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5th International Conference on Industrial Ecology

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Chapter 1
Keynote Speakers

Leith Sharp

Organizational Change Management for Sustainability

Abstract

The global environmental imperative requires us to undertake more change, innovation and transformation across all of our institutions than we have ever before achieved. This presentation will engage conference participants in thinking about the frontier of change management for sustainability, addressing everything from planning, building construction, renewable energy and purchasing, to governance, finance and accounting, leadership, capacity building and systems thinking. The primary case study for this exploration will be Harvard University and its 10 year effort to transform itself into a global leader in campus sustainability.

Short Bio

Leith Sharp has a bachelor of engineering (environmental) from UNSW, Australia and a Master of Education (human development & psychology) from Harvard University. She has 18 years of experience in greening universities, beginning her career as an elected student union environment officer before being employed to create the University of New South Wales Environmental Management Program in 1995. In 1999 Harvard recruited Leith to become the founding director of Harvard's Green Campus Initiative. Over the next 9 years Leith worked to build the largest green campus organization in the world funding this effort largely on the savings it produced, employing over 23 full time professional staff and 30 part time students, bringing Harvard to the forefront as a global leader in campus sustainability. Specific achievements include over 50+ LEED building projects (mostly Gold or better), a $12 million revolving loan fund achieving an ROI of 30%+, wide scale engagement in occupant behavioral change, onsite renewable energy, a significant GHG reduction commitment, alternative fuels for vehicles, green cleaning, environmental purchasing and much more.

Leith instructs two courses offered through the Harvard Extension School, Organizational Change Management for Sustainability and Sustainable Buildings: Design, Construction and Operations, and has consulted and presented to over 100 organizations. Leith sits on the governing committees and editorial boards of numerous organizations dedicated to greening higher education including AASHE and the International Journal of Sustainability in Higher

Education. Leith has received numerous awards for her work including a Churchill Fellowship and Young Australian of the Year, NSW Environment Category.

Leith recently left her position at Harvard to engage in a range of writing, teaching and consulting activities and can be contacted via lsharp@hsph.harvard.edu or leithsharp@yahoo.co.uk

Jan Rotmans

Short Bio

Jan Rotmans is the scientific director of DRIFT. In September 2004 he established the new research institute DRIFT: Dutch Research Institute For Transitions and received a position as full professor in transitions and transition management at the Erasmus University Rotterdam.

Jan Rotmans is one of the founding fathers of Integrated Assessment and an expert in the field of integrated modelling, scenario-analysis, indicator-development and uncertainty-analysis and –management. He created the IMAGE and TARGETS Integrated Assessment Models. In the nineties, he was involved in quite a few innovative activities in the fields of climate change & global change research, integrated assessment modelling and sustainable development research (sustainability science). In the field of scenario-development, he directed the European VISIONS-project for the European Commission, DG-XII. The last few years, he has focused his research on the further development of the concepts of transitions and transition management. He is scientific director of the Dutch Network on System Innovations: Transitions to a Sustainable Society (KSI), which in 2004 received a grant from Dutch government of 10 Million Euros. He also leads the big European MATISSE-project of 7 Million Euro that deals with the development of new tools and methods for assessing sustainability in Europe.

From 1998 till 2004 he was director of ICIS: International Centre for Integrative Studies, at Maastricht University, that he founded in 1998. From 1992-1997 he was part-time professor Integrated Assessment at the University Maastricht. From 1995-1997 he worked as scientific advisor for the Commission on Sustainable Development (CSD) within the Division of Sustainable Development. Before that, he worked for ten years at RIVM (National Institute for Public Health and Environment). He was initiator of the scientific journal 'Environmental Modelling and Assessment', and he is initiator and editor-in-chief of the international scientific journal 'Integrated Assessment' and editor of several scientific journals. He is initiator of the Global Modelling Forum for Sustainable Development, vice-chairman of the European Forum on Integrated Environmental Assessment (EFIEA), and vice-president of TIAS: The Integrated Assessment Society. From 1994-2000 he was vice-chairman of the PIK-Institute in Potsdam, and from 2004 he is a member of the Supervisory Board of the Tyndall Institute in Norwich, UK.

Jan Rotmans has more than 200 publications in the field of climate change & global change modelling, sustainable development, and transitions and system innovations. He has given numerous

keynote lectures all over the world and attended numerous conferences and workshops. For his PhD-research he received the SNS-prize, and in 2003 he received the IIAS-Award, on behalf of the International Institute for Advanced Studies in Systems Research and Cybernetics.

Robert Socolow

Climate Change and the Industrial Ecology of Carbon

Abstract

The industrial ecology research community should consider itself part-owner of carbon management for climate change mitigation. Life-cycle analysis leads to a focus on flows of carbon from below ground in fossil fuel extraction, the transformation of reduced carbon to oxidized carbon during energy extraction, and carbon "disposal" in the atmosphere or elsewhere. Flows of carbon among reservoirs in the atmosphere, on land, and in the ocean interact with these anthropogenic flows. Conceivably, commercially viable technology for carbon extraction from the atmosphere will emerge, if carbon flows into and out of the atmosphere command a high price.

Short Bio

Robert Socolow is a Professor of Mechanical and Aerospace Engineering at Princeton University. Socolow's current research focuses on the characteristics of a global energy system responsive to global and local environmental and security constraints. His specific areas of interest include carbon dioxide capture from fossil fuels and storage in geological formations, nuclear power, energy efficiency in buildings, and the acceleration of deployment of advanced technologies in developing countries. He is the co-principal investigator (with ecologist, Stephen Pacala) of Princeton University's Carbon Mitigation Initiative (CMI) www.princeton.edu/~cmi/, a fifteen-year (2001-2015) project, supported by BP and Ford. Pacala and Socolow are the authors of "Stabilization wedges: Solving the climate problem for the next 50 years with current technologies," which appeared in the August 13, 2004 issue of Science.

Socolow is a member of two current committees of the National Academies: The Committee on America's Energy Future and the Committee on America's Climate Choices. He was a member of the Grand Challenges for Engineering Committee of the National Academy of Engineering. He was the editor of Annual Review of Energy and the Environment, 1992-2002. In July 1997 he co-chaired the Workshop on Fuels Decarbonization and Carbon Sequestration, sponsored by the U.S. Department of Energy. In 1995, he was a member of the Fusion Review Panel of the President's Committee of Advisors on Science and Technology (PCAST). In the l970s and 80s, he directed a team of physical scientists, engineers, architects, statisticians, and behavioral

scientists in a series of unique research projects on energy conservation in housing. With John Harte, Socolow co-edited Patient Earth (Holt, Rinehart, l97l), one of the first college textbooks in environmental studies.

Socolow has a B.A. (summa cum laude) and a Ph.D. in theoretical high energy physics in l964 from Harvard University. He was an assistant professor of physics at Yale University from l966 to l97l. He is a Fellow of the American Physical Society and the American Association for the Advancement of Science. He was awarded the 2003 Leo Szilard Lectureship Award by the American Physical Society: "For leadership in establishing energy and environmental problems as legitimate research fields for physicists, and for demonstrating that these broadly defined problems can be addressed with the highest scientific standards."

John R. Ehrenfeld

Industrial ecology: Moving beyond technological innovation to culture change

Abstract

Besides providing concepts for much improved production systems, industrial ecology can also guide a transition to sustainability by changing key cultural beliefs and norms. More efficient production cannot alone alter unsustainable patterns of consumption. Sustainable consumption requires a shift in cultural values and beliefs. Extending the ecological metaphor that shapes the field to incorporate complexity can interrupt and shift what are now normal, but unsustainable, practices.

Short Bio

Dr. Ehrenfeld is currently Executive Director of the International Society for Industrial Ecology. His research focus is sustainability and culture change. He is the author of Sustainability by Design: A Subversive Strategy for Transforming our Consumer Culture. He currently serves on the Council of the Society for Organizational Learning. He retired in 2000 as the Director of the MIT Program on Technology, Business, and Environment. In October 1999, the World Resources Institute honored him with a lifetime achievement award. He received the Founders Award for Distinguished Service from the Academy of Management's Organization and Natural Environment Division in August 2000. He holds a B. S. and Sc. D. in Chemical Engineering from MIT, and is author or co-author of over 200 papers, and other publications.

5th International Conference on Industrial Ecology

2009 ISIE Conference

Chapter 2
Platform Presentations
Designing Sustainable Cities

Designing an Optimal Urban Community Mix for Aquifer Thermal Energy Storage

Ryan Zizzo, Christopher Kennedy, Alan S. Fung, Bill Wong, Bernie McIntyre

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"Underground thermal energy storage (UTES) is a technology that makes use of the thermal capacity of soil bedrock and groundwater as a storage medium. It can be used for inter-seasonal storage to store heat during the summer and use it in the winter and vice versa for winter chill. It has been used extensively in Europe and is becoming more recognized throughout North America. UTES is promising because it can store energy for long periods of time to better meet demand using less fuel. This was demonstrated in Okotoks Alberta where a new development utilizing UTES meets approximately 90% of energy requirements using heat which is stored underground and used throughout the year. UTES usually supplies the majority of the energy base load while fossil fuels mainly natural gas are used to supply peak energy loads. Therefore for UTES to be most effective peak demand must be decreased and a flatter energy demand profile must be created.

To reduce energy demand variation an optimal building-type mix must be found. Energy requirements vary significantly over time among different building types. The annual energy demand profile for various building archetypes including detached residential attached residential office institutional and commercial was modelled using the Energy-10 building energy simulation program. The results were then verified by comparing them with actual energy-use data. These profiles were combined to create an optimal community building-mix which results in the flattest collective energy demand profile.

This ideal building-mix can greatly reduce the need for natural gas auxiliary energy systems and their associated greenhouse gas emissions. Until now incremental improvements in energy efficient buildings and load shifting have aimed to reduce peak energy use. This new idea of using the intrinsic differences in various building-type demand profiles represents a system innovation which could result in significant energy savings."

