system that contains it, the emergy indices will not be congruent and thus their meaning across levels will have to be interpreted considering these differences.

World economy in a cube

Federico Pulselli, Luca Coscieme, Simone Bastianoni
Ecodynamics Group, Dept. of Earth, Environmental and Physical Sciences, University of Siena, Italy

World economy must develop within physical limits. Overcoming these limits means un-sustainability. The economic activity is a natural expression of human behavior, and must be treated as a multidimensional phenomenon. In this sense, the use of different tools - like emergy - for representing system dynamics adds complementary information to the multilayer picture of the complex reality in which we live. A categorization of national economies is proposed according to a combination of measures that reflect an input-state-output scheme for system description. In particular, a set of three indicators, organized in a three axis diagram, is used to identify different expressions of world economy. These indicators are: emergy per person, as an environmental measure of input; employed percentage, as a social measure of state; per capita GDP, as an economic measure of output. The position of every national economy in the 3D space - depicted as a cube - can inspire comments about that country, comparisons, and observation of clusters, as well as indication for progressing in the right way, possibly in compliance with natural, social and economic purposes.

1:15 – 2:30 Session 3 ~ Technological Systems: Fuel Production

Influence of cellulase enzyme production on emergy efficiency of lignocellulosic ethanol

Feni Agostinho, Ana B.B. Bertaglia
Paulista University (UNIP), São Paulo, Brazil

Second generation ethanol is being considered as a good alternative to complement the current first generation ethanol production by avoiding the food vs. energy debate and potentially releasing lesser amount of greenhouse gases. This technological route requires cellulase enzymes to hydrolyze the cellulose and hemicellulose from vegetal biomass into fermentable sugars, thus, knowing the enzyme production cost is important when assessing lignocellulosic ethanol production. Usually, enzyme is accounted for as an economic input and/or as produced internally within the Biorefinery boundaries, but market tendencies indicates that enzymes will be purchased from specialized producers. In this sense, this work aims to assess the emergy cost (Unit Emergy Value, UEV) of industrial cellulase enzyme production at large scale under submerged fermentation process, and verify its influence on the emergy cost of lignocellulosic ethanol production. Due to uncertainties in system's primary data inputs and their UEVs available at literature, a Monte Carlo simulation was carried out within the framework calculation. Results show that producing 1kg of cellulase enzyme requires about 4.11E+14 seJ (including labor and services inputs), and that this emergy cost can be considered as insignificant (from 0.02% to 0.14%) when evaluating the total emergy of lignocellulosic ethanol production. Even these results reflects a specific scenario for enzyme production, they could be considered as the starting point for more in depth evaluations, at the same time in which the enzyme's UEV estimated could be used for other emergy analysts in further evaluations on lignocellulosic ethanol production.

Emergy evaluation of a partial substitution of gasoline with 2nd generation ethanol: theoretical aspects and practical consequences

Simone Bastianoni, Nicoletta Patrizi, Fabiana Morandi, Federico M. Pulselli
Ecodynamics Group, Dept. of Earth, Environmental and Physical Sciences, University of Siena, Italy

Patrizi et al. (2013) have shown that is possible implement a second generation bioethanol production chain within the Province of Siena (Tuscany, Italy), in

which the production chain is completely fed by local residual inputs (straw and residual geothermal heat). The aim of such a plant would be to accomplish the European requirements for partial substitution of 10% bioethanol for gasoline by 2020. By means of emergy evaluation we compare a biorefinery to be built around existing agricultural systems and geothermal power plant, with traditional oil based liquid fuel. The co-production process typical of the biorefinery pushes towards a complex comparison with solutions that are consistent with an expansion of boundaries. This approach shows also that a comparison is possible between the emergy invested to add the biorefinery to the already existing systems and the transformity of the fossil fuel. The results of the emergy evaluation of the entire production chain demonstrate that the benefit due to the saving of gasoline, in emergy terms, almost doubles the emergy invested for the biorefinery chain. It is important to note that if the biorefinery were not fed by the local residual geothermal heat, the ratio of emergy investment to benefit would significantly decrease due to the need for non renewable energy resources.

Emergy analysis of emerging methods of fossil fuel production

Elliott Campbell
University of Maryland, College Park, MD, USA

The production of energy from novel sources of fossil fuels, (e.g. shale oil, tar sand, and natural gas from hydraulic fracturing), is forming an increasingly large proportion of global energy use. This research evaluates the two most prominent emerging methods of fossil fuel production, petroleum from tar sands and hydraulic fracturing for natural gas extraction. Currently, 42% of natural gas production in the United States is produced through hydraulic fracturing and 60% of new wells use the method. The Alberta region of Canada produces 1.7 million barrels of oil from tar sands, exporting 1.3 million barrels to the US every day, comprising ~7% of daily US petroleum consumption. Past work has shown these methods of fossil fuel extraction generally have lower emergy yield ratio's (EYR) than traditional fossil fuel extraction methods. However, the EYR of traditional extraction methods has decreased over time as resources become more scarce, possibly to the point where new methods are competitive. Preliminary results show that natural gas produced through hydraulic fracturing has an EYR of >17 at the well and >9 for electrical production. Petroleum from tar sands was found to have an EYR >6. Using a Maximum Empower Transformity calculated for global natural gas and petroleum production, the EYR rises to 12 for electricity from natural gas and 9.5 for petroleum from tar sands. Independent of supply constraints or variability, these results indicate that emerging fossil fuel sources are competitive with traditional production methods.

2:55 – 5:00 Session 4 ~ Built Environments

A review of integrated environmental assessment methodologies in the built environment using a case study building

Ravi Srinivasan[1], Wes Ingwersen[2], Christian Trucco[1], Robert Ries[1], Daniel Campbell[3]

[1]*M.E. Rinker, Sr. School of Building Construction, Univ. of Florida, Gainesville, FL*
[2]*National Risk Management Research Laboratory, US EPA, Cincinnati, OH*
[3]*US Environmental Protection Agency, Narragansett, RI*

Past and on-going efforts using Life Cycle Assessment (LCA) and environmental accounting approaches have identified a critical need for integrating life cycle methodologies for product selection and extending environmental impact assessment methodologies to address ecosystem goods and services. However, a review of these assessment methodologies and the appropriateness of its use in the built environment is lacking. This paper evaluates the environmental impacts of a case study building using two LCA methods, i.e., hybrid versions of Economic Input-Output LCA and Ecologically-based LCA, and an environmental accounting method, Emergy. For completeness, a life cycle cost analysis of the building is presented. These methodologies are applied to the full service life of the building, i.e., material ingredients, extraction & manufacturing, material placement, operations & maintenance, and decommissioning phases. The paper compares and contrasts the capabilities of the three assessment methodologies presented above and concludes with the strengths and weaknesses of each methodology as it relates to the built environment.

Environmental building design: Hierarchies of production and use in buildings

William Braham

Dept. of Architecture, School of Design, Univ. of Pennsylvania, Philadelphia, PA

The use of emergy intensity as a measure of quality was initially developed to reveal the natural production hierarchies in ecosystems established over long periods of time. Applying the concept of energy quality to human constructions developed over shorter periods with high-intensity fossil fuels suggests a tactic for identifying arrangements that might succeed in a transition to lower-intensity, renewable sources of power. The challenge is to develop arrangements that exceed those developed under purely agricultural forms of

production, utilizing contemporary refinements in organization and information processing to better leverage environmental energies and processes.

Buildings operate at many different spatial and temporal scales, providing many different forms of work and services for their occupants. The energies (direct and indirect) used by buildings can be divided into three kinds of activity: shelter, setting, and location. The basic task of buildings is to modify the local climate—temperature, humidity, illumination levels, etc.—to shelter the occupants and make them comfortable. The second task is the provision of a setting for work and living, to facilitate the many different activities in which people are engaged. While the third is the enhancement of the location, whose value is determined by its relative position in the urban, spatial hierarchy. A basic hierarchy of residential uses is shown in the attached diagram and calculation for the Ellis house, which is used to explore the hierarchies of use in contemporary buildings, and to suggest a design approach for buildings based on renewable energies.

The premise of production hierarchies is to match the emergy intensity of the work and resources being used to the quality of building services provided. For the building as a shelter, climatic modification involves the configuration of the building envelope and the manipulation of low-quality heat, and so uses the investment in construction to amplify environmental energies. For the building as a setting, Abel's work has demonstrated the fundamental connection between production (work) and consumption (living). In other words, the standard of work and living in any building is established by the wealth and occupation of its occupants, which reflects (never perfectly) their value to the society at large. Finally, the cost and value of location is largely determined by investments made in the surrounding infrastructure, buildings, and institutions, as cities and regions self-organize in national and global hierarchies. Any transition to renewable resources will involve radical rearrangements of urban and global hierarchies, requiring buildings to adapt to the changes in their locations over time.

Environmental Value Engineering: An environmental life cycle assessment methodology for comparing built environment alternatives

Wilfred H. Roudebush
College of Technology, Architecture, and Applied Engineering
Bowling Green State University, Bowling Green, Ohio

People selecting built environment alternatives should properly consider the environmental impact of their decisions toward sustainable development. Built environment alternatives compete for inputs of environment, fuel energy, goods, and services (labor). Current life cycle assessment methodologies for comparing built environment alternatives usually consider money related to

labor or embodied energy in terms of fuel energy. Environmental life cycle assessment methodologies are being developed that consider all inputs and their related environmental impacts.

The purpose of this paper is to present one environmental life cycle assessment methodology called Environmental Value Engineering that can be used during the decision making process to compare the environmental impact of built environment alternatives. The basis of Environmental Value Engineering is the late Dr. Howard T. Odum's EMERGY Analysis methodology. Environmental Value Engineering provides a systems approach to account for all inputs of environment, fuel energy, goods, and services (labor) in terms of EMERGY to the built environment alternatives being compared through a 10 phase life cycle. EMERGY is defined as all the available energy that was used in the work of making a product. The 10 phase life cycle includes: natural resource formation, natural resource exploration and extraction, material production, design, component production, construction (assembly), use, demolition, natural resource recycling, and disposal.

An Environmental Value Engineering research project that was conducted for the Portland Cement Association (PCA) to compare concrete and asphalt highway pavement systems will be utilized to present the Environmental Value Engineering methodology. Environmental Value Engineering offers an environmental life cycle assessment platform for identification of built environment alternatives leading toward sustainable development.

Evaluating the impacts of built environments on ecosystem goods and services using University of Florida campus as a case study: Maintenance of soil quality and drainage services

Christian Trucco[1], Ravi Srinivasan[1], Cynnamon Dobbs[2]

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Ecosystem Goods and Services (EGS) are a derivation of ecosystem functions and products which are critical to human wellbeing. Although there is a growing body of research focusing on quantifying and assigning monetary and non-monetary values to ecosystem goods and services, there are only a handful of studies conducted linking built environments and their impact to EGS. Built environments have a direct impact on, among others, soil hydrology thereby leading to loss of soil quality and drainage. The building footprint alters the soil imperviousness causing stormwater runoffs that may change soil hydrology. Besides, water used in the buildings is treated and discharged altering soil quality. Using the urban forest functional model, this paper discusses the impact of the built environment on two ecosystem services namely, maintenance of soil quality and drainage using the 2000-acre ($8.1km^2$)

University of Florida campus in the City of Gainesville, Florida, as a case study. While soil fertility and soil bulk density indicators are used to estimate soil quality, curve number and soil filtration indicators are used to derive drainage services. Emergy evaluation is conducted to assess natural resource depletion and appropriation of ecosystem services. In order to quantify the environmental changes over time, an ethnographic case study approach is applied. The study assesses the university campus site dating to pre-1900s when there were no buildings and for every 10-year interval from thereon to the present day. Using a recently conducted survey of sample plots to study urban forest ESG, this study quantifies changes to soil hydrology over time following the growth of buildings within the campus. Such a study will help guide decision-making for future growth of the campus.