Metabolism of building and infrastructure in Japan: Scenario analysis and implications for future waste and carbon management

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“Building and infrastructure stocks are considered to represent a reserve for future wastes and secondary resources as well as a carbon pool of wood. In this analysis future metabolism (i.e. flows and stocks) of construction materials such as sand gravel stone steel and wood were estimated based on dynamic modeling for Japan to elucidate: (1) the future demand and supply of recycled construction materials and (2) the future carbon stock in building and infrastructure. A scenario analysis was conducted based on predictions of population and several other factors that are expected to affect future demand for construction in Japan. From those results the following conclusions were drawn: (1) The amounts of future construction and demolition wastes were estimated to increase even though considerable amounts of input construction materials (ca. 70%) were estimated not to emerge as wastes. (2) An imbalance in the supply of and demand for recycled crushed stone will likely occur in the near future if an expected decline in future road construction occurs. (3) The future carbon stock in building and infrastructure is expected to decrease concomitantly with decreased population in Japan suggesting that wood used in building and infrastructure will become a carbon source.”

Hour by Hour Analysis of Greenhouse Gas Emissions for a Near-Zero Carbon Condominium Design

David Bristow, Russell Richman, Adam Kirsh, Chris Kennedy, Kim Pressnail

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“Energy conscious building designs represent an important avenue for reducing greenhouse gas emissions associated with building operation. As it stands the current method for measuring the building operation carbon footprint utilizes average greenhouse gas emissions rates from centralized grid electricity supplies in addition to historical climate norms. This traditional method ignores the impact of time varying demand and time varying emissions from peak electricity production and changing climate.

This research focuses on an hour by hour energy demand and greenhouse gas emissions analysis of a 105 unit five storey condominium building design planned for construction in the city of Markham Ontario (Canada). In an effort to reduce the carbon footprint of the building the design includes ground source heat pumps reduced air leakage rates through the building envelope a roof mounted photovoltaic array and vertical axis wind turbines. The hourly carbon footprint is processed in a building simulation using historical hourly climate data and historical hourly grid electricity production. The grid data is made available by the Ontario electricity grid operator while the weather data comes from a local weather station.

This paper presents the analysis results along with a comparison to the carbon footprint determined by using the traditional method. Results indicate that grid greenhouse gas emissions vary with a standard deviation of over 35% of the mean. The Greenhouse gas reduction from the photovoltaic array calculated from the hourly emissions factors is over 7% higher than the reduction calculated using the mean emissions factor.”

Urban Metabolic Profiles and Typologies

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“The biophysical inputs and outputs of a city required by its population and necessary for the maintenance and growth of its infrastructure are the subject matter of urban metabolism studies. The last decades have seen an increasing interest in the sustainability of urban areas which now contain more than half the world population. Metabolic information can provide valuable insights into the energy and resource requirements of a given urban area. While the urban metabolism concept has been used to study specific urban areas its applicability to sustainability analyses remains limited.

Metabolic information is potentially powerful analytically when it enables a comparison between different types of cities. In order to realize this analytic potential we propose two concepts: that of urban metabolic profiles and typologies. The context of our work is the EU project on Sustainable Urban Metabolism for Europe (SUME).

The metabolic profile of a city is determined by the specific composition and magnitude of its material and energy inputs and outputs. We derive metabolic profiles for cities and urban areas covering a variety of climatic conditions as well as levels of population density. Based on the comparison of metabolic profiles urban metabolic typologies are developed. The metabolic typologies enable us to classify diverse cities according to a few basic categories and to gain a deeper understanding of the driving factors of urban metabolism. Ultimately urban metabolic information may guide environmental policy choices for instance informing the current debates on cities’ contribution to global greenhouse gas emissions.”

Integrated agent-based decision-making modelling and spatially explicit material flow simulation. The Swiss recycling construction material market

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“Large and growing amounts of construction waste are produced annually in Switzer-land. Even tough in 1997 82% of the mineral construction waste in Switzerland was recycled the recycling rates differed significantly across regions ranging from 67% in the Canton of Basel City to 87% in the Canton of Valais.

In order to support policy and industrial decision-makers and give recommendations for a sustainable construction material management we analyze and model the supply and demand for recycling mineral construction materials (RMCM). In doing so we combine an agent based decision-making model of the RMCM demand with a regionalized material flow model of RMCM supply.

The analysis shows that the demand for RMCM is determined by four interacting agent groups i.e. contractors architects engineers and awarding authorities. Their decisions are based on various internal (e.g. personal experience image or social desirability) and external (e.g. material prices law norms and trends) decision parameters. The supply for RMCM is manly driven by the regional building and infrastructure stocks and their life cycles defined by the local construction reconstruction and demolition rates.

The main influencing factors for the RMCM demand model (decision parameters) and supply model (building and infrastructure stocks and flows) both show spatial differences. Considering a combination of the two models highlights that their influencing factors are mutually dependent on two levels on the individual level (e.g. personal experience depends on the utilized materi-als in construction) as well as on the regional level (e.g. RMCM prices depend on the local construction waste flows).

We present and discuss an integrative modeling approach which captures both the spatial variability of the main influencing factors and their interdependencies on the individual and regional level.”

Greening roofs for sustainable development of compact tropical cities

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“As an exceptionally compact city Hong Kong attempts to adopt the sustainable development mode. Urban greening offers a feasible way to attain environmental sustainability. With seven million population concentrated largely in 200 km2 of land the urban public open space provision at merely 3 m2/person is usually low. High-rise buildings with barren flat rooftops and facades are seldom employed to introduce nature into the vertical dimension. Numerous hardly serve any useful purpose. Besides providing outdoor amenity and recreational spaces green roofs can bring significant cooling and amelioration of the urban heat island effect especially for the tropical city. The scientific aspects of establishment and the environmental benefits need to be ascertained in the context of the humid-tropical regime. An extensive green roof was retrofitted on a four-storey building at the University of Hong Kong in 2006 denoting the first research green roof in the city. It covers 240 m2 of four plots planted respectively with turfgrass (Zoysia tenuifolia Korean Velvet Grass) groundcover vine (Arachis pintoi Perennial Peanut) and shrub (Duranta repens Golden Dewdrops) plus a barren control plot. Environmental monitoring equipments with data loggers were installed at the plots. The objectives of the study were to evaluate: (1) growth performance of the three vegetation growth forms at the rooftop habitat (2) evaporative cooling of air temperature (3) surface temperature reduction (4) thermal insulation effect and (5) heat flux to the indoor space below the roof. Significant reduction in surface and below green roof temperatures and energy conservation were recorded with about 15oC drop at summer midday for turfgrass and groundcover and more so for shrub. Top floor indoor temperature was reduced by about 2oC under the vegetated plots. The research offered valuable findings and practical experience to establish and maintain extensive green roofs using different vegetation types.”

Expansion of infrastructure networks in growing cities and the future demand for material stocks

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“Networks of technical infrastructure shape modern cities and are major deposits of in-use materials. The growth patterns of infrastructures therefore have significant implications for material use and potential availability of scrap once these infrastructures or parts of them reach the end of their life. However such growth patterns are hardly understood. In this presentation we explain a first attempt to understand the evolution of infrastructures in terms of the services they provide to the users and the material stock they incorporate. Infrastructures are networks that are often structured hierarchically with each stage dedicated to a specific purpose. As an example consider different classes of roads in the transportation network of a city. In the first step we account for topologies of infrastructure networks that is the physical arrangement of connections between nodes such as road junctions or pipe branchings. The work focuses on tree-shaped networks with a centre using the urban water and wastewater system in Norwegian cities as a case study. For different topologies we provide measures for the service provided by each stage and relate this service of the network to the demand drivers which in this model are the population the population density and several lifestyle indicators. The aim is to provide a complementary model to the one which has been used successfully to model residential buildings and to characterize cities as a whole irrespective of the depth of detail to which information is available. Based on the correlation of the historic development of the population density with the growth of networks we estimate the future demand for service and the materials in stock according to spatial growth scenarios for cities.”

Evaluating the usability of green buildings

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“This paper is about problems such as the energy-saving programmable thermostat that no-one can program or the adjustable window blinds that once closed against the sun’s momentary glare are not re-opened for weeks because users forget about them. Building occupants and operators are failing to use some green building features properly with adverse environmental and economic consequences that threaten the market success of the green building movement.

To generalize like other technologically-optimistic industrial ecologists green builders are systematically attempting to introduce eco-innovations into a very conservative industry. In proposing better ways to do things green designers promote cutting-edge technologies and system configurations however some of these solutions are better labeled “immature” and others are not very user-friendly. This paper investigates reasons and ways to elevate usability as a green design criterion.

Post-occupancy surveys of green buildings provide empirical insights into the usability question by giving voice to building occupants and operators. These surveys coupled with behavioral observation provide valuable feedback to designers about what works well and what does not. The surveys can also be used to enhance building information models by allowing more realistic representations of occupant and operator behavior. This paper pushes that particular frontier.

The paper shares illustrative models of engineered systems in buildings (using a system dynamics formulation) coupled with realistic models of occupant and operator behavior (using an agent-based modeling formulation). This modeling framework highlights the implications for overall building performance of realistically heterogeneous occupant preferences and the bounded rationality of both operators and occupants. The framework provides an improved basis for identifying “behaviorally-robust” designs and design principles.

This work was funded by National Science Foundation grant 0725503.”

Urban MFA with sector and spatial resolution. The case of the Lisbon's Metropolitan Area

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"Urban areas are characterized by a concentration of economic activities a high demography and large material stock densities inducing considerable energy and material flows which are associated with potential ecosystem impacts.

Material flows accounting (MFA) characterize the material consumption of a system for a certain base year - corresponding to a static analysis of material flows - but also permits evaluating trends of material consumption of the economic system by developing time series. It can thus be considered a tool that provides simultaneously data disaggregation and a timely response allowing for the characterization of the dynamics of an economy metabolism.

In an earlier study a Lisbon Material Balance based on EUROSTAT methodology was prepared for the Lisbon Municipality (LM). The main purpose was to establish a generalized methodological framework to depict urban areas relying on published data by the National statistical office. The methodology was developed in a way so that it could be applied to different cities at least in the European Union countries due to the standardization made by Eurostat.

In this paper we extend this methodology to the scale of the Metropolitan Area (AML). A comprehensive accounting of the aggregate flows into and out of the Lisbon Metropolitan Area (AML) is performed. This results in the collection and processing of data on the inputs outputs domestic extraction sinks (landfills) and additions to stock as well as losses such as dispersions to the environment hidden flows pass-through flows and any other physical flows of the AML. The material flows are distributed among activity sectors such as households industry commerce buildings infrastructures services leisure and culture based on time-resolved data for AML from 2000 to 2005. This paper results in a new method that is applied to a case study providing two different dimensions in an urban MFA - spatial resolution and activity sector's distribution - and its relevance for city planning is discussed."

Unified methodology for evaluating sustainable consumption options in an urban metabolism context

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“Urban areas constitute a key challenge for sustainability both because of the growing population that they attract worldwide and as they host the major economic activity in any country. As a consequence there is a growing interest in analyzing the Urban Sustainability which has stimulated the development of different methods studies and monitoring schemes but comprehensive methods that may provide an integrated approach covering cities from a systemic point of view are not available.

The Urban Metabolism approach based on energy and material flows of the interrelations between the economy and the environment may provide a framework that can contribute to fill this gap.

In a more detailed analysis it is clear that within the Urban Metabolism framework special attention has to be given to the role of households and their critical contribution for the overall material flows within a city. As such there is an opportunity to develop a methodological framework that may characterize the household sector providing the tools to properly manage their material flows.

This paper discusses the relevance of different methods and tools such as Material Flow Analysis Input-Output Tables Life Cycle Analysis Consumers and commodities statistics and Market studies and Consumption clustering in order to promote a better understanding on how the existing methods and tools can be used as different components of a new model. This paper offers a new model that can describe Urban Material flows and provide valuable information for municipal planners in their effort to design more sustainable cities”

Evaluating the Sustainability of Urban Development Projects: The Case of Lisbon Municipality

Samuel Niza, Paulo Ferrão

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“The growing awareness of the global environmental and social burdens of contemporary cities has generated great interest in strategies for the design and planning of resource efficient urban centers.

But while several multicriteria methods were developed to evaluate the sustainability of buildings (e.g. LEED BREEAM or the LiderA in Portugal) very few were developed to asses higher scale projects in the city like new settlements.

Based on the “LEED pilot system for Neighborhood Development” a team at the Lisbon Municipality developed a Sustainability Assessment System for Allotments and Block Plans.

The system is based on a checklist organized in two sections – Efficient Location and Urban Design - involving an overall 23 evaluation credits (including Air quality and noise Public transport demand management Energy Efficiency Urban retrofitting Accessibility etc.). Similarly to the LEED system each credit is organized in one or more scoring requirements.

In the first phase of its implementation the system will only be used to evaluate plans of municipal initiative (mainly block plans). But in the future the system will also evaluate private initiative plans and allotments. The evaluation process involves filling a grid scoring and commenting each credit. After a report is produced and delivered to the team of the plan with the comments and improvement suggestions. Concerning private plans the system can also be used to choose the best proposal in terms of sustainability when several promoters compete for a project.

The checklist was tested in several recently developed plans of the municipality and the main results will be presented. The innovative issues of the system are highlighted and an evaluation of the strengths and weaknesses is developed.”

Partners in Project Green – Canada's largest employment area goes Eco-Industrial

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"Partners in Project Green is a new initiative in the Greater Toronto Area that aims to apply the principles of industrial ecology to create North America's largest eco-business zone. Partners in Project Green is tackling one of the largest challenges facing cities worldwide – how to keep industrial operations and jobs while striving for sustainable communities.

The Partners in Project Green region includes over 12000 hectares of industrial and commercial land surrounding Lester B. Pearson International Airport Canada's largest and busiest airport. Each year businesses in the eco-business zone area consume 109 million cubic meters of water while buildings in the area consume approximately 5.8 million MWh of electricity 46 million gigajoules of natural gas and generate 1.7 million tonnes of carbon dioxide emissions.

This session will provide an overview of the process followed to develop an eco-industrial strategy for an area comprising 4 municipalities an airport authority a conservation authority 12 500 businesses and 350000+ employees. The process included extensive consultation and stakeholder engagement analysis of municipal planning and policy tools and innovative use of geographic information systems (GIS) technology to analyze business resource consumption utilize municipal data and characterize the area. In developing the strategy partial eco-industrial performance measurement and benchmarking was completed for the area's 23 industrial parks the strategy recommended a more detailed and structured benchmarking exercise in the next phase. Other recommendations included targeted by-product synergy strategies long-term district energy systems service-based symbiosis and collaborative eco-efficiency and green building efforts."

Energy for Melbourne: Past Present and Future

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“This paper presents data from the recent history (1961- 2005) of operational energy demand and supply for the City of Melbourne the major urbanised area of the State of Victoria Australia. We discuss the historical path that has led to the current state of energy consumption and planned or foreseeable scenarios of the future. Since 1961 Melbourne’s demand for energy has more than tripled even while the business of the city has moved away from industry towards the service sector. We suggest this is driven by increases in the size of the total population (75%) and the space occupied by residential areas (265%) and also by changes to the energy lifestyle of Melbourne’s inhabitants represented in per-capita energy requirements which have more than doubled (220%). Following World War II Melbourne’s population and economy expanded rapidly and this coincided with increased automobile ownership. Early planning strategies allowed for geographical expansion further entrenching automobiles as the dominant mode of personal transport. The legacy of that era is a dispersed city which today has an area twice the size of Paris with only 2/3 of the population. Historically Melbourne has been dependent on local brown coal for electricity production and the State of Victoria has increased its coal-powered generation capacity over the last 40 years both in absolute and relative terms (the fraction of electricity generated using coal has increased from 75% to 96%). While this has locked-in coal dependence for some decades to come an increasing component of total energy needs is being provided by natural gas and renewable sources. In addition to global drivers such as climate change and peak oil there are several local factors that may affect demand: plans for higher density living near distributed activity hubs eco-sensitive new buildings retro fittings and a nationally implemented emissions trading scheme.”

Evolution of regional industrial metabolism: a case study in Suzhou of China

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“China has begun implementing a strategy named circular economy since 2005 which tends to restructure the current economy into a high resources and energy efficiency one with an ambitious object that energy consumption and pollution emission per GDP should decline by 20% and 10% in 2010 than that of 2005 integrated policy was adopted to achieve this goal in regional level. This study aims to investigate current urban industrial metabolism and identify the affection of the mentioned strategy on promoting a sustainable city. Suzhou city as a major manufacturing center and a typical export-orient city was chosen as our case. With the panel statistics data in 2007 a profile of regional material flow through the industrial system was clarified to character the current industrial metabolism. Further more 5-year time series data since 2003 was collected which was analyzed to clarify the potential policy relevance in general. Interviews to more than a hundred local enterprises institutes and government officials were carried out between 2007 and 2008 local major industries including electronics manufacturing ferrous metal production non-ferrous metal production and textile manufacturing were studied deeply which gave us detailed information about how the macro strategy affected micro enterprises in production energy using and waste recycling. Some suggestions on the strategy were given according to the results.”

Developing Industrial Ecology tools for the measurement of urban metabolism: a case study

Maria Christina Fragkou, Xavier Gabarrell, Teresa Vicent

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“Based on the Material Flow Accounting (MFA) methodological guidelines presented by Eurostat in 2001 two methodologies have been developed with the aim to measure equivalent important aspects of urban sustainability from a metabolic perspective water and Municipal Waste (MW) management. The first one complements MFA and accounts for all artificial water flows of a system referring to the water flows consisting of piped and drained water input and output related indirect flows are also considered corresponding to water losses in the distribution networks. The second methodology describes efficiently the flows of Municipal Waste (MW) not only within but between neighbouring municipalities as well. Accordingly two indicators have been suggested for the measurement of urban sustainability on these issues.

A water use sustainability indicator is proposed based on the system\’s demands in terms of water and the renewable water it receives in the form of rainwater.

The indicator suitable for the revision of MW management strategies is in line with basic waste management principles and reflects the capacity of a system to manage the amount of MW it accepts and the grade of sustainability of the treatment practices followed within the system valuing as the best option the use of residues as prime materials.

The two methodologies are applied in five (5) highly urbanised municipalities in the coast of the Barcelona Province in Catalonia. In this work we present the derived values for the two indicators for these municipalities along with their energetic profiles for a period of 5 years.

Based on these results Barcelona the neuralgic commercial and industrial centre of the greater coastal region is compared with the other four peripheral municipalities. Employing basic socioeconomic indicators and the urbanisation characteristics of the studied cities issues of resources management policies and environmental justice are investigated.”

Conservation of resources by reusing building components

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“As a part of material culture buildings have to support human needs. But because of their static nature obtained through design most contemporary buildings and their components have a negative impact on their surroundings. The huge quantities of waste produced during demolition and the still rising emission of greenhouse gases created during use of the building manufacture and waste treatment of its components are environmental indicators of an inefficient and unhealthy design.

Reusing building components is an effective way of conserving embodied resources materials as well as energy in a life cycle perspective. However this will require innovative design strategies which anticipate an eventual demolition and provide versatile and adaptable constructions.

This paper shows how the HENDRICKX-VANWALLEGHEM design approach provides constructions and their components with the necessary reuse qualities. These are different from most existing building solutions since they are not designed to deliver an end-product. On the contrary a multitude of adaptable configurations is realised using a minimum number of different components. Like in a Meccano building set the components can be reused in other configurations as a result of the formulation of geometrical standardisation rules.

To monitor the environmental load of such Meccano-like designs an assessment method that focuses on the conservation of natural resources and energy in a life cycle perspective is detailed in this paper. The technical constraints and environmental benefits of the H-V design approach are discussed through a case study i.e. a temporary construction.”

Analysis of the relationship of industrial structure change and environmental impact in Kawasaki city Japan

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“Industrial structure as one of factors in determining the relationship between economic growth and environmental pressure is important. In Japan both serious industrial pollution problems that people experienced before and waste issues which are happening now are linked to Industrial structure.

In this study to quantitatively highlight the factors of regional environmental improvement and to provide numerical targets for reducing environmental pressure on a regional level and industrial sector level we focus on the effects of industries on the environment in the process of the structural change of industries in Kawasaki city.

Firstly we analyze the relationship between economic growth (GDP and PFC) and environmental pressure (SOx NOx emission and water consumption and waste generation) in Kawasaki city over the period 1963-2007 by decoupling procedure. Secondly to show the detailed relationship between economic growth and environmental pressure we highlight the effects of three factors (technological and industrial change and economic growth) on environmental pressure in eight main industrial sectors by effects analysis. Thirdly we discuss the factors that lead to environment improvements such as environmental and industrial policies and external factors and evaluate environmental measures by the administration or enterprises. Lastly we use IPAT formula to calculate the rates which the environmental pressure indicators of Kawasaki city and industrial sectors should attain in order to achieve absolute decoupling.