A case study in emergy based building retrofits

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The aim of this study is to clarify conflicting claims about the energy-retrofit of buildings, and to criticize the conventional focus on operational energy-efficiency, instead of the total energy and environmental cost represented by emergy analysis. Building energy reduction strategies without a holistic view lead to the neglect of substantial resource use and inappropriate designs. To explore the design consequences of a more holistic approach, an average size (101.85 m^2) single family house in South Korea was sampled as a benchmark case, and the analysis of energy and material use was conducted as the baseline. This case allows us to concentrate on investigation of variance of passive design components, since they are relatively more independent of mechanical systems than large buildings. Performance simulations of operating energies were developed and analyzed separately from the calculation of the emergy of construction, and then the total demand of each proposed design was evaluated. Emergy synthesis results indicate that the model using the least operating energy requires considerably greater investment in building construction, so the combined measurement provides the correct design goal.

Poster Session ~ Ustler Hall

Emergy analysis of an English school located in the south of Minas Gerais Brazil

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It is well known that English has become the most important language for business, technology, science and communication over the years. It is quite big the number of people that have studied English either as a second language or as a foreign language throughout the world. In Brazil, this is not different. The number of English schools has increased a lot. According to the Brazilian Association of Franchising (ABF) there are more than 35 different types of franchising of English schools in Brazil with more than 6,000 schools nowadays, and this number is increasing. The aim of this work intends to identify all the natural and purchased global resources needed to accomplish English teaching-learning process in an English school located in Ouro Fino – Minas Gerais State, Brazil and quantify them in emergy terms. This includes quantifying the sources corresponding both to implementation (infrastructure, stock of materials that form the building, furniture and so on) and to operation (water, electricity, human labor due to maintenance and teaching). Also the needed emergy to make an individual proficient in the English language was quantified as well as verified if there is any mathematics correlation between the global resources and the English language learning by the students with their scores in the TOEIC (test of English as International Communication.

Emergy assessment of integrated swine-crops-eucalyptus systems with manure anaerobic biodigestion, greenhouse gases management and energy recycling

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Brazil became an important pork meat exporter and the swine farms have shifted from the South to the Midwest, specifically the Plateau of the Upper Paraguay River Basin where Cerrado biome deforestation has reached 58.9% of the original area. Intensive pig farming can be highly polluting and requires careful handling and disposal of wastes. The Federal Program for Low Carbon Agriculture set up by the Brazilian Government, through the Ministry of Agriculture, Livestock and Food Supply aims to reduce carbon emissions by encouraging technological processes that neutralize or can absorb the greenhouse gases, with goals and expected outcomes to be obtained in a

decade. In this context, Brazilian Agricultural Research Corporation in partnership with the Ministry of Agriculture and several universities has established an experimental unit (in São Gabriel do Oeste, Mato Grosso do Sul, Cerrado region) to evaluate the development of intensive pig farming systems with biogas and biofertilizer production derived from the digestion of wastes in association with the development of integrated swine-crops-eucalyptus systems and native vegetation restoration (20% of the farm area). The conciliation of swine agroforestry-livestock systems aiming to convert pollution into productivity gains for small and medium sized producers can also support social inclusion projects through highly diversified and efficient production systems. Emergy Assessment was chosen as the methodology to assess the sustainability of the integrated systems, to diagnosis the current system design and to evaluate land use change scenarios for the region. This article deals with the diagnosis of the experimental unit that is being implemented.

Digital photography – there is more to it than "point and click"

Robin Burgess (Dan Campbell presenting)
The Glasgow School of Art, United Kingdom

We all like to take photographs, and today a "point and click" culture has developed in photography, because of the relative ease and automation of the process to simply capture an image with a single click. However, if you are an artist or researcher who uses digital photography as the medium for your study, it is often necessary to quantify and subsequently qualify the integrity of your work, which can often be difficult, but is necessary for comparison of the relative quality of photographs that is needed to help ensure future funding and enhancing ones own profile as an artist. By applying emergy methods an alternative and novel way of assessing the impact and effort involved in digital photography can be determined. This research aims to show how emergy can be applied to quantify the process of digital photography, looking at aspects related to the decisions made when taking a photograph, the technology used, the consideration given towards subject matter and image, and the further enhancement/digitization of the photograph. The emergy methods will also be used to illustrate the effort put in by the photographer in producing a photographic composition by quantifying the process and giving a numerical figure to quantify effort. This is something new and has not been applied within the visual arts, so it can be seen as an exciting opportunity to demonstrate the effort that has gone in to a particular photograph or into the photography of an individual. Another result of the study will be that of being able to give another level of assessment of the potential impact of the photographic research, something that funding bodies in the UK are keen to de aware of.

The real wealth purchased in a New England fish dinner

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There is a growing realization within the scientific community and the public at large that the environment makes a real contribution to wealth that is not adequately valued by markets. In addition, almost everyone recognizes the feeling if they are getting a "good deal" on a purchase; i.e., in economic terms, there is surplus value in the consumption of the item. We hypothesize that the surplus value in products of the environment can be quantified through emergy methods. Emergy quantifies real wealth or the amount of quality-adjusted work that an item can do when it is used for its intended purpose. In other words, emergy evaluation allows us to attribute a fair and objective value to both the work of the environment and the work of people. In this study, we used emergy evaluations to determine the real wealth in Rhode Island (RI) fishery and organic farm products that might be used by restaurateurs in creating a New England fish dinner. These estimates of real wealth were expressed in emdollars (Em$), a combined emergy-money unit that represents value based on distributing the buying power (money flow) in proportion to the emergy flows in an economy. Our study includes emergy evaluations of the State of RI, the Narragansett Bay and RI coastal shelf, the winter flounder fishery in RI during the 1970s and 1980s, a RI organic farm, and a restaurant located in Newport, RI. The Em$ value of the portions of fish and vegetables served with a fish dinner at the restaurant was compared with the emdollar value that could be purchased by spending the dollar cost of the dinner on an average product in the RI and the national economies. The difference shows the additional real wealth or surplus value purchased by the consumer in buying a RI fish dinner. For example, tourists dining at the restaurant receive 2.12 times the real wealth (Em$) in purchasing the RI fish dinner compared to the real wealth that they could purchase by spending the $16.95 cost of the fish dinner on a product for which the emergy purchased reflects the average U.S. emergy to money ratio. In this study, we demonstrate that emergy evaluation is a practical method for quantifying the work contributions of the environment and for revealing the surplus value in farm and fishery products.

The United States of Abraham: A path toward peace in the Middle East?

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Throughout history, small geographic areas have been united either by conquest or negotiation. The central determining issue has been available supplies of energy for creating the initial organization and for maintaining it against depreciation or conquest. The contemporary Middle East and North Africa consists of many nation states that are too small for long-term individual viability, but perhaps offering the potential for a regional union, because of the large oil and gas reserves that exist in some of these countries. In particular, the present conflict between the people of Israel and the people of Palestine has deep historical roots grounded in the differences in ethnicity, religious beliefs and customs, as well as, the conflict of the hopes and dreams that the two people's hold for a single small geographic area. The United States of Abraham, analogous to the United States of America, is examined as a democratic solution that may serve as a path toward peace in this contentious part of the world. Specifically, in the case of the Arab-Israeli conflict, we focus on the fact that both Arabs and Jews are called the Sons of Abraham and through this fraternal relationship each should be able to respect the identity of the other within a broader democratic context in which the freedom of religious determination is recognized. The first step on the path toward peace and reconciliation is to begin talking with one another. In this regard, we recommend that international discussions begin immediately between all parties to the multiple disputes present in this geographic region of the world today.

Dynamic planetary emergy baseline applied to crustal minerals

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The magnitudes of Earth's sources of available potential energy (exergy), namely sunlight, tidal gradient, and deep earth heat, have changed through time. This paper investigates the degree to which such changes can be incorporated into understanding the dynamic magnitude of the planet's emergy baseline (PEB). Preliminary results indicate that the PEB of 4 billion years ago was about 74% larger than present day. The decay of the PEB can be accurately modeled by a polynomial equation, the integral of which represents the emergy embodied in the planet over a given time window. This integral function is applied to the 2.5 billion year time window estimated to represent the average age of the continental crust, thus estimating the emergy embodied in the crust by a dynamic PEB. Preliminary results indicate a mere 3.5% increase

in the emergy embodied in the crust. Further refinements are needed as well as corrections for any 'drift' that may be associated with the trend line.

Computing the Unit Emergy Value of computers – a first attempt

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Three decades after the beginning of personal computers produced at large scale, they can now be considered as essential of several human-made production systems and for the domestic users as well. Computer's dependence was sharply increased during the last ten years mainly due to availability of mobile computers as laptops, tablets, smartphones, and so on. Considering this tendency of continuous high-tech progress, it is expected that more and more computers will be a permanent part of any human-made production system, mainly for those ones closely tied to Information Technology (IT) issues, i.e. systems located on the far right of a hierarchical chain. When identified, computers should be considered for an emergy evaluation, because they could play an important role for the systems empower. For this, a computer's Unit Emergy Value (UEV) is fundamental. In this sense, this work aims, as a first attempt, the estimation of computer's UEV. Top ten commercial computers are considered as case study, and the uncertainties related to parameters value (raw data and their UEVs) are evaluated under a Monte Carlo simulation. Results show that while the estimated computer's UEV accounting for services input (i.e., market economic cost) is 1.93E+12 seJ/$g_{computer}$, its correspondent without services is 8.82E+10 seJ/$g_{computer}$. This huge difference related to services input highlights that the "information embodied" on the computers production (for example, technology, knowhow, research, specialized personal involved, etc) is the most meaningful on the computer's empower than the input materials. Thus, accounting the computer input only as its market value should not affect decisively on the final results of an emergy evaluation.

SCASE: web application for calculation and analysis of environmental sustainability in emergy

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This paper presents the software SCASE, a web application in client/server model of four layers, for calculation and analysis of the indices of environmental sustainability of any regional system, according to the analysis

methodology in emergy proposed by H. T. Odum (1996). The software receives data from primary resources renewable, nonrenewable, economic, imported and exported, and their transformities, as user input, calculate flows and indicators in emergy, records, simulates, query and analysis compares. The results are presented in charts and tables. Compare the analysis values in emergy to Brazil in 2007 presented by software with the values found in Demetrio (2011) for the same primary data input, obtaining an average error of 0.4 in the set of indicators. Comparative testing proved the efficiency of the software in calculating flows and indicators.

Emergy synthesis as a tool to assess soil quality change

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The concern about soil quality has increased, since its use and intense mobilization may decreased its ability to keep a biological and sustainable production. However, since soil quality cannot be comprehensively measured by a single indicator, emergy synthesis rises as an alternative to assess this issue. This study aimed to present a comparative method for soil quality vis-a-vis the resource demand on intensified biomass production. For this purpose we used environmental accounting, converting inputs (environmental, material and labor) to emergy units. The largest contributions for the total purchased emergy inputs in sugarcane production (3.8E+15 sej) were diesel, limestone, gypsum, nitrogen and phosphorus with 27.38 %, 25.45 %, 13.25 %, 11.52 % and 11.31 % respectively. Diesel and limestone are obtained from petroleum and mining deposits, explaining the largest fractions of emergy, and gypsum, obtained from the manufacture of phosphoric acid, used for the production of triple superphosphate, monoammonium phosphate and diammonium phosphate. The higher biomass production due to the use of inputs shows lower embodiment of resources per unit of mass (sej Mg-1), whose yield increase is higher. Typic Hapludox soil presented 11.7 % more additional biomass production and 13.2 % less additional input demand than Arenic Hapludult soil, due to better fertility conditions. Indicators based on emergy synthesis are able to support analyses of land use change for intensive biomass production, since it showed to be a promising tool for evaluating soil quality change.