The main conclusions are as follows. Firstly the relative decoupling happened between GDP and SOx NOx emissions and water consumption in Kawasaki city during 1996-2007 while waste generation was linked to economic growth especially in several heavy industrial sectors such as steel industry chemical industry and service industry. Secondly some environmental and industrial policies are successful such as the technological change policy and eco-town policy. Thirdly to decouple the economic growth and environmental pressure Kawasaki city should focus on the improvement of energy efficiency and the reuse of wastes particularly for five industrial sectors.”

Using Foundation Species to Enhance the Resilience of Urban Service Profiles

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"Urban systems are now the primary nodes of physical social and economic organization. As concentrators of resource capital there is a growing need to manage the mobilization and metabolism of materials associated with the infrastructure systems necessary to support service provision within these complex urban networks. It is possible to use a combination of material flow analysis (MFA) and geospatial statistics to characterize the spatial distribution of materials at the household-level. By extending the ecological metaphor employed in industrial ecology to consider the identification of foundation species within urban systems important service configurations across the urban landscape can be defined. A foundation species "defines much of the structure of a community by creating locally stable conditions for other species and by modulating and stabilizing fundamental ecosystem processes."(Dayton 1972, Ellison et al. 2005). In urban systems foundation species can be determined based on their relative abundance and impact on resource availability. Proxies for aspects of social capacity were combined with descriptors of the built environment materials stocks and historic risk exposures to identify service demand configurations that exhibit foundational characteristics across the United States. Principle component analysis (PCA) was used to select a subset of unrelated components that explain the majority of variation amongst components related to the demand for infrastructure services in urban areas. Clustering methods were applied to these nonstandardized components to define a number of classifications or foundation species within urban areas based on historical hazards.(Grabher 1993 Asheim et al. 2006) Implicit in the consideration of urban foundation constituents and urban infrastructure resilience are dynamic spatial and temporal boundaries. Examination of the foundation species within urban agglomerations can facilitate planning for selective senescence and renewal through the identification of opportunities for the introduction of transformative alternative technologies in the event of a natural disaster."

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Eco-Design: Products and Services of the Future

The assessment of ecodesign application using the Analytic Hierarchy Process: a case study in three furniture companies.

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“This paper presents a case study in which the assessment of ecodesign items application was performed based on a multi-criteria decision support method the Analytic Hierarchy Process (AHP). The assessment took place in three furniture companies. A methodology was developed considering that the application in other industries is available. First a theoretical framework about ecodesign concepts and practices were made. After a focused group with a multidisciplinary team with specialists in eco-conception and furniture manufacturing was made and the constructs able to represent the top term ecodesign was established. The constructs are: materials components products and process characteristics use of energy products distribution and stocks packaging and scraps. Each construct was deployed in items. Using a AHP with a multidisciplinary team from each company the ecodesign constructs were weighted and the relative importance for each company was defined. At the end a questionnaire was answered by the team from each company in order to check the performance of each item. By comparing the assessed performance with the relative importance of each ecodesign constructs it is possible to prioritize strategies for environmental improvement related from eco-conception.”

Eco Design in Malaysian Industries: Challenges and Opportunities

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“Malaysia has long established manufacturing industries as one of main source of nation’s economy. Malaysian manufacturers have long demonstrated a strong global market presence but that is now threatened with growing pressures from tighter environmental regulations stronger green consumerism demand and decreasing natural resources due to the lack of implementation of sustainable manufacturing practices. This paper attempts to investigate the current state of ecodesign implementation and local driving force in local Malaysian industry. The pilot study conducted through interview survey has shown that the current state of implementation and awareness among local industry is fairly low. The soft approach of the local legislation does not contribute much towards seeing a major change in attitude as will be discuss further in the paper. The above two concerns are major challenges that requires immediate attention. None the less there seem to be growing concerns from the industry and the government that pushes the need for options that could leap frog the current situation. This present an opportunity for the local research community to come up with various strategies that will be discussed. The approach from early intervention as well as end pipe solution will be discussed and its contribution towards sustainable manufacturing practices examined. Finally the paper would propose a more comprehensive strategy which is tailored to local business environment in order for the local industry to be capable of maintaining its market presence.”

Dealing with unknowns – How to optimise nano material production

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“Nanotechnology is seen as the key technology of the 21st century which initiates (in a certain way) a new industrial revolution with forecasted tremendous impacts on industry society and environment. Not all properties of nano materials are even identified but in many visions the possible advantages in applications are well discussed. Already over 800 nanotechnology consumer products as well as a growing number of industrial products are on the market due to the technical advantages. From a life cycle point of view the consequences of these products are less investigated and understood.

Nanotubes belong to a new material group with very promising technological properties like tensile strength (by low weight) good electric and heat conductivity. Using filtration techniques of carbon nanotubes dispersions free standing papers can be produced. This paper consists of 100% multi walled carbon nanotubes meaning without any supporting fibres.

Carbon nanotube papers referred to as bucky papers are attracting a growing attention in different disciplines and application fields. The production of bucky papers is still considered to be too elaborate and costly for a broader application. Additional there are limitations for the size of producible bucky papers.

In the presented approach Life Cycle Thinking is used to optimise the manufacturing process of bucky papers by the consideration of technical but also economic and ecological aspects.

For a decision support to identify the most promising optimisation option a qualitative assessment is conducted which also considers potential nano particle emissions.

The result provides crucial information for the upscale of bucky paper production which is essential for a broader application in the future.”

Eco-Design by Natural Materials: Jute Fibers

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“In developing countries design innovation associated to sustainable design is getting the best strategy to improve companies and to keep up their products and process to expand the market share. To promote this there is the necessity to make industrial products and processes more sustainable based on social environmental and economical factors and its boundaries. Nowadays a lot of companies and people look and perceive industrial products besides their look and perform in fact they are asking about all its life cycle how they are made and how are disposed of. So is very important the designer’s role to increase awareness regarding to the social and environmental problems in developing societies.

According Edwin Datschefski (2001) by analyzing the materials used in a product we can make a significant environmental improve but some times change materials doesn’t mean the best environmental act. In fact change materials also can mean negative environmental impacts if so its employment in industrial products needs to be analyzed by Life-Cycle approach into Eco-Design context. Since design phase is too important to entire life-cycle of products LCA approach since the beginning of project can improve de decisions make of companies.

In this context the present work shows the inclusion of the environmental factors in the beginning of the development of projects through the management of materials. Its goal is to analyze and cover the study of environmental advantages and mechanical behavior of composite materials reinforced with renewable resources of vegetable fibers. After that the results are compared with usually used industrial composite material (Fiberglass – GFRP) highly pollutant. The composites were studied according to ASTM methods and by Simapro (LCA). All specimens used in practical tests were manufactured by Resin Transfer Molding (RTM) process in which regarding to technology was necessary to achieve new setup procedures to produce green products different from those already used to produce fiberglass components due to the particularity of vegetable fibers.

Although the lower mechanical properties of jute fiber than fiberglass the results pointed out them as great solution to promote technical environmental and economical improvements in industrial products by Eco-design concepts. They also showed social advantages such how important are that materials to achieve sustainable incomes for small communities in Brazil and then avoiding rural exodus.”

Strategic perspectives on ecodesign practice in small to medium sized manufacturers

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"Over the last decade there has been an evolution in environmental policies related to products and materials. Emphasis is now given to preventative strategies and integrated approaches to sustainable consumption and production. Ecodesign as a strategic design management process takes into account key environmental and social impacts throughout the life of a product or service. Ecodesign is currently high on the policy agenda because a proportionally high degree of environmental and social impact of products is determined at the design stage.

This paper aims at providing empirically-based insights into strategic and operational perspectives on ecodesign practice in small to medium sized manufacturers. The paper is based on case study data originating from 12 month national ecodesign demonstration projects in Wales UK. The rationale behind the ecodesign demonstration projects is that SMEs face significant barriers when implementing ecodesign and existing market and policy mechanisms have been inadequate in increasing ecodesign implementation.

While placing the activities in the broader manufacturing context the paper will use single company case study data to explore specific issues for the opto-electronics sector. The investigation will include a characterisation of design-led businesses from the opto-electronics manufacturing and service sectors undertaking product development projects when environmental performance requirements could be considered. The purpose of the paper is to inform a methodological framework for future capacity building activities with these businesses and the wider sector."

Technology selection for improvement of fuel economy across an automaker's vehicle fleet

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"Despite recent decreases in gas prices improving fuel economy remains a key goal in vehicle design for automakers. Not only do the manufacturers have to meet increasing CAFE standards in the coming years they also have to ensure their vehicles align with consumer preferences. Complicating this objective though are the numerous technology options automakers have to choose from as well as the many vehicle model designs each automaker has to modify—often years in advance of their market release dates.

To address this selection decision we developed a multi-product multi-period technology selection model designed to identify a portfolio of preferred technologies for implementation on a fleet of vehicles over the coming years. The model employs a genetic algorithm to identify which technologies best enable an automaker to satisfy CAFE as well as optimize profit based on estimated consumer preferences for fuel economy. Since the selection decision takes place over time time-dependent effects such as learning curves for new technologies are incorporated into the model.

We illustrate this model with a simple case in which an automaker has to decide when (if at all) to implement four generic technologies on its three vehicles over a time span of four years. Model results indicate that net revenue can be improved when the four years over which the technology selection decisions take place are considered collectively rather than as four independent periods with a selection decision made for each period."

Comparison of Traditional Retail and E-commerce Logistics for Electronic Products

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“Consumers now have the option of driving to a traditional retail store or shopping on-line for many products. US E-commerce has grown from less than 1% of retail sales in 2000 to 3% in 2008. The alternative retail channels have some distinct differences. Retail stores have over-stock inventory and physical store spaces with environmental costs. However the individual packaging and last mile delivery are energy intensive for e-commerce. Similarly bulk packaging and primarily truck delivery can reduce energy use and cost for traditional retail but individual consumer trips account for significant CO2 equivalent emissions. We use Life Cycle Assessment (LCA) to quantify these variations using data received from the e-commerce industry for electronic products and building on prior logistics LCA research. This paper reviews our LCA detailed analysis provides conclusions and offer recommendations to decrease logistics LCA uncertainties.”

Green by design: Conceptualization of a smart materials database for designers

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“Design has a crucial role in the creation of a strong sustainability. On one hand it is recognized as a tool for market-oriented value creation in companies on the other hand a sustainable society asks for a social learning process where different forms of creativity knowledge and organizational skills will be valued. Design can act as a trandisciplinary facilitator that integrates companies’ visions with consumers’ desires and needs guiding and materializing a new material culture and mentality. To play this role designers need tools. This paper specifies a database for material selection with environmental concerns by designers. In our culture material objects we possess became indicators of our perception of well-being. Materials matter. Material selection is not only reflected in the technical performance of a product but also in what a product reflects as an object of desire and life style aspirations. Therefore materials selection is an innovation tool and one of the most important aspects in the product development process. Designers have specific needs of information due to their singular way of problem solutions learning style and work habits. This separates them from the classic engineering and so tools to this profession must be created within these considerations. The database aims to cover a big part of the gaps detected in most of the ecodesign tools in literature. It is an open participatory and dynamic methodology which seeks to incorporate environmental issues in the selection of materials in an intuitive easy and effective way. The presence of technical social environmental aesthetic and sensorial profiles of materials complemented with inspirational and educational information results in an innovative tool. Tools that help designers to optimize their work can be drivers of their role as actors of change giving them more time and freedom to creatively look for new solutions that help change paradigms.”

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Environmentally Extended Input Output

The Interregional Waste Transportation Model for the Compilation of Interregional Waste Input-output Table

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“Waste treatment issue is closely related to economic and social structure of each local region. It may frequently cause frictions among local policies of various regions. Then it is important to develop some analytic tools to support policy making to accommodate such frictions by considering the public weal of the whole society.Interregional waste input-output (IR-WIO) analysis is one of the powerful tools to analyze the economic activities and waste emissions simultaneously (Nakamura et. al. 2002 Takase et. al. 2002 Urabe 2001 and Tsukui 2004 2007). In our previous work we compiled IR-WIO table of Tokyo however we didn’t sufficiently consider the environmental loads and the inputs of goods services and energy that were necessarily accompanied with the waste transportation between regions. In this study we shall try to improve the estimation method of waste treatment model of our previous work and then construct a waste transportation model with more practical and detailed assumptions than the preceding study (Kagawa Kondo 2007). From the related statistical data we can grasp the flow of waste between prefectures in Japan and find that most of those wastes are for landfilling. We can also obtain the information about measure means of waste transportation i.e. by truck or ship. Based on those practical data we construct a waste transportation model which can be applied to the estimation of IR-WIO table with improved waste treatment sub-model. In the model we first estimate the input and the environmental loads of each region. Then we apply the waste transportation model to estimate those inventories accompanied with the waste transportation between prefectures. After that we estimate the amount of waste to landfill and summarise the inputs and the environmental loads in each region.”

Searching for the frontier of emission reduction: A linear programming model based on wastewater treatment IO model

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“This paper proposes a linear programming model to search for the frontier of emission reduction of the wastewater treatment system. The model can be considered as a decision analytic extension of the wastewater treatment Input–Output model. Then the model was applied by using Tokyo Metropolis data. In a space with landfill volume GWP and BOD as its x-axis y-axis and z-axis respectively a frontier of emission reduction the points on which are not strictly dominated by any other was given by using this model. Finally the model was used to discuss the effects of application of high temperature incineration. The results obtained shows that the application of high temperature incineration can bring the frontier of emission reduction nearer to the origin.”

Global dimensions of sustainable growth in Europe

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“The paper presents results of the petrE project that will finish in June 2009. PetrE is a three-year project one of four funded by the Anglo-German Foundation as part of its “Creating sustainable growth in Europe” research initiative. Analysis is based on the extensive and disaggregated GINFORS model that explicitly contains 50 countries and two regions and their bilateral trade relations energy balances macro-economic and structural data including input-output tables. Material input models are based on a global material extraction dataset. GINFORS is closed on the global level.

GINFORS is applied to analyze the impacts of major environmental tax reforms (ETR) and the EU ETS to reach the EU GHG reduction targets until 2020. The ETR includes a carbon tax for all non-ETS sectors and a material tax. Scenarios look at unilateral EU action and at international co-operation of all OECD countries and the major emerging economies. The paper will focus on the global dimensions of more sustainable growth in Europe investigating the implications for world-wide patterns of natural resource extraction and of production trade and consumption and the policy implications.”

An automated data handling protocol for environmentally extended input-output models

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“A common problem in compiling and updating input-output models especially large multi-regional input-output (MRIO) models is that of incomplete data. Missing matrix elements may be due to a variety of reasons such as costly and therefore incomplete industry surveys the suppression of confidential information or simply classification changes. Further handling data in a number of different classifications or including external data points can quickly become confusing and messy.

Significant time and effort is put in by analysts in order to get data into a useable format – often by using bi-proportional scaling methods such as RAS on subsets of a large system. Instead we describe here an automated data handling protocol developed at the University of Sydney specifically for handling input-output and associated data.

The three components of the system include the initial estimate of the full system in all its generality a variable length list of constraints describing relationships between sub-components of the system and between sub-components of the system and external data sources in any classification and an optimisation routine. Generating the list of constraints is often the most onerous task and we describe methods undertaken to simplify and generalise these efforts.

Such a framework is very flexible and easily expandable. Time series applications adding trading partners including additional primary inputs etc all become straightforward within the general architecture of the framework.”

The EU Integrated Project (IP) EXIOPOL

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"The EU Integrated Project (IP) EXIOPOL (A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis) has been set up by FEEM and TNO under the EU's 6th Framework Program. It has a budget of 5 Mio Euro and runs between Spring 2007 and 2011. A key goal is to to set up an environmentally extended (EE) Input-Output (I-O) framework with environmental extensions in which as many of these estimates as possible are included allowing the estimation of environmental impacts and external costs of different economic sector activities final consumption activities and resource consumption for countries in the EU. The EE IO part is supported by many well known European players from the IE community such as NTNU Wuppertal Institute and CML

The EE I-O work in project forces scientists that worked on rather separate fields such as IO analysis (IOA) Material Flow Analysis (MFA) and Life cycle assessment of products (LCA) to organise their approaches and data in a unified framework. Where in theory such unified frameworks have been developed (e.g. SEEA UN et al 2003) EXIOPOL is probably one of the first projects that integrates data on such a broad scale. In this paper we want to discuss the architecture of the project This paper discusses the architecture of the proposed database and our experiences and proposed solutions for problems related to integrating data and indicators systems that have been set up using different conventions (FEEM&TNO 2006 Tukker et al. 2007).

In the scoping phase of the project a great number of choices has been made. This paper introduces the project indicates the scoping choices and provides the 'big picture' of the project. Subsequent talks in the EE IO session by the EXIOPOL team will go in more depth into key activities in the project (transforming/harmonizing SUT and IOTs gathering extensions linking SUT and IOT via trade the development of a relational database system and how the database can be used for policy applications and used with models). Other talks in the EE IO sessions have been sollicited from other projects working on EEIO with as implicit hope that IESIE can contribute to a joint global effort across such EE IO projectsin producing a true global database."

Environmentally extended input-output tables (EE-IO) at the regional level – a case study for the Flemish region of Belgium

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“The presentation will discuss the process of composing environmentally extended input-output (EE-IO) tables for the Flemish region of Belgium with a focus on the environmental extension part.

As in most countries a monetary input-output table is available at a national level in Belgium. However since the three regions in Belgium are fully competent for their environmental policy there is a need for a regional IO table including environmental extensions.

We first developed a regional monetary IO table for Flanders with a dimension of 117x117 sectors. Next we developed an environmental extension table consistent with the regional monetary IO table. Conversion tables to move from a national to a regional IO table and to link this table with environmental data for different industrial sectors were elaborated and a method for integrating the various modules was designed. As a result the core of the Flemish EE-IO table is ready and we now moved to the second phase of the project in which we gather more detailed environmental data about i) non-Flemish production (i.e. the environmental pressure related to imported products) and ii) the final consumption (i.e. the environmental pressure related to the consumption of goods and services produced in Flanders).

In a third and final phase of the project the EE-IO model will be made fully operational and a user-friendly software tool will be developed in order to simplify the use of the model and the process of updating data. It is expected that the full version of the model will be operational by 2010.

The presentation discusses the development of EE-IO tables from a regional perspective and includes a discussion of the commissioner’s (government) objectives the cooperation between and the integration of knowledge of experts of different research fields (economic and environmental sciences) the data inventarisation (with a focus on the environmental data bottom-up versus top-down) the bottlenecks and opportunities to develop a consistent EE-IO model. In addition we will present the approach for integrating into the model information about the environmental pressure of non-Flemish production (imports) and the (non-industry) consumption matrix as well as the method for including data on resource use in the environmental extension tables.”

Modeling the emissions of characteristic electricity consumption profiles of various customer groups in the EU

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“Input-output (IO) models become a useful tool for environmental analysis when they can accurately be used to model the problem formulated by the practitioner. A better understanding of impacts from the production and use of electricity using Environmentally-Extended IO analysis can be achieved if detail is increased in the models. For electricity consumption one of the challenges is that different consumers such as households services or industry have different characteristic profiles of power demand on a daily and seasonal basis. While some industries operate with a roughly constant electricity demand other consumers such as the services sector consume most of their electricity at peak demand hours. Differences in demand profile and contracts will result in differences in the price and the power mix consumed by each type of customer. Here we contribute to understanding these issues in the context of IO modeling. First we provide increased detail for electricity production by disaggregating the generation technologies: coal gas nuclear hydro wind and others (including biomass and waste) as well as transmission and distribution. The disaggregation presented here has been developed for use in the EXIOPOL multiregional (MRIO) database and the work will focus on European countries. We provide a quantitative analysis of how consumption of peak and off-peak electricity by different customers affect LCI results for electricity consumption by different customers. Finally we provide a qualitative discussion of power imports and how they affect the consumption mix for European countries. Previous work has been done in this topic but for the US. We will also discuss challenges of modelling capital investments in the power sector using IO models.”