Emergy analysis of the cover crop of the banana tree pseudo stem, an applied study in Pedralva south of Minas Gerais Brazil

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The Tripper Group Pedra Branca (TGPB) which is a social environmental and nongovernmental organization that operates in Pedralva-MG-Brazil developed a cover from the banana tree pseudo stem to be applied in the recovery of the degraded areas. The present paper constitutes in determining and quantifying the fluxes of the energy process of the cover crop confection of the banana tree pseudo stem to analyze the environmental impacts indexes. The cover crop of the Fiber of the banana tree pseudo stem aims to contribute to solve or to mitigate problems such as disaggregation and entrainment of the soil. The use of the Emergy Methodology developed by Odum (1996) enables the evaluation of the environmental performance of a system in the biosphere which is an important tool for decision making. The data obtained in this paper were collected through visits in the area to be analyzed. The farm Rancho Santo Antonio is located in a rural area in the Santo Antonio neighborhood in the south of Minas Gerais – Brazil. This farm has had an Organic Production Certification since 2001 by the IBD (Organic and Brazil Organic) and it produces an average of 1,200 boxes of bananas a year which is equivalent to 25,000 kg/year.The Emergy Yield Ratio (EYR) found for this paper was 2.48 which shows a low efficiency in the use of natural resources related to its economic contribution. The Emergy Loading Ration (ELR) is 0.72. This value found respects the capacity of the system to provide local resources generating very low stress in the environment. The Emergy Investment Ratio (EIR) found is 0.67 which means that the system is consuming low economy resources. The Emergy Sustainability Index (ESI) is 3.43 which shows that the Bio-soil-cover is sustainable in a mid-term period (over 10 years). The percentage of the renewable energy found is 58% which is a very high percentage for sustainability according to Kyoto Protocol (1997) that established a 10% percentage of the energetic matrix (Braga et al, 2002). With these indices it can be asserted that the work achieved good results.

Carrying capacity by emergy evaluation and ecological foot print

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In order to improve the emergy assessment of Ibiúna county, São Paulo, Brazil, its carrying capacity was evaluated. Ibiúna county has an area at 105,800 hectare (ha) and is located at a distance of 70 km at the West of São Paulo city,

the biggest Brazilian city. It has 72,029 inhabitants then it has the proportion of the 1,4 ha per person and 0,44 ha per person of forest area. The city is only 154 years old and about 67% of its population live in the rural area and other 33% in the urban space. In that assessment, it was possible to observe that the renewability of this municipality is low (5.5%). To determine the renewable support area, the carrying capacity methodology suggested by Brown and Ulgiati (2001) was applied and the support area obtained was 627,300 ha or 8.7 ha per person. This result reveals a great value for the equivalent natural area needed to absorb the impact of the fossil fuel consumed in the production of industrial inputs used in the region. The use a new ecological footprint methodology proposed by Merkel (2009) was considered interesting in order to calculate the support area according to the consumption profile of population. The result is 346,842 ha or 4.8 ha per person. This study presents the importance of preserving the environmental natural area and introduces the needs of changes in the configuration of the county economy and its population lifestyle in order to turn it into a really sustainable region.

Assessing alternative developments for milk production in the southern region of Minas Gerais State, Brazil: an emergy perspective

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Milk and its derived products are recognized as an essential item within the human food chain. Brazil is responsible for about 5% of worldwide production, in which 27% of this total is produced at southern region of Minas Gerais State. In this region, there are diverse kinds for milk production systems, differing on productivity, rural property area, dependence of economic resources, and so on. Recognizing that sustainability issues are more and more being considered within any decision making, public policies at local scale (i.e., the technical activities regarding best management practices) as well as regional scale (i.e., a landscape planning) perspectives are being considered under sustainability concepts instead of a purely economic view. Regarding the second perspective, emergy accounting arises as a powerful methodology providing subsidies for a landscape planning under a holistic view. In this sense, this work aims to evaluate a regional alternative of development for milk production on the southern region of Minas Gerais State, Brazil. Data from 94 milk rural properties are considered in establishing the five representative system groups under a non-parametric statistical approach (cluster). A Monte Carlo analysis is used to evaluate the uncertainties related to unit emergy values. The Potential Emergy Matching Approach (PEMA) is considered to evaluate a development pattern aiming a maximum empower for milk production at a regional scale.

Emergy accounting of the distance teaching version of a technical course on management by IFSULDEMINAS: a case study

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The SETEC (Secretary Office for Technological Teaching) department of the Ministry of Education of Brazil has strongly invested in the offer of technical courses, especially dedicated to citizens who either cannot afford private schooling or dwell far from their intended courses. Distance teaching is one of the most convenient strategies in promoting citizens' inclusion in the educational system. This paper presents the use of Emergy synthesis in the accounting of the initial environmental budget preview of a two-year term distance teaching version of a technical level course on Management at the Federal Institute of Education, Science and Technology of the South of Minas Gerais – IFSULDEMINAS - campus in Inconfidentes, MG, Brazil. The study comprises the environmental accounting of the support pole facilities and equipment, the students' equipment and the flow of information within the system. Additionally, a preview for CO2 emissions resulting from the operation is included. Computers made available for occasional students' use and a web server make up the largest material contribution to the total emergy of the pole's physical structure at 4.10×10^{16} sej, whilst the emergy of the 43 enrolled students' own home PCs amounts to 6.78×10^{16} sej. Information flows are the highest transformity inputs, and in this case study, the emergy contribution from the flow of information is especially high, due the involvement of a large number of professionals during the students' mandatory training stage.

A rational system that can interpret emergy indicators is needed

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It is assumed that those that take decisions are interested and understand the results of emergy assessments. The experience in Brazil and the interpretation of what is happening in other countries' economies reveal that it is not the case. The fact is that non sustainable and low liquid energy projects are being implemented everywhere as a common effort of national governments and private enterprises. How is this possible? As result of reflections, we now consider that important decisions are taken basically to maintain the political power and non-fair exchange relationships between high and low structured systems. This procedure is based on a pragmatically oriented Philosophy that has as principle neglecting other cultures values and also denying Nature´s

rights. The competitive excluding systems are overcoming those collaborative-including, as many ecosystems and "primitive" societies. As result of capitalist-imperialist and class struggles strategies prevailing there are several global crises: financial, global warming, species extinctions, rain disturbances, soil erosion and fertility loss, water pollution and acidification, increasing inequality within classes in countries and between different countries, culture losses and alienation. If it is aimed to overcome this disastrous global situation, it should be made a great effort, but for sure it will not be possible to be made only by Emergy scientists alone, it will be necessary to interact with groups and movements interested in an ecological mode of production and consumption. It is needed a global interacting movement, that at some time will demand scientific information on sustainable equitable organic arrangements. In order to be prepared for that situation, Emergy Methodology deserves to be critically revised and it will be necessary to build interfaces with the most important social movements and this means discussing analysis categories between emergy science and other philosophical approaches. Some these ideas and specific proposals are presented.

Impacts of fuel collecting radius on biomass direct-fired power system: insights from the emergy analysis of a case plant in China

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Encouraged and promoted by local and central governments, the biomass direct-fired power industry in China has not achieved expected rapid development as its renewable energy counterparts (e.g., small hydropower, wind power and photovoltaic power). The difficulties in fuel collecting are regarded to be responsible for the slow development of this renewable energy alternative, which involves the different collection radius and multilateral trade with farmers. Through the emergy analysis of a case plant in Inner Mongolia in 2011, this study aims to gain the insights of the environmental performance of biomass direct-fired power system as well as the impact of fuel collecting radius on it in China. The results show that the overall biomass direct-fired power system could attain outstanding performance and good sustainability when the feedstock supply is relatively sufficient with a collection radius no more than 100km. However, sensitivity analysis reveals that the environmental performance of the system gets worse significantly with the increasing of collection radius. When the collecting radius increases to 600km, the transformity of electricity would be 1.58E+05sej/J, which is very similar to that of electricity generated in the coal-fired plant (1.71E+05sej/J). At the same time, the emergy sustainability index (ESI) of the system also declines dramatically

from 3.86 to 0.86. The findings reported in this paper highlight the necessity of policy innovation to ensure the stable feedstock supply and acceptable collection radius as well as healthy development of biomass direct-fired power industry in China.

Emergy Evaluation of mass and energy flows in semi deciduous forest in Brazil

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This work aims to identify and quantify the mass and energy inflows and the internal stocks of in a semi-deciduous forest in the state of São Paulo, Brazil developed along a period of 200 years. The mathematical calculation model combines 65 variables yet, 28 inputs, 17 processes, 13 internal stocks and 7 outputs. Data were collected in fieldwork, in literature and laboratory analysis to quantify temporal variations, according with the forest structure inventories, the data was interpolated with the help of software Origin 8.5.1. Preliminary results show that water (H2O) is the largest mass entry, followed by carbon dioxide (CO2), the CO2 is already the largest contribution for photosynthesis, followed by nitrogen (N2). The largest mass output emerging from the forest is soil-infiltrated water, it is followed by transpired water, the largest volume product of photosynthesis. The forest´s products transformities were calculated allocating emergy of ecological processes by mass and also energy of products. These results highlight the relative importance of inputs and outputs and are valuable to understand the semi-deciduous forest ecological economy; Beyond contributes for elaboration the ecology restoration projects.

Urban metabolism of cities: the case of Uppsala, Sweden

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Urban systems can be considered like living organisms supplied by material and energy flows used to maintain structures and functions, and the production of goods and services. In this paper, we integrate economic cost analysis with a method of biophysical accounting (namely Emergy Synthesis) to assess the main inputs and output flows characterizing the urban metabolism of the city of Uppsala (Sweden). Natural and human-driven resource flows supporting the metabolism of the city were evaluated and compared by using an ecological-economics perspective. Finally, economic and emergy-based indicators were calculated and discussed. Results highlighted a lack of self-sufficiency

characterizing most of modern cities especially in terms of food and energy supplied from larger environmental systems. Considering the existing problems of environmental sustainability of most cities and the current trend towards urbanization, the proposed multi-criteria assessment to the study of urban metabolism can represent an important component of sustainability research and policy. An ecological-economic perspective integrated with a deeper investigation of social variables can provide useful scientific knowledge about the metabolism of cities. Such knowledge can inform city managers and policy makers and, ultimately, stimulate environmental policies based on the notion of "integrated wealth assessment" as the base for a productive and sustainable future.

Modeling and simulation of the Billings Reservoir resilience - São Paulo, Brazil

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Billings is the largest reservoir of the biggest Brazilian Metropolitan Region. This reservoir cannot have their water resources fully utilized due to the high degree of pollution and degradation of the water quality and sediments which were contaminated for decades, principally by the reversal of the Tietê River to the channel of the Pinheiros River in direction of the Billings reservoir. Blooms of blue-green algae and macrophytes have been increasingly frequent. The Billings reservoir has an irregular shape and can be divided into many parts, one of them is called "Taquacetuba arm". Taquaquecetuba arm is located far away from the main reservoir body and is used to the public water supply. The main goal of this work is to apply the system modeling and simulation of Taquaquecetuba in order to analyze the main variables which indicate the quality of the system along time. Dynamic simulations of scenarios will be used including different levels of "system disturbances" which will be applied to evaluate its ability into return to initial conditions. The measure of system resilience will also identify how far from the stability the system can be and how quickly it can return to its initial condition or if the system returned to another domain of stability.

Emergy account for production of fuel ethanol from ardent spirits

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In the present days there's pursuit for energy sources diverse from the ones derived from petroleum. This study presents the analysis on emergy for the production of ethanol obtained from seized ardent spirits and generated on the rectification column installed on Câmpus Inconfidentes of IFSULDEMINAS. The studied system is compared with the ethanol production conventional process

studied by Lanzotti (2000). It was verified that the EYR of the latter is 22% bigger than the one present on this study, that the EIR of this production is 66 times bigger than the conventional system, the ELR of the studied system is 442 times bigger than the value for the conventional system, the NSI is 7.9E+08 times bigger than it is for the conventional, which uses 51% of renewable resources, as the present system has only 0.5% of renewable resources. These numbers indicate that the conventional system presents better performance than the studied case when the mitigation of the environmental impact generated by the inadequate disposal of the seized spirits is not considered. This leads us to carry on with the studies concerning the environmental liabilities.

An assessment of Maryland and West Virginia's urban ecosystem health state using Emergy Synthesis

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Urban areas can be considered complex, constructed systems with natural, societal, and economic aspects. These urban ecosystems have an associated health state similar to natural ecological ecosystems. Urban ecosystem health should be of concern because health status is an indicator of economic wealth and social progress and can lead to a greater understanding of how ecosystem services are provisioned. Assessing urban ecosystem health requires a systems perspective where health status is determined in an integrated way that reflects the anthropogenic effects of human decisions and activities. A method of energy accounting can be used to describe flows of material and energy. Emergy synthesis provides an integrated evaluation of the ecological and economic flows through a system and makes it possible to study all aspects of urban metabolism. The emergy based methodology of urban ecosystem health assessment set forth by Su et al. (2013) and the methodology of energy accounting by Campbell were used to assess the urban ecosystem health state of Maryland and West Virginia. The five chosen ecosystem health indicators to represent the emergy-based urban ecosystem health state were 1) Vigor, 2) Structure, 3) Resilience, 4) Maintenance of urban ecosystem service function, and 5) Environmental Impact. Fourteen specific indices and their mathematical expressions were used to model these five health indicators. Data were collected for material, energy, and economic flows originating externally entering the system, internal flows, and internal flows that exit the system. Using the methodology and procedures, urban ecosystem health for Maryland and West Virginia were assessed for the year 2010. The identification and evaluation of urban environmental problems revealed information concerning energy use throughout the systems. The health states were evaluated and guidelines for better management were posited.

Emergy accounting of a specialized Danish pig production – Potential allocation of resource use

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Emergy analysis performed on different Danish pig production farms identified four noteworthy methodological issues: How to include or exclude co-products, how to distinct renewable and re-usable inputs, how to distinguish inputs of national versus global resources, and how to allocate emergy use to pigs of different weight classes. Here, we focus on the latter problem. Danish pig production is very specialized meaning that some farms yield both piglets (<7 kg), weaners (7-30 kg) and finishers (>30 kg) while others produce only one or two weight classes – and rarely in the same proportions. This mode of mixed production makes comparison between farms complicated because different weight classes have deviating resource requirements per gram of output, e.g. a farm only selling finishers is more resource efficient than a farm selling piglets and weaners, due to a lower feed conversion ratio for these classes. Emergy assessment was performed for three farms of which one produced only weaners and the others produced several weight classes. We have developed a methodology to allocate emergy to the different weight classes depending on the amount of days the pigs have stayed at the farm. Using this allocation made it possible to compare the farms across weight classes instead of by means of total output and thus evaluate the efficiency of the production methods independently of the composition of output.

Emergy evaluation of the forest ecosystems in Jigongshan Mountain Natural Reserve of China: A case study for ecosystems valuation and environmental decision making

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Emergy evaluation of the forest ecosystems in the Jigongshan Mountain Reserve were conducted to assess the relative values of several ecological functions (most often referred to as ecosystem services) and main ecosystem storages (so-called natural capital). The main driving energies, internal processes and storages were evaluated. The main functions including

transpiration, GPP and infiltration are evaluated, and expressed in terms of their emergy-based economic value (so-called emdollars) as respectively 97.5 em$/ha/yr, 883 em$/ha/yr and 73.8 em$/ha/yr. The total values of major environmental services were 2.57E+05 em$/yr, 2.33E+06 em$/yr and 1.95E+05em$/yr in the Jigongshan forest ecosystem. The main storages of natural capital including live biomass, soil moisture, organic matter, underground water and landform are estimated as respectively8.16E+07em$ em$, 3.82E+03em$, 1.72E+07em$, 3.16E+04em$ and 4.24E+9 em$. The largest value is for landform. The concept of replacement value is explored based on emergy accounting of both ecosystem services and natural capital. The total calculated replacement value is about 7.28E+04 em$/ha and 1.92E+08 em$ in 2639.32 ha areas of forest ecosystems.

Ecological network analysis of emergy flows: a quantitative characterization of ecosystem structure and function

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Ecosystems cycle energy and material through an intricate network of interactions between components. The processes that result from these interactions are unique and define the conditions that support the ecosystem's biotic community and drive change. Cycles, interactions and derived processes, while little understood in their entirety, are the ultimate determinants of the functions an ecosystem can perform. These system level qualities are not linear, cannot be isolated, and have not been well elucidated as the core of value assigned to ecosystems and ecosystem services. A more holistic perspective for assessing ecosystem services suggests analyzing system-scale energy dynamics (Odum and Odum 2000, Jørgensen 2010, Pulselli et al. 2011).
In this project we explore and propose methods to describe ecosystems structure and function and their relationship to ecosystem services by analyzing its patterns of emergy flows and storages. For this purpose concepts from Emergy theory are combined with elements of other theoretic frameworks, the Ecological Network Analysis (Ulanowicz 1986, Ulanowicz 2004) and Network Environ Analysis (Fath et al. 2001), which have developed a comprehensive battery of indices for describing ecosystems based on network properties. In addition, we follow the network-based emergy methodology (Odum and Collins 2003), recognizing internal cycling energy as an additional force driving the system, and incorporating dynamism to the calculation of the transformities.

Using emergy network evaluating the ecosystem services for the payment of a watershed-scale wetland restoration project

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Nansi Lake in North China is at the east route of National South-to-North Water Transfer Project and faces both loss of wetlands and deterioration of water quality. To ensure the water safety during the drinking water transfer, the government of Shandong Province started a large-scale lakeshore wetland restoration project in 2008, and a sound payment for ecosystem services program is needed to pay participating farmland owners for the benefits of watershed protection and water quality improvement. In this paper, emergy accounting was conducted to evaluate the ecosystem services and the water service of the transferred drinking water. Based on the quantitative accounting, a Payment for Water Service (PWS) Program was designed, the process of policy design of the PWS was described, and the main stakeholders involved in the program and the operating rules were elaborated. The PWS solved the limitation of payments for ecosystem services in different watersheds and administrative areas in China and would be an effective complement to other policy responses during the restoration project.

Friday, January 17, 2014

8:30 - 10:10 Session 5 ~ Technological Systems: Pollution, Waste, and Recycling (*Ballroom A*)

Emergy evaluation of the urban solid waste metabolism in Liaoning Province

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Different kinds of urban solid waste treatment systems require different resource inputs, energy consumption and economic costs, but demonstrated different production efficiencies and environmental impacts. Thus, a thorough ecological economic evaluation is required to assess and guide resource and energy saving of urban solid treatment systems in Liaoning Province. This paper compared four garbage treatment systems, including sanitary landfills systems, fluidized bed incineration system, grate type incineration system and current landfills system. By considering the economic and environmental impacts of wastes treatment and disposal, impact of emissions, and contribution of wastes input, this paper constructed an emergy based urban solid waste model for evaluating the sustainability of the holistic systems. The results in Liaoning indicate that the human health losses caused by the harmful air emissions are ranked in this order: fluidized bed incineration > grate type incineration > current landfills > sanitary landfills, while the ecosystem losses are ranked: grate type incineration > fluidized bed incineration > sanitary landfills > current landfills. The electricity yield ratios are ranked: grate type incineration > fluidized bed incineration > sanitary landfills > current landfills. It suggests that, in considering the incineration option, decision makers must weigh the benefits of incineration against the significant operating costs, potential environmental impacts, and technical difficulties of operating. Emergy analysis of the urban solid treatment systems can form a set of useful tools, which can be used to compare the comprehensive performances of different waste treatment processes for decision-making and optimizing the whole process.

Emergy based model for recycling processes accounting for material losses

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This paper aims to contribute to the development of the emergy theory for recycling processes. The original contribution lies in the development of previous proposed mathematical models of the emergy evolution in closed loop recycling processes. Recycling is not an ideal process where all matter that enters the boundaries of the systems exits with the exact same amount. Losses of matter can occur throughout the stages of the recycling process both originating from limits in the technologies used and anthropogenic sources. These losses will have an impact on the recycling sustainability of a product because of its lower capacity to reduce resource drainage from the biosphere. In terms of emergy accounting this loss was accounted for as the hypothetical cost in resources (translated into emergy) that would be required to compensate for the amount of matter lost in the product. This compensatory fraction was found to have an incremental impact on the emergy evolution from on recycling stage to the other. By incorporating this compensatory fraction, the developed model has the ability to predict more accurately the emergy evolution for a given product. The RBR (recycling benefit ratio) and the RYR (recycling yield ratio) used to quantify sustainability were adapted and there evolution was analysed aiming to predict until when it was worthy to continue recycling.

Relationships among energy import and consumption, economic growth and air emissions in Japan after the World War II

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The long-term trends of energy import, consumption and production, national economy and atmosphere quality and Greenhouse gases (GHGs) emission, and the relationships among them in Japan after the World War II were investigated and analysis. Both conventional energy and emergy are applied to quantify energy consumption and emissions' impact. The Shannon-Wiener diversity Index (SWI) was introduced and calculated to measure the security of primary energy structure, and the import structure of main fossil fuels used in Japan. Special attentions were paid on the ecological economic impact of fossil fuels import and the potential alternation fuels for nuclear electricity after the disaster in 2011. The results mainly showed that there was a strong linear correlation between primary energy supply and GDP of Japan during the past

over half century, and the energy efficiency on economic development increased 23.80% in the past decade after wiping off the deflator factor and counting in the quality change of energy supplied. Japan was ecological economically benefited from the import of fossil fuels with their emergy exchange ratio (EER) lower than one, which was kept higher than 5% of the normal GDP in the past 30 years. The total environmental cost of GHGs emission in Japan decreased since the adoption of Kyoto Protocol in 1997, although no CO2 reduction was seen. Liquid Natural Gas (LNG) is so far a reasonable alternation for nuclear power, with higher import diversity. However, coal might be a better option than LNG, with a relatively low EER and a constant SWI of its import.

Emergy assessment of local environmental sustainability of energy use - the case of Shanwei, Guangdong, China

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The study deals with emergy sustainability at local level through assessment of energy use processes and released pollutants. The emergy accounting method is applied, as a case study, to the city of Shanwwei, a seaside urban area in Guangdongregion, China. All fossil energy sources used within (coal for electricity, coal for industrial uses, gasoline and diesel for transport) are investigated and the emergy sustainability indicators (ESI) are calculated and compared. In particular, the ESIs of investigated local processes are compared with the average ESI of the Chinese economy. A lower ESI of local processes would contribute to decrease the sustainability of China as a whole, while instead local improvements (constraint: $ESI_{local} \geq ESI_{China}$) would translate into a contribution to national sustainability from the local to the global scale. ESI, an emergy based measure of economic and environmental sustainability, is a complex function of local versus imported resources as well as of renewable versus nonrenewable ones. As a consequence of its dependence on renewables, ESI increases if more land is assigned to the process either in the form of direct use of local renewables or buffering set-aside area. The buffer area is calculated under the constraint $ESI_{local}=ESI_{China}$. Results show that a modern 1200 MW coal powered plant requires a buffer area of 14.7E+05 ha; the other industrial activities in the surrounding districts require 1.46E+04 ha; diesel and gasoline use for transport require 7.54E+04 ha buffer land, totaling 15.9E+05 ha. The regional area is only 5.27E+05, therefore insufficient to ensure sustainability. Policy suggestion: the larger the use of renewables in the economy and the use efficiency of nonrenewables, the smaller the need for set-aside area.

8:30 - 10:10 Session 6 ~ Production Systems: Methodology & Conceptual Frameworks (*Ballroom E*)

Renewability and emergy footprint

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At present there are many definitions of what characterizes a sustainable society. In emergy terms, the energy consumed in any system should be in balance with the energy captured on the area constituting the system and the local renewable input is the corresponding indicator. For most production systems to function, a lot more energy (and materials) is required and the emergy used coming from outside the system is indicated by the feedback from society. This flow also often has a renewable component but this is related to another land area: regional, national or global. By expanding the system considered these renewable flows would be included as 'local'. Therefore, the total emergy flow for a production system can be divided into 4 classes: Renewable and local, renewable and global, non-renewable and local, and non-renewable and global. The connection between local renewable flows and land area directly leads to a concept of Emergy-based Footprint where the emergy use is converted to area by dividing it by annual renewable emergy inflow per m^2 (Björklund and Johansson, 2013). This indicator will be used to discuss which services we can get from a specific land area? We compare three contrasting production systems: high-input pig production in Denmark, low-input vegetable production in UK, and willow production for bioenergy in Denmark. The implications of the different definitions of renewable flows for evaluating requirements for sustainable development are discussed based on the impression that the presently used methodology is insufficient

Opportunities and limitations of emergy analysis in the evaluation and optimization of agricultural production systems: The case of the Slovenian dairy sector

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Agriculture is a complex system in which the economic principles of production are directly intertwined with its biological and ecological characteristics. The paper investigates synergetic potentials of multiple-criteria and multiple-

perspective evaluation of agricultural activity through a study of the dairy sector in Slovenia. Socio-economic and emergy evaluation was performed on nine farm types, formulated to represent the diversity of the country's dairy sector. The results indicate larger discrepancies in the performance of the farm types when defined by socio-economic or emergy based indicators. Standard socio-economic evaluation favours larger, intensive and more productive conventional systems that are cost efficient and financially independent. Emergy analysis however, favours less productive and labour intensive organic farms, which show greater ability to exploit free local resources and cause lower stress on local environment. Both, socio-economic and emergy indicators point to the poorest performance of the small conventional farm types, which are the most widely represented farm types in the country. To identify the constraints and possibilities that can affect the overall performance of the sector at the national level the conceptual optimisation model of the sector is also presented. The analysis of emergy flows reveals that within the current economic system agriculture itself has little ability to affect its sustainability. The paper suggests however, that the joint application of the approaches can improve the quality of the decision-making process in various stages of planning in agriculture and land use.