Creating a global environmental database for input-output applications

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“The main objective of the input-output related cluster in the EXIOPOL project is to develop an Environmentally Extended Input-Output (EE I-O) database linked through international trade and extended by environmental data on the sectoral level. The database covers the EU-27 and its most important trade partners (16 additional countries covering over 90% of the global GDP and over 80% of the imports to the EU). Environmental extensions are divided in the two broad themes Natural resources (inputs into the economy) and Residuals (outputs from the economy) and will cover the following categories: material extraction land occupation energy use water use and emissions to air soil and water. For all countries considered in the EXIOPOL database the team will prepare sectoral environmental data which will be attached either to the corresponding monetary flow data in the supply-and-use tables (SUTs) (in the case of products) or as physical extensions to these tables (in the case of primary resources and emissions). This paper presents ongoing work in the development of the database module on environmental extensions. For each category of environmental extensions we present the number of disaggregated categories and the main data sources used. We discuss the main limitations imposed by availability of primary data and levels of disaggregation when applying the data in an input-output framework. We discuss how primary data is transformed into a sectoral matrix structure and how data is integrated into the overall EXIOPOL database. Finally we provide an outlook towards how the created EE I-O database can be applied in the future to calculate environmental indicators in a world-wide context including among others indicators on global warming acidification nitrification and indicators on the use of materials energy land and water.”

The Ecological Footprint as a Sustainable Development Indicator: Critical Review and Connection with the System of Integrated Environmental and Economic Accounting

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"The ecological footprint provides "a measure of the hectares of biologically productive area required to support a human population of given size" (OECD). This is an evocative indicator: were they shared by all world inhabitants the consumption modes in Québec (Canada) would require about three planets. Based on a literature review the study examines the relevance of the ecological footprint as a sustainability indicator.

The interpretation of the ecological footprint as a sustainability indicator is not straightforward. It excludes qualitative changes to the stock of natural capital such as the accumulation of pollutants in the biosphere and the loss of biodiversity. On the global scale it defines sustainability as staying within the carrying capacity of the planet and hence represents a minimum requirement for sustainable development. On the country or regional basis the ecological footprint can only help to assess the equity of consumption among regions.

The policy objective underlying the ecological footprint – to reduce human appropriation of biological productivity - is of little use to decision making. Moreover the weighting factors allowing for the conversion of physical units to hectares are arbitrary relative to social preferences. Besides reducing the ecological deficit of a population may suggest orienting development towards autarky. Specifically the methodology of the Global Footprint Network (GFN) lacks in transparency since the accounts it is based on are protected by a licence.

As an alternative to the GFN methodology the input-output approach based on the System of national accounts (SNA) makes calculations more robust. This approach helps link the ecological footprint measurement to more generally accepted frameworks such as the System of integrated environmental and economic accounting. The input-output method makes it easier to analyze the variation in ecological footprint according to changes in various industries and hence makes the ecological footprint more relevant for policy analysis."

A Consistent Set of Environmentally-Extended Supply and Use Tables bridging Monetary Transactions and Material Flows: Experiences and Opportunities of the EXIOPOL Database

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"The continued use of MFA and LCA to analyze increasingly complex supply webs requires increasingly sophisticated databases describing the relationships between a wide variety of products and processes occurring in many different countries. To enable future industrial ecology studies to build upon past experience it is necessary to improve models and data structure.

The use of input-output models together with environmental data is generally accepted as a method for reducing cut-off error associated with process-based life cycle inventories [1]. Hybrid IO-LCA models are becoming increasingly common in published LCA studies [2]. In many environmental policy assessments environmentally-extended input-output databases are already used directly to calculate the economy-wide social environmental and economic impacts of proposed policy.

Here we provide experiences in creating a global multi-regional input-output dataset describing flows of products between industries and consumers. The dataset based on national-level supply and use tables for the EU27 and other major world economies is created as part of the EU FP6 project 'New Environmental Accounting Framework using Externality Data and Input-Output Tools for Policy Analysis (EXIOPOL)' [3]. By coupling these economic transactions data with environmental emissions and material use the EXIOPOL database provides a valuable background database for MFA and LCA studies.

The EXIOPOL supply and use tables include 130 product/industry sectors for 44 countries. To reach the desired level of detail use tables created by national statistical offices are disaggregated using statistics published by the International Energy Agency [4] Food and Agriculture Organization British Geological Survey International Labor Organization United Nations [5] Eurostat [6] and other international statistical institutes. Flows of energy and materials are incorporated in the EXIOPOL database both in monetary and physical units. Here we discuss the assembly disaggregation and balancing of the EXIOPOL supply and use tables and the opportunities they offer for advanced analysis of material flows and environmental impacts associated with societal consumption."

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Degrees of truncation: When are multilateral trade linkages significant in multiregional input-output analyses?

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“Researchers in many countries have used input-output analysis to quantify the environmental impacts (e.g. energy greenhouse gases water) embodied in their consumption and/or trade. Traditionally researchers have relied on single-country input-output models and have assumed that greenhouse gas emissions associated with imports are the same as if they had been produced domestically (known as the domestic technology assumption DTA). While the method of multi-region input-output (MRIO) analysis has been long established applications have been infrequent because of limited and inconsistent global datasets. With the recent development of consistent global datasets MRIO has been used in several studies to quantify greenhouse gas emissions embodied in imported good and services. It has been reported in the literature that a full MRIO analysis is unnecessary and that only single international trade linkages are required to capture the majority of imported emissions. However there is little information available on which to base a decision whether to use DTA or full MRIO. This paper uses the GTAP-based MRIO model of Peters et al. (2006) to determine the approximation error introduced in the estimates produced by the simpler methods compared to those produced by MRIO for each country/region in the GTAP database.”

Virtual Global Carbon Network Supporting Japan's Economy: Application of Global Link Input-Output Model

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"Today's globalized national economies are embedded in structures associated with high CO2 emissions both domestically and internationally. At the same time measures to reduce these emissions are set to be introduced increasingly around the world. This study considers the policy implications of these two concurrent trends by focusing on the structural relationship between a country's economy and the global CO2 emissions it induces.

World input-output models are useful for measurement of CO2 emissions generated outside a country by that country's production and consumption. They have been widely used worldwide. One advantage of using world input-output models is that they help identify CO2 emissions from foreign production activities induced by consumption of a particular country's products. Constructing data that describe domestic and international transactions of goods and services nonetheless involves serious challenges. There are not many countries and production activity sectors that can be considered realistically in the world input-output system. In particular development of detailed data for countries producing oil and mineral resources upon which Japan relies for a large part of its imports proves to be a complex task. Conventional world input-output models are incapable of facilitating the analyses that involve such countries.

Taking Japan as a case study the study develops the Global Link Input-Output (GLIO) model and uses it to calculate the CO2 emissions of the global supply chain network supporting Japanese household consumption. Also the GLIO model identified the global virtual carbon network formed by Japan's economy by focusing on the embedded CO2 emissions of the global supply chain network."

Embodied carbon emissions in a multi-regional input-output model

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“In the modern world economy value chains are often long and cross borders.

Under these conditions environmental damage such as greenhouse gas emissions that contribute to global warming is often generated at a specific location in order to provide revenue and satisfy consumer demand located elsewhere in the world.

In this paper we try to quantify the displacement between the actual location of greenhouse gas emissions - and we shall focus specifically on CO_2 (or carbon) emissions - and the location of the economic beneficiaries of those emisisons.

This is achieved by computing embodied carbon emissions the sum of direct emissions that take place throughout the life cycle of an economic flow and which can occur upstream and downstream of the flow.

We compute carbon emissions using a global multi-regional input-output (MRIO) model. An input-output (IO) model divides the economy into a finite set of economic sectors and lists the economic transactions between them. By linking economictransactions and direct carbon emissions data it is possible to compute the embodied emissions of economic flows.

We obtained the source data from the GTAP database which reports economic transactions for the year 2001 for a set of 87 world regions and 57 sectors per region and also reports carbon emissions resulting from fossil fuel combustion in an auxiliary document. We processed this source data in order to build the full MRIO model.

We reported carbon responsibilities of world regions and observed that small open economies can have carbon responsibilities that strongly deviate from direct emissions. We reported carbon intensities of economic sectors and observed that there is strong variability either across sectors in the same region or across regions for the same sector. “

Using Input-Output Models to Identify Carbon Risk

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“Industry executives are tasked with managing the risk their corporations face in developing new products and expanding operations. Increasingly this risk management extends beyond capital resources to include environmental and social concerns and specifically carbon emissions. However most industries tend to focus on their direct operations - the carbon emissions from their own facilities - rather than taking a life cycle perspective and recognizing the indirect emissions that occur in the supply chain.

Economic input-output (I-O) accounts show how industries interact specifically they show how industries provide input to and use output from each other to produce the gross domestic product. Leontief IO models are used to identify the industry sectors that make up the supply chain for a single industry sector with increased demand. In a reverse manner Ghosh IO models use the same economic IO accounts and relationships to identify how a given sector contributes to the supply chain of many industry sectors down stream. It starts with the input industry and estimates the top direct and indirect sectors that use that sector’s output in their own supply chains.

Ghosh models have been used to analyze critical infrastructure relationships in supply chains. For example electric power generation is dependent on supplies from the natural gas sector as fuel while at the same time the natural gas sector requires electric power to operate pipelines to deliver its product. A breakdown in the possible supply of output from either industry sector leads to cascading problems in the supply chains of numerous industries. Ghosh models can be used in a similar manner to identify areas of high environmental risk in supply chains. Our talk will explore the use of Ghosh models as an industrial ecology tool to identify critical supply chain paths such as those with high carbon risk.”

A Waste Input-Output Framework with Cumulative Product Lifetime Distributions and its Application

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“In Kagawa et al. (2006, 2008, 2009) we not only contributed to modeling a structural decomposition method with cumulative product lifetime distributions and a simple social accounting method with cumulative product lifetime distributions but also argued how product lifetime shifts of automobiles affect impacts of changes in final demand patterns on embodied energy consumptions but also income flow throughout the entire economic system. However the social accounting framework lacks waste treatment processes of scrapped automobiles and household waste productions affected by the product lifetime shifts. In this paper we not only proposed a new social accounting framework which includes the waste treatment processes of scrapped automobiles and the household waste productions following Nakamura and Kondo (2002) Kondo and Nakamura (2004, 2005) and Kagawa (2005) but also quantitatively examined the relationship among the embodied energy consumptions associated with the automobile production and automobile use landfill consumptions associated with the scrapped automobiles and income flow associated with the automobile production and disposals of the scrapped automobiles.”