Effect of time scale on renewable emergy accounting: a case study of forest ecosystems in south China

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Based on emergy accounting rules, only the bigger one between two emergy inputs from the same source, e.g., solar radiation and rainfall, should be accounted to avoid double-accounting. For a year as a time scale, the rainfall emergy is usually bigger than that of solar energy in south China because of a large precipitation and its transformity with four orders of magnitudes, and so the rain emergy is accounted as the renewable emergy. However, for a day as a time scale, only the solar emergy is accounted as the renewable emergy input to forest ecosystem in south China when it does not rain rather than be sunny. Therefore, different time scale may produce some effect on renewable emergy accounting of ecosystems. In this paper, we explored the effect of four time scales (year, season, month, and day) on renewable emergy accounting of forest ecosystems in south China in 1985-2007. The results showed that, at the time scale of year or season, rain emergy was much larger than that of solar

energy. Under the time scale of month or day, rain emergy was still larger than that of solar energy in most cases, but when it did not rain or rain a little, rain emergy was less than that of solar energy. In general, there was a little difference of renewable emergy accounting among four time scales, and the largest difference existed between the time scales of day and year, i.e., 1.46% in average and 2.55% in 23 years. Besides, the rain which can be actually used by the forests is only evapotranspiration (ET) and the left one is not used rather than run off. Regardless of it rains or not, evapotranspiration (ET) always exists and have larger emergy than that of solar energy. Therefore, the ET emergy instead of rain emergy can not only improve the exact calculation of real emergy input, but also avoid the effect of time scale on renewable emergy accounting.

Emergy synthesis of the effects of paddy rice landscape changes on agro-ecosystem services in Taiwan

Ying-Chieh Lee
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Paddy rice field is the major type of agricultural landscape in Taiwan and throughout Eastern Asia. The loss of paddy rice field ultimately results in the reduction and degradation not only of its food production function but also of many other agro-ecosystem services. Agro-ecosystem services include various provisioning, regulating, and cultural services provided by agricultural land. Changes in paddy rice landscape can impact the entire agricultural environment by reducing the agro-ecosystem services. To study how paddy rice landscape change affects the sustainability of agricultural environment, this research incorporates emergy synthesis to evaluate the changes in ecological energetic flows of agricultural system in 1971 and 2006. The agro-ecosystem services of the agricultural land in the study area are identified and represented by the energy system diagram. Seven sites, each 2 km × 2 km, which represent the paddy rice landscape in the peri-urban areas of Taiwan are selected as sample areas. Landscape metrics and ecological energetic analysis are applied in this research to study the relationship between the landscape change of paddy rice landscape and its agro-ecosystem service loss. The analysis reveals that agro-ecosystem services are related to the spatial configuration of paddy rice field. Maintaining larger tract and preventing paddy rice fields from fragmentation will help to improve the environmental sustainability in agricultural landscape.

10:35 - 12:15 Session 7 ~ Spatial Approaches in Urban & Regional Systems (*Ballroom A*)

GIS use of empower density for environmental protection

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The National Ecological Framework is a GIS based model of the connectivity of natural landscapes in the lower 48 United States. It was developed to provide a guide for the protection of the natural ecosystem processes that give us clean air, pure water and protected lands that are part of EPA's mission to protect. It was developed as an update to the Southeastern Ecological Framework from 2001. As part of the GIS processing of the model, the non-renewable empower density was calculated for a 30m grid resolution of the lower 48 states. This was used in the development of a human disturbance cost surface. Areas of important ecological significance were isolated (hubs) and then connected using the cost surface to derive the least cost path between individual hubs. The connections were then expanded across the cost surface to derive corridors that connected the hubs. Analysis of the individual hubs and corridors using the cost surface and other factors help to prioritize areas for potential protection and restoration with EPA's partners.

A spatial comparative analysis of urban metabolic efficiencies in the Yangtze River Delta

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The Yangtze River delta is an open ecosystem exchanging energy and materials with the surrounding environment. Based on emergy quantified as embodied solar energy, the social energy and material metabolism of 10 typical cities of the Yangtze River delta was aggregated into emergy equivalents to assess the level of resource depletion, environmental impact and local sustainability within the region. Moreover, a metabolic efficiency index was established according to a set of emergy indices to manifest the ecological status of these cities of the Yangtze River delta ecosystem. Due to different geographic features, economic development levels and availability of local energy sources, the results offered not only a classification of urban metabolic effects during the investigation period, but also showed the spatial hierarchy, which may explain the spatial pattern of urban development on the landscape. This paper provides a reference towards improving the governance policies to promote sustainability of the Yangtze River delta.

Regional differences of solarshare in Taiwan food consumption

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This study integrates emergy evaluation with GIS (Geographic Information Systems) to investigate the renewable resources flow, the cost of food consumption, and the solarshare in Taiwan. Taiwan is an island country with limited natural resources and high population density; consequently, it is important to give consideration to the sustainable food production environment while simultaneously satisfying the demand of food consumption. First, the renewable resources flow in Taiwan was assessed. The food items consumed in 2006 were then estimated based on the food balance sheet, demographic data, and the Nutrition and Health Survey in Taiwan (NAHSIT). Finally, this study incorporates the concept of solarshare to analyze the environmental carrying capacity for food, and attempts to discuss the regional differences. The emergy synthesis in this study revealed the following: (1) The Taiwan renewable emergy flow in 2006 was about 1.31 E+22 seJ, and the areas with higher renewable emergy are located in the mountain areas; (2) the dietary behavior of Taiwanese consumed about 3.77 E+22 seJ (4.53 E+12 seJ per capita per day) in 2006; (3) the estimated solarshare of Taiwan was about 1.57 E+12 seJ per day in 2006, which was only about a quarter of the global standard (6.0 E+12 seJ per day). It shows that there are relatively low renewable resources which could be used in Taiwan; (4) the results of the Environmental Carrying Capacity of Food (ECCOF) indicate that the resources used for food consumption in Taiwan are much higher than the natural environment could provide (2.88 times), especially in the highly urbanized areas.

An emergy approach for urban vulnerability assessment: A case study of Taiwan's western coastal plain

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Vulnerability assessments represent an important research theme under the context of climate change for adapting and managing change. Currently, over 90% of the populations of Taiwan are concentrated in western coastal plain. Owning to the stresses of urban development, land use and land cover change in the peri-urban areas of the major cities of Taiwan that tends to affect biophysical processes and ecosystem services, and result in the increase of the vulnerability of cities to climate change. The assessment of vulnerability should consider the interaction between components of the ecological and economic systems of the specific place. The primary aim of this research is to develop a framework of assessing the vulnerability spatially of Taiwan's western coastal plain that incorporate the interaction between the three components of

vulnerability - exposure, sensitivity, and adaptive capacity. To achieve this goal, this research comprises four phases: 1) interpret urban vulnerability from emergy concepts; 2) develop emergy indices to assess urban vulnerability; 3) exhibit the spatial heterogeneity of urban vulnerability via GIS; and 4) discuss how the results of spatial analysis of vulnerability assessment can support urban spatial planning.

10:35 - 12:15 Session 8 ~ Production Systems: Agricultural Case Studies (*Ballroom E*)

Food and biogas production in a Ghanaian village - Results and modelling issues

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Integrated food and energy production based on small-scale, semi-mechanized farming in rural Ghana was studied in a context of reducing dependence on purchased materials, particularly inorganic fertilizer, petrochemicals, diesel and wood fuel. The aim of the study was to evaluate two food and energy-for-cooking production systems, the current and a modeled, suggested future system. The current system is comprised of a maize-bean farming system and with wood fuel for cooking. The modeled system is also based on a maize-bean farming system but utilizes residue-based, local biogas production to partially substitute for wood fuel and inorganic fertilizer. Both systems produce the same amount of food products and energy carriers able to satisfy the same cooking demand. Emergy accounting was used to compare resource use efficiency and composition of production inventories of the two systems. The alternative material input and labor requirements of introducing biogas are discussed. Emergy analysis results were found to be especially sensitive to the method of accounting for direct and indirect labor, particularly that the use of a national average emergy conversion rate for labor seems inapplicable under the studied conditions.

Emergy evaluation of grazing cattle in a Mediterranean agro-silvo-pastoral system

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The Mediterranean agro-silvo-pastoral system known as Montado in Portugal, or Dehesa in Spain, occupies around 55 000 km^2 mainly in the southern part of those two countries. This system is characterized by a savannah-like landscape, with an open tree stratum dominated by holm oaks and/or cork oaks and an herbaceous layer dominated by annual species and some shrubs. This is a semi-

natural system where the manager controls the shrubs to produce more pasture for livestock. The Montado preserves some characteristics of the natural systems, like: good adaptation to natural constraints of the Mediterranean climate and soil; a greater complexity and resilience to changes in management practices; important inputs of renewable resources that can be used to raise livestock. Cattle are not considered the best breed to have in the Montado, due to their weight and the damage that they can cause to the soil by compression and by the trampling of the young trees. Despite the negative impacts that cattle can have in this complex system, compromising its sustainability, they have become, recently, an important component of the Montado. The ease of cattle management and the European Common Agriculture Policy support to cattle breading are the reasons behind the broad adoption of cattle rearing in the Montado. The Emergy Evaluation Method allows considering different aspects of an ecosystem such as human activities, biophysical and ecological aspects, management practices and economic fluxes at the same time. It does so through the evaluation of all energy, material and information fluxes in terms of the energy of one type (e.g., solar joules) used up directly and indirectly to make a service or product. The transformity or the total emergy required in relation to the available energy of this service or product is a measure the quality of the product and the efficiency of the production process. So this method is a good way to understand the impact of cattle breeding activity on the Montado and evaluate the sustainability of management practices associated with cattle grazing. In this paper we will apply the Emergy Evaluation Method to a farm raising cattle in the Montado and we will present some results about the sustainability of this system.

Environmental sustainability of Chinese agriculture: an overview of case analysis of farming systems using emergy synthesis

Lixiao Zhang, Mingyue Pang, Zhifeng Yang, Bin Chen, Gengyuan Liu
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It's never too excessive to attach importance to the environmental sustainability of agricultural practices in China, due to its high relations to food security of China and even the world, land degradation as well as environmental pollutions. During the past several years, 10 farming systems with regard to different cropping and cultivating model and different rearing activities of fish and chiken has been extensivley analyzed using emergy method by our research group. Drawing on these research results, an overview of environmental sustainability of Chinese agricultural practices are presented in this paper. The most evident characteristic of Chinese agricultural systems is the transition from traditional Chinese agricultural civilization to modern oil-agriculture which used to be popular in developed countries. Such transition illustrates a very important fact that environmental performance has to give

way to production efficiency, since some traditional farming practices as cropping in Inner Mongolia and cage fish farming in Weishan Lake having a good ESI as 7.14 and 4.61 suffered from relative poor production efficiency, compared to their counterparts charaterzied by high energy intensive inputs. The greatest challenge for China's newly advocated organic development is how to ensure the production efficiency when sticks to certain criteria associated with organic food cultivation. What's more, the available emergy analysis works for agricultural system put forward new demand for more systematic indicator other than ESI to measure the environmental sustainability, for instance, the overall cropping system is shown with outstanding production competence compared with agricultural systems in some other provinces and the national average in China, but it is confronted with severe desertification associated with soil loss. In a long term, it is an unacceptable practice and regarded as unsustainable since the soil condition is very fragile and can't afford years' loss, but in a static view point of one year's evaluation, it takes a good indicator of environmental perforce.

Changes in the values of Emergy Sustainability Indices for agricultural holdings in Pomerania after accession of Poland to the European Union

Anna Lewandowska-Czarnecka**,** Andrzej Nienartowicz, Adam J. Czarnecki
Nicolaus Copernicus University, Torun, Poland

Energy synthesis was conducted for two groups of agricultural holdings (farms) in Pomerania, northern Poland. The first group consisted of 13 farms operating in 2002-2003, i.e. before accession of Poland to the European Union (i.e. in 2004). The second group consisted of 8 farms operating in 2009-2012. The objective of this study was to determine the extent to which EU subsidies and access to modern technologies affected the Emergy Sustainability Index (ESI). All the investigated farms were characterised by the conventional method of agricultural production with mixed and animal profiles. The size of farms ranged from 8 to 81 ha. The agricultural production was conducted in agricultural holdings with similar physiographic, soil and climatic conditions. It has been found that ESI for farms operating during the pre-accession period ranged from 0.089 to 0.605. Whereas for agricultural holdings operating after 2004, the ESI range was much narrower compared to the pre-accession period and fluctuated around the medians from 2002-2003, i.e. 0.164 and 0.462. Much higher ESI values for farms studied after 2004 compared to the lowest values from 2002-2003 indicate that in the conditions of more extensive mechanization of farms, followed by the increased density of emergy, the agriculture has become more sustainable after 2004. Whereas, ESI values of agricultural holdings during the pre-accession period higher than 0.462 resulted from the worse equipment and technology rather than greater sustainability compared to modern farms.

1:30 – 3:10 Session 9 ~ Ecosystem Services

Emergy analysis for quantifying nutrient regulating ecosystem services of subtidal oyster reefs

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Oyster reefs are an important component of estuarine ecosystems and provide many ecological and economic benefits. Though traditionally prized as an important food source, oysters have gained greater recognition for providing numerous other ecosystem services (e.g. cultural and regulating services). Regulating services provided by oyster reefs include disturbance regulation (e.g. buffer storm surge, protect shorelines), sediment retention (e.g. stabilize sediment, control erosion), and nutrient regulation (e.g. reduce water column nutrients). Oyster reefs play a major role in the acquisition, processing, and storage of nutrients within estuaries, and help maintain ecologically-acceptable levels of major nutrients, such as nitrogen. This research focuses on nutrient regulation services provided by subtidal oyster reefs in Texas, and their value as quantified through energetic modeling and emergy analysis. In this study, the service of nutrient regulation is valued as the amount of nutrients (e.g. nitrogen) removed from the water column. This amount can be partitioned into amounts assimilated by oysters (e.g. incorporation into tissue and shell), and amounts voided as biodeposits and excreted as waste. Nitrogen shunted from the water column to sediments via oyster biodeposits and waste may then undergo burial and/or denitrification, resulting in nitrogen removal from the system. Nitrogen sequestered in oyster shell and tissue may be removed from the system via harvest. To adequately represent the importance of oyster reefs to society beyond typical market values, we must also include the numerous ecosystem services important for human well-being. By linking emergy analysis to ecosystem services, we can begin to quantify the total value of ecosystems.

Dynamic evaluation of ecological assets and human well-being - A case study of Zhifanggou valley in Shanxi province, China

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Ecological assets are integral components of natural capital and ecosystem services to effectively maintain sustainable development of human society. Changes on regional ecological assets impacting the process and the law on human well-being have become an important part of the ecological research at the present stage. In this study, based on summing up the research progress on ecological assets and human well-being in domestic and international and field research data, taking Loess Plateau Region typical Zhifanggou valley as the research area, selecting in two typical years before 1998 and after 2011, the grain for green project (grass) as research time, change of ecological asset was evaluated using emergy theory. The results show that: after the grain for green project, Zhifanggou valley's natural capital and ecosystem services value had increased in 2011 compared with that in 1998, and the rise rate of ecosystem services was greater than the natural capital. Slowly increasing of natural capital was mainly due to the local exploitation of oil after the grain for green project. Changes in ecological assets and land use changes were closely related. By interpreting the remote sensing image of Zhifanggou Catchment before and after the grain for green project, the proportion of farmland dropped significantly, contrarily, the proportion of woodland area increased rapidly.

The relations between the change of Zhifanggou Catchment's ecological assets and human well-being before and after the grain for green project were analyzed. The change of ecological assets was closely related to the human well-being.

Emergy accounting of ecosystem services in a green economy

Torbjörn Rydberg

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By applying general systems principles and open systems thermodynamic upon systems of human and environment, we want to learn and develop the ability to evaluate the effect and consequences upon generation of ecosystem services when a green economy are developed and implemented in the landscape as a response to diminishing local and global non-renewable resources. There is increasing demand globally for substitute to fossil fuel. The use of land for food and fuel will have consequences for the generation of

environmental services and it will generate a request for several non-renewable resources to run the production process. Using the environmental accounting system, emergy synthesis, the value of natural capital and ecosystem services can be quantified on a scientific basis. Emergy synthesis quantifies the value provided by the work and services of nature as well as the storages within the environment on an energetic basis. This is of greatest importance since the quantified contribution from the environment is independent from market valuations. The goal of this initial phase of the project is to map statistics and other data sources in order to find measurable and quantifiable aspects of ecosystem services. The hope is that through this survey we can identify how data availability looks, in what areas do we find missing data and to some extent what is the potential for development or improvement of existing data with the intent of improving conditions for quantifying ecosystem services and transfer them into emergy.

The emerging exits of grazing livestock

Bo Falk
Inocula Scandinavia, Hovmantorp, Sweden

The atmosphere holds today 750 Gt carbon, the vegetation on earth 610 Gt and already now there is 1580 Gt carbon in soils. Two thirds of the earth's land surface has only sporadic rainfall. Allan Savory has shown that desert formation can effectively and in short time be reversed through using grazing livestock in a holistic way. This consists of often moving enough big grazing herds and thereby increasing the surface with growing grass. This gives active roots and more carbon buildup in the soil. Not so much more biomass but more grazed, active growing vegetation. With vast surface available, the effects can be remarkable. In earlier time periods a lot of grazing animals may have been the critical factor in creating ice-ages. More grazing animals also creates the possibility to strongly affect the carbon buildup in the soil of those areas that we today farming in a far from renewable way. When growing cereals and oilcrops much soil carbon is released by tilling and nitrogen fertilization. This has recently been shown by a research team from Minnesota. Soil destruction can be at the level of 10 tons per ton of cereal produced. Cereals and oilseeds provide unsuitable food. Both directly and indirectly via livestock compared to grazing animals who only get pasture and hay. In this case the fat composition becomes perfect also containing EPA (essential animal omega-3). The Engine in the unsustainable farming has been fossil fuels with high net energy. The extraction is in decline and nowadays only less than a third of all extracted fossil fuels are exported. Continuously difficult extraction is also lowering the net energy which is nearing the limit that can sustain our recent societies. With less profit the oil companies have increased their borrowing which by recent loan bubble of epic levels means that the fossil fuel era can be over anytime.

For example, the oil extraction in Norway is in permanent decline, companies reduce their investments and loans collapse in the whole economy as a result. Without fossil fuels and nitrogen fertilizer and without growing of cereals and oilcrops the agriculture can become renewable again. Using ley cropping with legumes for winterfodder and some pasture doesn´t need that much tillage which also suite the possibility to use draft animals. Reserve areas for grazing are also available in forests, meadows and mountains. At the same time the carbon builds up and fertility increases in all soils. Already now we have on the earth 1,5 billion cattle and 1 billion sheep. More grazing and ley cropping and reducing pigs and poultry can make a tripling of the amount of grazers reasonable. With the reduced availability of fossil fuels at the door, grazing livestock becomes the biggest regulating factor to influence the carbon buildup in soil and thereby the content in the atmosphere. With many animals we can also feed many people although we have to make different societies. We also have also in our hand to keep suitable the amount of carbon dioxide in the atmosphere.

3:35 – 5:15 Session 10 ~ Theory & Conceptual Frameworks

Odum and the Vicious Circle Principle

Craig Dilworth

Department of Philosophy, Uppsala University, Sweden

The work of the systems-ecologist Howard Odum presages the vicious circle principle (VCP) presented in Too Smart for Our Own Good. As presented in Too Smart, the VCP is as follows: “Humankind’s development consists in an accelerating movement from situations of scarcity/need, to technological innovation, to increased resource availability, to increased consumption, to population growth, to resource depletion, to scarcity once again, and so on” (p. 110). Fundamental here is Odum’s notion of emergy – the free energy used in the making of a product or the performing of a service. Applying Odum’s thinking to the VCP’s interpretation of changes in the development of humankind suggests that with each technological revolution in our development there has resulted an increase in available emergy. On the VCP this has been expressed as an increase in the usable energy available to our species, which has resulted in population growth and a subsequent demand for constantly increasing quantities of energy/emergy. On the VCP this demand has to date generally been met, with the result that the vicious circle of humankind’s development has grown in both size and environmental impact. Other points of contact between the Odum conception and that of the VCP are discussed, including the concepts of pulsing, ecological equilibrium, sustainability, power, hierarchy, self-organization, and maximization versus optimization.

Emergy/Symplexity

Dennis Collins
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This paper follows up on Corrado Giannantoni's factorization of emergy into generative and dissipative components (Emergy Synthesis 4, Ch. 15 Emergy Analysis as the First Ordinal Theory of Complex Systems, p.11) and the Author's LEGO block study (Emergy Synthesis 4, Ch. 14 "Tropical " Emergy and (Dis-) Order of 2006. Based on the Author's symmetry patent (2011) the symmetry measure SYM can measure the generative symmetry of a figure. Since it is possible to calculate the maximum discrete symmetry MAXSYM, the quantity MAXSYM–SYM measures how much symmetry is left, that is the dissipative symmetry. The product SYM*(MAXSYM–SYM) thus gives a measure of transformity, which will be proportional to emergy according to the formula Emergy=Transformity*Energy. The above-mentioned product SYM*(MAXSYM–SYM) is closely related to what Jeffrey Kluger calls "symplexity," cf. Complexity Arc Graph on p. 28 of the book Symplexity (2008) by Jeffrey Kluger. This paper calculates these quantities for the case of 5 points where MAXSYM = 45, which can be obtained as the unit vectors in 5-dimensional space, but has no content, so-to-speak, so that the product becomes symplexity = 45*(45-45) = 0. Supposing energy constant, the maximum emergy can be calculated as a simple calculus problem as occurring at SYM = 22.5. Sneferu's attempt to build a pyramid with SYM = 29 collapsed and was re-built as the "bent" pyramid.

Convergence and divergence in the production of energy transformation hierarchies

Tom Abel
Human Development, Tzu Chi University, Hualien, Taiwan

Divergence (dispersal) is the undertheorized process in energy transformation hierarchies. Energy transformation hierarchies are generally described as a stepwise convergence of energy and materials, with characteristic properties of increasing storage size, turnover time, and spatial scale, but they also include intermediate steps of divergence that feeds coexistent parallel channels of convergence. These patterns are particularly obvious when systems theory is applied to understanding economic "production (or commodity) chains" in the global economy. Dispersal is also a fundamental process in the production of culture in "information cycles". After a conversation, for example, the dispersal of people with new information to the world, where that information is tested and possibly selected again, is a fundamental step in the wide sharing and upgrading of cultural information.

Saturday, January 18, 2014

8:30 – 9:20 Session 11 ~ Emergy and LCA

Progress and questions: The emergy method in LCA

Chris De Vilbiss[1], Mark Brown[1], Wesley Ingwerson[2], Cissy Ma[2]
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Time and space overlap with the multitude of unit emergy values (UEVs) that characterize raw natural (elementary) resources in life cycle assessment (LCA) datasets. Current accounting procedures in LCA are unable to accept the algebra which distinguishes emergy synthesis as a systemic analysis tool. This reduces emergy synthesis to a geo-biosphere-scale cumulative exergy analysis method able to capture the generation time of elementary resources. LCA basically sums (or subtracts) emergy from an aggregated mass/energy account of defined processes. UEVs computed from simplified global models tend towards maximum cardinality thus skewing LCA results. Furthermore the sum of all non-overlapping sub-systems results in an emergy signature exceeding the system itself, leading to un-comparable results with any analysis of a different scale. To smooth the playing field of the plethora of UEVs a common framework is sought for which to calculate UEVs of various time/space scales. Previous models are updated with new data, new accounting procedures, and/or wholly new methods to strengthen the co-dependence between exergy and emergy, transformity and specific emergy, and LCA and emergy synthesis. In particular renewable accounting, global co-products, co-occurring processes in fossil fuel generation, and the thermodynamics crustal mineral concentration and quality are discussed. The conclusion introduces the potential effect of a long-term dynamic emergy baseline on the UEV of crustal materials.