Assessing impacts with a local perspective: a combined global multi-regional IO model pollutant diffusion through air and food and environmental health impacts.

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“Assessing environmental impacts of goods services and regions with Multi-Regional Input-Output models has lately attracted considerable interest. Accounting for the regional and not only global environmental impacts of current production and trade patterns requires however going one step further to also consider the effective trans-boundary transfers of pollutants on a large scale. We present here the final results of the TREI-C (Tracking Environmental Impacts of Consumption) project extending a world MRIO model with two ways of transferring local pollutants (air and food) and the resulting impact assessment on human health.”

5th International Conference on Industrial Ecology

2009 ISIE Conference

Industrial Ecology in Developing Countries

From industrial eco-innovation to circular economy: The application of industrial ecology in China

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"The conflict between from high input- low output productivity economic growth and the natural environmental depletion is becoming a bottleneck to China's sustainable development in the long term. This paper explores the opportunity to create harmony between economic development and environmental quality improvement via industrial ecology. To realize the ultimate goal of a circular economy it is necessary to integrate industrial eco-innovation ecological industrial park construction regional economy and environmental sustainable development. On industrial eco-innovation level traditional firms and industries need technology innovation and organizational transformation to realize green manufacturing and clean production on ecological industrial park level it is necessary to make effective and efficient use of materials and energy by forming industrial symbiosis network and industrial ecological systems to exchange by-products or wastes under the planning and guidance of industrial ecology principles on regional level the integration of economic social and environmental policies related to sustainable development will foster a circular economy.

A case study from Cangjiang eco-industrial park in Foshan region of south China is presented in this paper. We demonstrate that industrial eco-innovation and transformation can improve resource productivity reduce production cost and protect environment simultaneously. With the construction of Cangjiang eco-industrial park industrial symbiosis and wastes exchange reduce discharges of wastes and pollutants and monitoring data indicates that regional environmental quality also improved remarkably. The process of fostering a circular economy integrating industrial eco-innovation and eco-industrial park construction requires the involvement of enterprise government and public within a coherent policy framework. It is worth to note that the government regulations and industrial policy (such as tax financial support and subsidy) also play a key role in the fostering eco-industrial park development."

Development of circular economy in heavy pollution Industry Park — a case study in China

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“Development of circular economy is an important method in China for solving the bottle-neck problems between resource and environment. The legislation of the promoting recycle economy will be implemented in Jan. 2009. At present a group of recycle economy demonstrations have be started while the key is focused on the development of circular economy in heavy pollution Industry Park. Qingshuitang Industry Park in Hunan province is a typical chemical and metallic enterprises density region with lag technology and seriously pollution and it became a recycle economy demonstration in China.

Based on the typical case of Qingshuitang Industry Park the development mode of recycle economy in a high consumption heavy pollution and enterprises density region had been established. Through metabolism analysis of the important resource the bearing capacity of the resource and energy in this region has been investigated firstly and a indexes system for the development of circular economy was suggested. Moreover based on the key technology analysis integrated technological system scheme for the development of circular economy was also suggested. Finally three networks involving sulphur recycling utilization waste water recovery and minimizing discharge large-scale solid waste exchange have been constructed. And the industry ecological linkage network in Qingshuitang Industry Park was also proposed based on those networks. According to the above mentioned program it can be concluded that the resource utilization efficiency will be increased above 40% while the waste discharge will be reduced by 30% in this Industry Park.”

Eco-innovation in the emerging industrial ecosystems—the case of China

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“Eco-innovation referring the innovation contributing to the ecologically specified sustainability targets and/or the reduction of environmental burdens has received increasing attention recently. However our understanding is still limited on what eco-innovations happen in industrial ecosystems and how they contribute to the evolution of industrial ecosystems. This paper with four parts examines the eco-innovation in some typical industrial ecosystems in China including the Guigang cane-processing system the Lubei fertilizer chemical system and the Baotou aluminum production system.

The first part introduces what is eco-innovation and its underlying theoretical basis such as innovation economics and evolutionary economics. The second part describes what eco-innovations happened in industrial ecosystems including innovation creation acquisition integration as well as the supporting network formulation. The potential benefit of eco-innovation and what challenges in establishing industrial ecosystems are also identified. The third part discusses the co-evolutionary process and determinants of eco-innovations by examining complex interrelations between technological organizational and institutional issues. The last part gives policy implication and options on how to promote eco-innovation for industrial ecosystem.”

Material and Energy Use in Brazil 1970 - 2005

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“During the last decades the largest South American country, Brazil, has undergone a phase of rapid industrialization and is about to become a global player on a political and economic level. Brazil is characterized by a low population density and a high endowment with natural resources. Hence Brazil extracts a lot of resources and provides those on world markets. The metabolic profile of the Brazilian economy is characterized by a high share of biomass in overall material use and a comparatively low share of fossil energy carriers in primary energy supply. In reaction to the oil crisis Brazil has chosen an alternative path of energy supply. It was among the first countries that aimed at getting independent from petroleum imports and launched 1975 the PROALCOOL program which fosters the substitution of biomass based fuels for fossil fuels for transportation.

In order to understand the structure of the social metabolism of the Brazilian economy and the resulting pressures on the environment a comprehensive examination of material and energy flows is necessary. This presentation will highlight the changes in the biophysical and energetic basis of the Brazilian economy during the process of industrialization and the “valorisation” of the rich natural endowment in the period from 1970 to 2005. Apart from standard material flow indicators like domestic material extraction (DE) material use (DMC) and physical trade balances (PTB) I will focus on the linkages between material and energy flows and their contribution to domestic energy demand and exports.”

Collection point system to manage environmental impacts of informal reuse/recycling of electronics

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"International flows in end-of-life electronics has emerged as a new challenge for sustainability management. There are environmental challenges to address the environmental impacts of informal recycling in developing countries as well as to extend product lifespan. There are social and economic challenges to increase the availability of low-cost IT equipment in the developing world and to promote work opportunities. It is important to explore alternative e-waste policy approaches which attempt to realize triple-bottom line objectives.

We propose a new policy approach: eliminate environmentally damaging processes in the informal chain by paying recyclers not to process certain parts which cause the most significant environmental damages: circuit boards copper bearing wires and non-sellable waste. The concept of the new system is to set up three types of collection points in informal recycling areas. The first type collects circuit boards the second copper-bearing wires and the third takes unsellable residues. Informal recyclers are paid to bring material to collection points at a price set to create an incentive for informal recyclers to deliver parts rather than process on their own. Circuit boards are collected and sent to formal recycling facilities currently among the five advanced smelters in Europe Japan or Canada. Copper-bearing wires collected are sent to a formal wire chopping/separation plant. Unsellable residues are shipped to a properly managed sanitary landfill.

It is our working hypothesis that the main environmental impacts of informal recycling would be largely mitigated by this three tiered collection point system. We build an economic model of the overall system including labor processing and transport costs and revenues based on sales of recovered materials. Even if the economics of the collection points runs a net cost the overall economics of the overall reuse/recycling system could yield a net profit due of income generated through efficient reuse of machines and parts."

Transferring Japanese Urban Symbiosis Model to China

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“A distinguishing feature of Japanese eco-towns is urban symbiosis which refers to utilizing municipal solid waste as alternative materials or energy in adjacent industrial parks. Similar to industrial symbiosis urban symbiosis is based on the synergistic opportunity arising from the geographic proximity transferring “waste materials” to resource in production and creating environmental and economic benefits. Due to continuous resource depletion and environmental degradation in China it is appropriate for Chinese cities to transfer such an urban symbiosis model from Japan. However many challenges and barriers may exist to such a transfer. The potential for applying urban symbiosis in Chinese cities needs to be investigated in case studies. This study is one attempt by investigating Kawasaki in Japan and Shenyang in China. First the case of Kawasaki is introduced to identify several key factors for its success in industrial and urban symbioses. The potential of applying such a model in Shenyang is then analyzed with regard to the local realities. Several key aspects such as legislation and policies market demands for recycled products key recycling technologies environmental infrastructure and public awareness and participation will be examined in detail. Furthermore this study also proposes a simulation model to quantitatively assess the potential environmental benefits of urban symbiosis. The simulation model contains a database that includes GIS data social statistics data and technological inventories. By employing a life cycle assessment approach this model can simulate potential greenhouse gas emission reduction and landfill saving in Shenyang under various policy scenarios and therefore provides evidence and suggestions for decision making.”

Eco-Industrial Networking for Sustainable Development in Asia – A Review of Issues and Development Strategies

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“Achieving sustainability of systems needs to satisfy both the criteria of external and internal sustainability. While the subsets of the system viz. social economics and environment interact the resulting externalities define the degree of sustainability. Among the five basic components for sustainability viz. eco-sanitation eco-security eco-landscape eco-culture and eco-industry this paper addresses “eco-industry” component. Achieving eco-efficiency of production is guided by various exchange-principles and driven by certain socio-economic factors such as cost savings and competitiveness reduced infrastructure development cost revenue generation opportunity for new investments improved human resources and access to new technologies. This paper addresses all those factors that drive the development of Eco-industrial Parks and also identifies all critical strategies required at various levels of bureaucracy in order to develop a new or convert existing industrial clusters/parks in to eco-industrial cluster/parks. It concludes by addressing the same in the context of Asia and the relevance of EIP development in their quest towards sustainable development.”

Flows and Fates of Cadmium in the City of Cape Town

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“Examining the use and disposal of toxic substances forms an important part of resource and waste management. Through the use of material flow analysis (MFA) methodology this study undertakes such an examination for one toxic element – cadmium – in the City of Cape Town. This heavy metal is incorporated into a variety of consumer products. At the end of their useful lives many of these are recognized as hazardous wastes yet few effective channels exist for their special disposal. National and local studies in other countries – primarily in the developed world – have confirmed that this situation results in considerable quantities of cadmium being discarded with general waste especially arising from the use of nickel-cadmium rechargeable batteries. Results in the case of Cape Town indicate that environmentally significant amounts of cadmium are used of which the majority accumulates in the city economy and in its sanitary landfill stocks. Whilst most of the cadmium is likely to be immobilized under prevailing conditions in landfills for long time periods this disposal practice is still considered unsafe at least in terms of the precautionary principle. The existing link between landfill and agriculture – via leachate treatment and wastewater sludge use – provides a pathway for potential contamination the food supply. Additionally although there are signs that NiCd batteries are being phased out of many applications it is likely that a considerable cadmium stock remains both within the economy and within established landfills which must be considered with respect to future waste management choices.