Dealing with waste management in emergy and LCA: Overview and synergies

Maddalena Ripa[1], Marco Raugei[2], Alba Bala Gala[3], Sergio Ulgiati[1]
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According to Lotka's Maximum Power Principle, sustainable growth of systems requires the optimum use of available resources for maximum power output and waste minimization. Ecosystems invariably seem to apply this strategy, in that all matter flows are circular and the very concept of waste

does not apply: waste flows from a process always become inputs to other processes. Instead, human-dominated systems typically generate large amounts of waste due to inefficient or sometimes inappropriate processes, and this leads to the depletion of natural resources and an increased load on the environment, unless suitable waste management strategies are applied. The latter do not come for free, though, and it is of paramount importance to be able to correctly assess the benefits and cost of resource use efficiency as well as waste management.

This paper deals with the different approaches taken in dealing with waste management in Life Cycle Assessment and Emergy Accounting, from a methodological point of view, and aims to develop more standardized and synergistic procedures.

Life Cycle Assessment is a well-established methodology which deals with the waste issue from the point of view of the impact of their disposal, as well as the potential benefit afforded by the avoided extraction and processing of additional primary resources when waste is recycled or its energy content recovered. LCA adopts 'cut-off' rules in order to clearly allocate the cost of waste generation to only one product cycle, thereby avoiding double counting and only focusing on the costs and burdens of waste disposal or conversion.

Emergy Accounting, being a donor-side approach, only accounts for input flows needed to generate products; waste disposal is typically only considered as an additional cost charged to the main product(s). When waste has the potential to be used elsewhere (or to be recycled back to earlier steps of the same process), though, it calls for a clearly defined set of dedicated emergy algebra rules in order to avoid double counting. Published efforts to this end have thus far been partial and at times unsatisfactory and we believe that more work needs to be done to reach an agreed upon standardized procedure consistent with the emergy concept. We propose here that a better and more consistent methodological solution may be arrived at by leveraging the work done in LCA.

9:20 – 10:20 Emergy and LCA Panel

Chair: Marco Raugei

10:20 – 10:40 Break

10:40 – 11:30 Session 12 ~ Emergy Baseline

Emergy, transformity, the emergy unit and the emergy baseline

Daniel Campbell
USEPA, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI

This paper addresses three important research areas subject to some disagreement within the community of emergy practitioners or to misunderstandings within the scientific community as a whole. Emergy and its sister idea, transformity, are important new concepts derived from the proposed laws of non-equilibrium thermodynamics developed by H.T. Odum. While the formal definition of emergy is well known, there is still some debate about the meaning of this new idea and those not trained in Energy Systems Theory may experience considerable difficulty in understanding its meaning. In this paper we consider the concepts of emergy and to a lesser degree transformity with the purpose of gaining a better understanding of their meaning. In addition, the origin of the word "emergy" is reexamined and an etymological argument is used in a re-derivation of the term. Furthermore, scientists performing emergy research have used different names and abbreviations for the emergy unit. Use of the various names for the emergy unit are reviewed and appropriate and inappropriate abbreviations are considered based on the rules and style conventions of the International System of Units (SI) and the standard rules governing use of the English language. Finally, we examine the planetary baselines currently in use and present criteria for determining their plausibility. Based on these criteria, we present a recalculation of the planetary emergy base line and explain why this recalculation produces a result that is superior to existing choices.

An emergy baseline derived from the Global Tripartite

Mark T. Brown[1] and Sergio Ulgiati[2]
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The empower that is derived from solar energy, tidal momentum and geothermal energy drives the productive processes of the geobiosphere and is responsible for developing gradients of potential energy transformed into secondary energy sources (wind, chemical potentials of water, and waves) and tertiary sources (chemical and geopotential energy of river discharges and the available energy in breaking waves). In this paper we establish the geobiosphere emergy baseline based on earlier methods proposed by Odum,

(2000) and refinements by Brown and Ulgiati (2010). We redefine the emergy driving secondary and tertiary sources propose a new method of accounting for primary, secondary and tertiary sources by relaxing the concern over double counting resulting from nonalignment of spatial and temporal scales between the global tripartite and secondary and tertiary sources.

9:20 – 10:20 **Emergy Baseline Panel**
Chair: Chen Bin

12:30 – 2:30 **Working lunch / Meeting of the International Society for the Advancement of Emergy Research (ISAER)**
Lunch provided by ISAER

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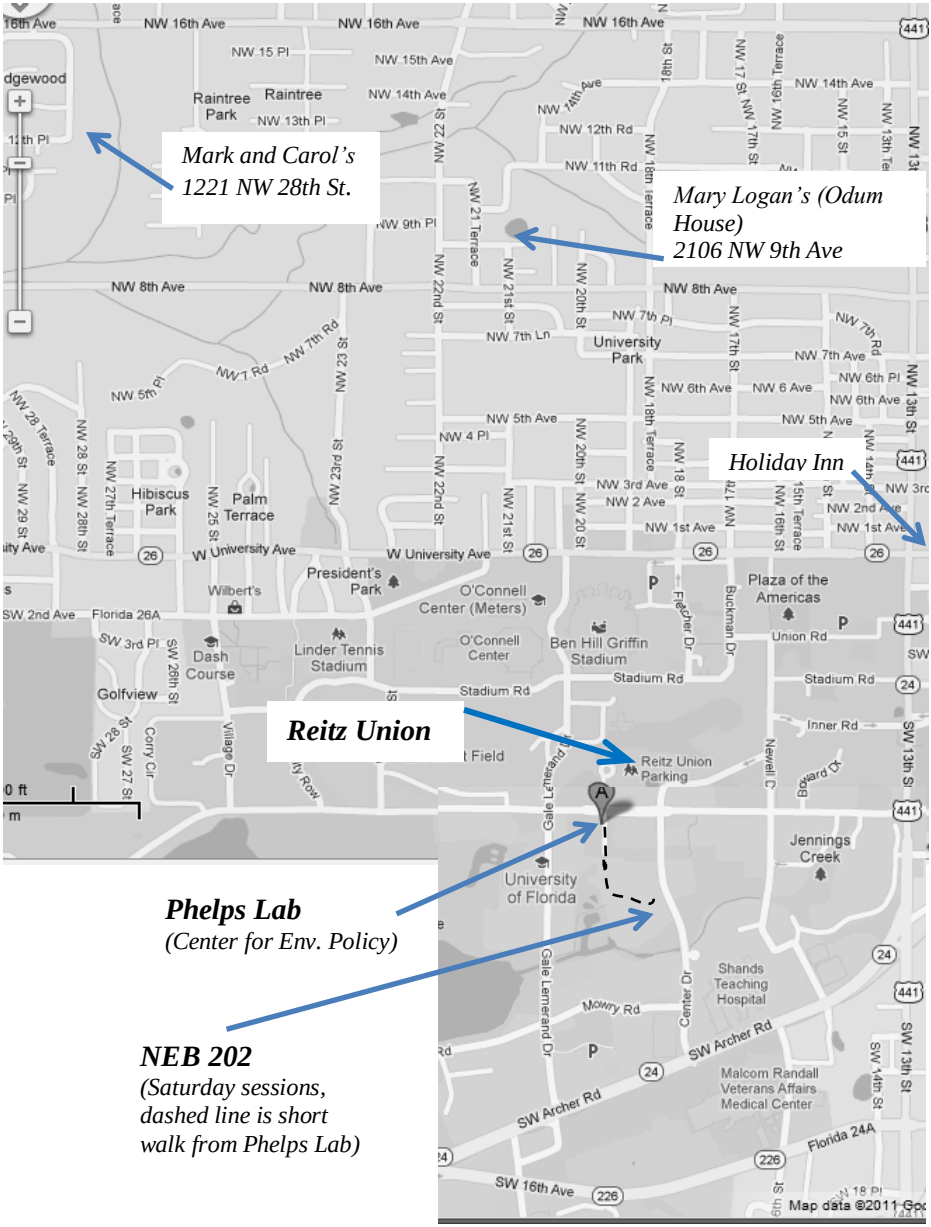
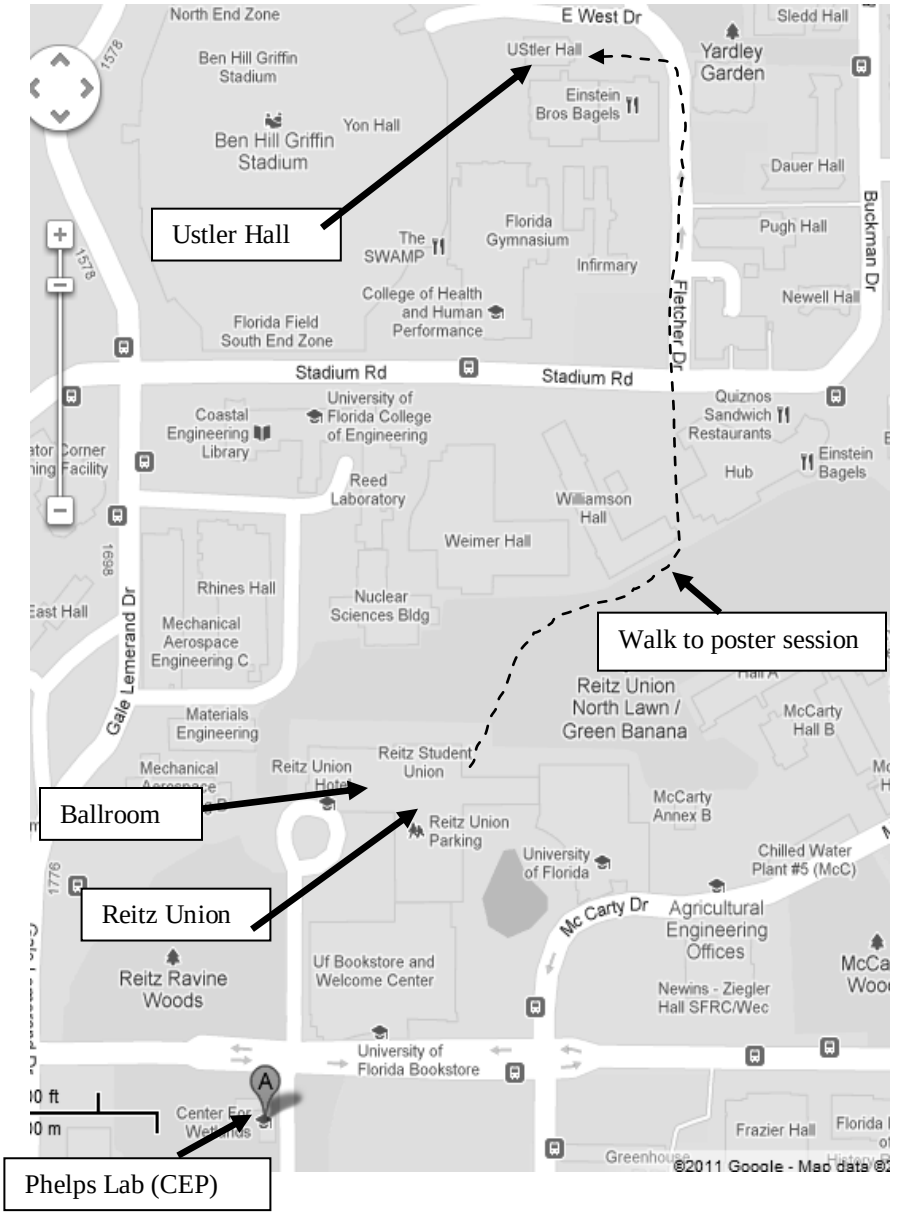
Map of general layout of the event sites