The study primarily considers cadmium use as a hazardous waste issue in the city but simultaneously offers insight into the characterization of heavy metal metabolism within an African context where regulation and data availability are often constraints for integrated waste management planning and practice.”

Establishment and evolution of a facilitated IS programme in Toluca-Lerma Mexico

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“In 2008 a facilitated industrial symbiosis programme was established in the diverse heavily industrialized Toluca-Lerma region of the State of Mexico Mexico. The programme was modelled after the NISP programme in the UK under the auspices of NISP UK funded by the UK Defra Sustainable Development Dialogs programme. By sharing the best practice that been developed in the UK over the last 5 yrs the team was able to fast track and develop synergies in the Toluca area which has already resulted in reduced CO2 reduced materials to landfill reduced costs and increased revenues for its member companies. In this presentation the development of the programme will be described in the context of the industries in Toluca Lerma which include major international corporations and a mixture of small and medium enterprises. UK best practice was used to train local facilitators/practitioners. Initial synergies will be presented along with their quantified economic and environmental impacts. The role of critical stakeholders in launching the programme and getting regional and national buy-in will be described including the national trade associations national policy makers and regulators and the British Embassy in Mexico. The national environmental agency SEMARNAT was critical in establishing the programme and through its support has generated interest in the programme from 4 states beyond that initially funded. The regional programme in Mexico has already attracted interest from a variety of other Mexican states and other Latin American countries the Mexico programme also served as the model for a NISP based Brazil programme which started end of 2008.”

Waste data collection in developing countries: Connecting the social and the material dimension

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“Reliable information and data is necessary to identify challenges and take decisions regarding urban solid waste management. Particularly in developing countries information on solid waste flows often lacks the desired quality. Thus a basis for waste management in such regions needs to be created by a combination of different approaches to estimate solid waste flows. This paper aims to review such data collection approaches in the context of urban solid waste management in developing countries and discuss their strengths and weaknesses.

At first selected research projects dealing with urban solid waste management in countries such as Bangladesh Botswana and Vietnam are reviewed. The aim of these projects the type of data which were collected and how the data collection was conducted is investigated. Following this scheme also the author’s research carried out by researchers from University Banda Aceh (Indonesia) and Vienna University of Technology (Austria) is presented. In this research methods from natural sciences as well as from social sciences were applied to determine the material flows of Banda Aceh’s municipal solid waste management system. Afterwards the different data collection approaches are briefly discussed.

Research efforts aiming to investigate social issues and material flows are often handled separately which is also manifested by the research methods applied (approaches from social and natural sciences). If research methods from social sciences such as interviews and questionnaire surveys are applied in material flow determination the intention is to overcome the existing information deficit on the material dimension of data. For future research it is concluded to connect the material and the social dimension of urban solid waste management not only by applying one research method “to help the other” (e.g. methods from social sciences to estimate material flows) but also to draw conclusions in both social issues and material flows.”

Industrial Ecology in India – Past present and future

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“Given India’s rapid growth in population accompanied by recent increases in industrial activity we cannot deny or ignore the toll that both these trends have taken on our environment. India’s cities are getting clogged with solid liquid and gaseous pollutants and its forest cover and biodiversity have rapidly decreased over the years. While we recognize that efficient use of energy and materials is our only hope for a sustainable future it is also an economically viable option. Industrial ecology provides a platform to measure review and plan for future consumption of resources in the quest for economic and environmental sustainability.

Although this new and exciting field is still gaining familiarity in India there have been considerable efforts in applying concepts of industrial ecology to assess and better manage our resources. Since the task of sustainably managing resources for over a billion people in India is far from trivial we need to assess these efforts periodically to proceed in a manner that will enable our future. In this review we present recent progress in applying industrial ecology to manage India’s resources. We examine suggestions made by such studies that were followed in actuality and discuss shortcomings of those that failed to materialize. Through the presentation we take stock of progress in industrial ecology thus far in addition to assessing relevant challenges that need to be addressed in the future.”

EIP Development Strategies in Korea

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“Despite recent growth in Korea’s service industry and increasing sophistication in its industrial structure the manufacturing industry still makes up 28% of the nation\’s industries with strengths in steel automobile and shipbuilding manufacturing as well as in the petrochemical and electronic/ electric industries. Also Korea\’s companies have a higher level of dependence on industrial parks than other countries. For example the Companies located inside these industrial parks have made up 32.3% (as of 2001) of the total production of the nation which also accounts for 20% of total employment. Thus Korea has a great potential for EIP development thanks to its high intensity of traditional manufacturing-related industrial parks which may help to find various potential industrial symbiosis networks.

This paper has intended to provide an overview of achievements and analysis on relevant problems in Korea\’s demo-EIP projects and their implications and to present EIP development strategies in Korea based on the above analysis. Since 2005 when the first demonstrative EIP projects was launched in Korea through years of discussions and experiments the basic direction of the projects has become clearer but more discussion is needed to further clarify EIP\’s basic strategies. In present as the period of demo-EIP projects is finished it needs to sum up the results of the projects and to specify the strategies of EIP development in Korea for further stages. The strategies developed were divided into five categories such as resource circulation networks ecological spatial planning and development companies’ participation enhancement building cooperation system with regional society implementation and management systems.”

Material Flow Analysis and Strategic Environmental Assessment (SEA) toward a Public Policy EcoDesign

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“Since “Measuring Material Flows and Resource Productivity” (OECD 2008) and the “Material Basis of Industrial Economies” (WRI 1997) Industrial Ecology has been used to assess public policies development steps namely by supplying relevant information to precise measures application.

Considering the information production and its use at the screening and scoping of public policies the MFA represents a model for identification and assessment of societies’ metabolism directly related to productive system structure.

The material needs of each society can thus be quantified in relation to the identification and categorization of impacts including the complexities the support and point to possibilities of enhancing productive efficiency reducing the amount of inputs needed to produce desired economical social and environmental results.

The SEA (Strategic Environmental Assessment) on the other hand aims at strategic and integrated assessment of policies plans and programs using social environmental and economical data to produce relevant information for planning and decision-making.

This complex economic production of biodiesel represents opportunities of evolution once it can be analysed under the concept of industrial agro-ecosystems that evolved from Georgescu-Roegen (1968) and Odum (1988) studies on economic structures and their ecological assessment.

The integration of those tools can provide a sustainability strategy aimed at producing a type III industrial ecosystem (Lifset and Graedel 2002) at the soybean biodiesel production from Brazil which represents opportunities to enhance the informational and technological aggregation in this chain.

The Brazilian policy for biodiesel production was set by the law number 11097 from 2005 and was designed to provide a national strategy of development which goals were to introduce 2% of total amount of biodiesel needed to mix with diesel starting in 2008. In this year the Brazilian producers needed 840 million litters of vegetal oil production which had its main source on soy oil (80% of the total produced in 2008).

The oil production from soy is an economic activity that lies on large material inputs due to land use use of fertilizers and pesticides and intensive use of water with the undesirable outputs of pesticides and fertilizers run-off water pollution and biodiversity loss. The ethanol production

needed to produce the transesterification reaction is too highly energy and material intensive with the production of large amounts of residues.

Some of the by-products generated in those processes are being used to produce natural fertilizers energy by co-generation and animal fodder persisting the problem of soil loss water contamination and biodiversity loss. Those impacts must be considered in MFA-based policies and Strategic Environmental Assessments once they can represent a commitment for technological advances on Eco-designed integrated and complex sustainability policies including the Brazilian productive chains that affect territorial and social issues."

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Assessment of Sulfur Metabolism in a Chinese Fine Chemical Industrial Park

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“Like most developing countries planning of eco-industrial parks in China is undermined by lacking comprehensive quantitative assessments of core material and energy flows in the industrial systems. Examining industrial metabolism through substance flow analysis (SFA) can lead to a shift in priorities in environmental management from a traditional end-of-pipe perspective to more holistic systems-oriented perspectives that link the use of resources and emissions of polluting substances to their underlying causes and transformation processes. SFA can also help identify the potentials for improving eco-efficiency and forming industrial symbiosis. In the course of planning an eco-industrial park we carry out an in-depth SFA to elucidate the complex sulfur metabolism in the Zhejiang Shangyu Fine Chemical Industrial Park in China which is the world leading manufacturing base of disperse dyes. Sulfur plays an essential role in the dye synthesis processes in the form of raw materials reaction media and energy sources. Nevertheless sulfur only has a minor presence in the final dye products but causes serious soil water and air pollution. The sulfur inputs primarily include elemental sulfur sulfur-containing chemicals and fuel coal while the sulfur outputs mainly include sulfur-containing dyes and chemicals by-products such as potassium sulfate sulfur dioxide and other gaseous emissions industrial wastewater and sludge and industrial solid wastes. In 2007 over 33 percent of 189959 tons of elemental sulfur purchased as raw materials ends up in the solid waste landfill via industrial sludge and residues and Hangzhou Bay via industrial wastewater discharges. Although the sulfur-containing gaseous emissions are small in volume they result in severe public health hazards. The findings of the sulfur SFA assisted by the economic assessment of various sulfur-containing products and residues can shed light on the significant hidden costs of sulfur-containing residues as compared to their direct treatment and disposal costs. The results of the research can not only help company managers to refine their production and technology innovation strategies but also facilitate the industrial park authorities to improve their holistic environmental management system.”

Applying industrial ecology tools to demand-side water management in Bangalore India

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“For many rapidly industrializing regions the lack of a clean regular water supply is one of the greatest hindrances to economic growth and to increased quality of life. Issues related to water – its quality supply public access and level of treatment – often dominate development discourse and are the focus of countless projects by myriad actors. Cities in particular are quite vulnerable as they concentrate demand and often force reliance on expensive centralized systems prone to various types of disruption. The combined factors of population growth urban migration economic growth and climate change are set to constrain the water resources and infrastructure of many cities ever further. The fast-growing city of Bangalore India has particularly severe water constraints as the city is located far from its main surface water source. In order to understand and quantify the end-uses of water and the demand on local groundwater outside of the formal municipal system a general survey was conducted among different socioeconomic classes. By combining industry