Map of campus sites



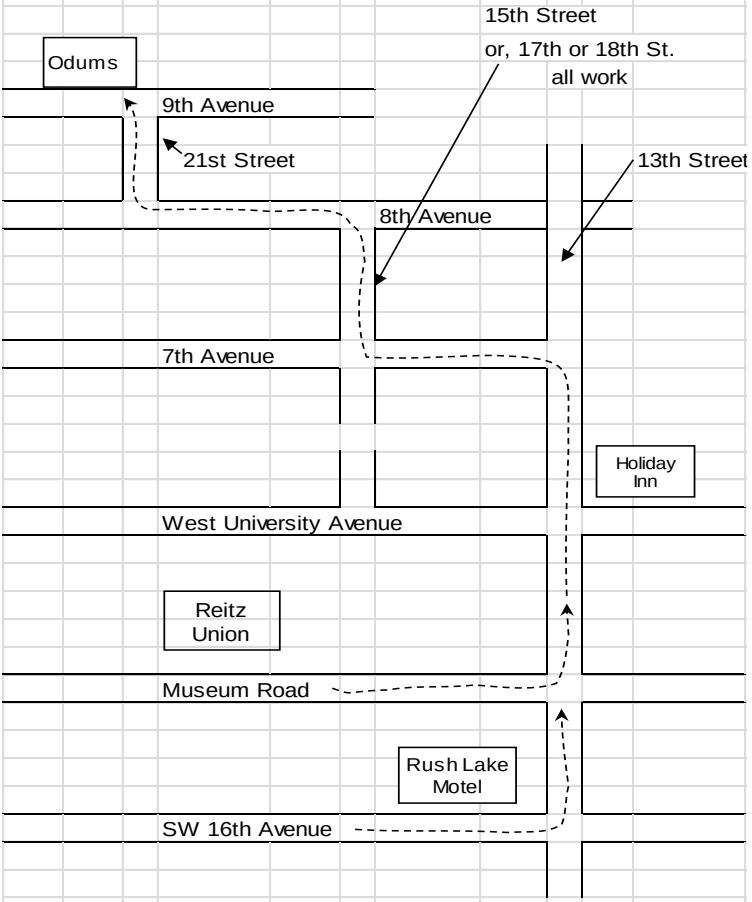
Invitation to

Participants and their Companions

Attending the Emergy Research Conference

Party hosted by Mary Logan at the
Odum House
6:30pm, Friday, January 17th
Enjoy sandwiches, appetizers, sides, beer, wine!
(map link on EmergySystems website)

2106 NW 9th Ave
Gainesville
Phone 378-8172



7:00pm, Saturday, January 18th

(map link on EmergySystems website)

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MARK BROWN AND CAROL BINELLO

1221 NW 28th Street

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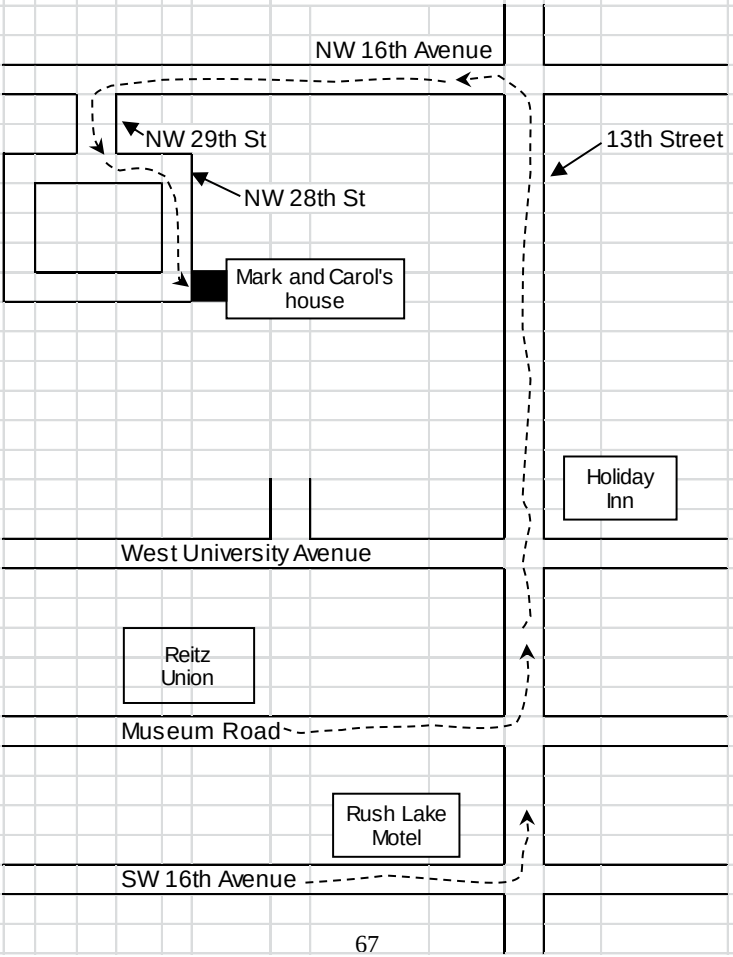

GAINESVILLE FLORIDA RESTAURANT GUIDE
(*recommended)

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Gatorfood.com – Breakfast, lunch, dinner, dessert, sweet, spicy, kosher. You name it, they deliver it. Restaurants to choose from. Mon-Sat 10:30a.m.-10:30p.m.; Sunday 10:30a.m.-9:30p.m.. Call them at (352)379-3663 or go online to www.gatorfood.com.

On SW 13th Street between campus and Paramount Hotel:
Arby's – Fast food. Breakfast, Lunch, Dinner. Sandwiches, hot and cold. 1405 SW 13th St. (352)378-6555.
*Blue Gill – One of the higher quality options in the area. Creative Southern/comfort food, lunch & dinner.1310 SW 13th Street.
Chop Stix Cafe – Great Pan-Asian food at low prices. Great for vegetarians and meat eaters alike. Open for lunch and dinner Monday through Saturday. 3500 SW 13th St. (352)367-0003.
El Toro Mexican Restaurant – 1723 SW 13th St. (352)376-6989.
Gyros Falafel Plus – Casual and cheap, but good Middle Eastern food. Good vegetarian/vegan options. 2401 SW 13th St. (352)372-4995.
La Familia Cuban Sandwich Shop – 1209 SW 16th Avenue (352) 378-2257.
Subway – Hot and cold sandwiches. 1805 SW 13th St. (352) 371-0311.
*La Tienda Latina Restaurante Market – Groceries from Mexico, fresh baked sweetbreads, authentic Mexican dishes and soups. 2204 SW 13th St. (352)367-0022.
Steak N Shake – Classic diner food. 1610 SW 13th St. (352)376-0588.
Virtually Cuban – Good Cuban food. 2409 S.W. 13th St. (352) 336-4125.

Walking Distance from Campus & Holiday Inn-University Centre (Mid-Town):
* Bagels & Noodles – Breakfast, bagels, Vietnamese food for lunch and dinner. 1244 W. University Ave.
* Bistro 1245 – Good food, including vegetarian options, and great wine selections. Open till 11 PM on weekends. 1245 W University Ave. (352)376-0000.
Burrito Brothers – Fast, good Mexican food made to order from scratch. Open 7 days a week from 11:00a.m. to 10:00p.m. 1402 W. University Ave. (352) 378-5948.
Caribbean Spice -- Inexpensive, lunch only. 1121 W. University Ave. (352) 377-2712.
* Chipotle Mexican Grill – Fast food. Gourmet burritos and tacos. Open Monday through Sunday from 11:00a.m. to 10:00p.m. 1421 W. University Avenue. (352) 372-5330.

Copper Monkey – Burgers and fries, mostly. 1700 W University Ave. (352)374-4984.
* El Indio – Fresh and quick Mexican take out. Breakfast, lunch, dinner. Open Monday – Friday 7:00a.m. to 10:00p.m.. Open Saturday & Sunday 9:00a.m. to 10:00p.m. 407 NW 13th St. (352) 377-5828.
*Gyro Plus – Great vegetarian menu plus gyros, falafels, hummus, etc. Good homemade desserts. 1011 W University Ave. Open Monday through Sunday 11:a.m. to 10:00p.m. (352)336-5323.
* Kabab House – A Pakistani restaurant. Great Indian dishes. All meat products are Halal. 1129 W. University Avenue. (352) 374-2114.
Karma Cream – Organic ice cream, frozen yogurt, shakes, coffee, desserts, beer. 1025 W. University Avenue. (352) 505-6566.
Krispy Kreme Doughnuts – Doughnuts, coffee. 310 N.W. 13th Street. (352) 377-0052.
* Leonardo 's 706 – Italian/creative cuisine restaurant, nice atmosphere, great food and wine selections. Good vegetarian options. 706 W University Ave.(352)378-2001.
* Leonardo's Pizza by the Slice – A popular pizza/pasta/coffee place. Good vegetarian/vegan options. 1245 W University Ave. (352)375-2007.
Mother's Pub & Grill – Burgers and usual pub menu. Good food. 1020 W. University Ave.
New Wok – Cheap Chinese cuisine. 421 NW 13th St. (352) 336-6566.
Papa John's Pizza – Pizza, calzone. 1133 W. University Ave.
Planet Smoothie -- Smoothies and shakes. 1620 W. University Avenue. (352) 377-9400.
*Reggae Shack Café -- Great vegetarian options in a café with lots of character. Open Monday through Saturday from 11:00a.m. to 10:00p.m. 619 W. University Avenue. (352) 377-5464.
Relish – Hamburgers and hot dogs. Open until midnight. 1702 W University Avenue.
Subway – Hot and cold sandwiches. 1000 W. University Ave.
Swamp Restaurant – Wide variety menu – something for everyone. Inside and outside dining. Open Monday through Saturday from 11:00a.m. to 2:00a.m. and on Sundays from 11:00a.m. to 11:00p.m. 1642 W. University Ave. (352) 377-9267.
Taco Bell – Mexican fast food. 826 W. University Aveue. (352) 373-2949.
Tatu – Sushi and Asian fusion cuisine. 1702 W. University Avenue. (352) 371-1700
Tijuana Flats Burrito Company –Mexican menu with great hot sauces. 1720 W. University Ave. (352) 692-3093.

Downtown Gainesville:

Amelia's – Traditional Italian cuisine with elegant outside seating. Reservations recommended. 235 S Main St. (352)373-1919.
**Dragonfly – Trendy atmosphere specializing in sushi and saki. Reservations recommended. 201 SE 2nd Avenue. (352)371-3359.
*Emiliano's Café – Caribbean restaurant with great tapas & brunch. Great outdoor seating. 7 SE First Ave. (352)375-7381.
Harry's Seafood Bar & Grille – Cajun-style food. 110 SE 1st St. (352) 372-1555.
Harvest Thyme – Good soup/salad/sandwich lunch spot. 2 W. University Ave. (352)384-9497.
Liquid Ginger – Huge and flavorful menu offering a range of Pan-Asian cuisine. 101 SE 2nd Place. (352)371-2323.
** Manuel's Vintage Room – Fine dining – Italian food and fine wine from around the world. 6 S. Main St. (352) 375-7372.
* Mark's US Prime – Fine dining. Expensive. Great steaks and wide variety menu. 201 SE 2nd Ave. (352) 336-0077.
Maude's Classic Café – Indoor and outdoor favorite of students. Coffee and desserts. Good vegetarian/vegan options. 101 SE 2nd Pl. (352)336-9646.
* Paramount Grill – Gourmet eclectic international menu. More expensive. 12 SW 1st Ave. (352)378-3398.
* Panache Bistro at The Wine &Cheese Gallery – Soup/salad/sandwich place with good wine and cheese (of course) with a nice back patio. 113 North Main Street.(352)372-8446.
Starbucks – Coffee. 207 SE 1st St. (352)374-8227.
** The Top - Creative, varied menu, good beer selection, funky, eclectic atmosphere. Serves food until 1am. 30 North Main Street.
**Stubbies and Steins – huge beer selection from around the world and good food (bar food, German food, a generally a few fancy specials)
** Volta - great hand poured coffees, gourmet teas, desserts, good background music, modern coffehouse, wireless. Open 8am-9pm(?). 48 SW 2nd Street.

Taxi Services

A1 Yellow Cab	(352)374-9696
Best Way Cab Company	(352)367-8222
Gainesville Cab	(352)371-1515
Unimet Taxicab Co.	(352)380-0830

For your notes: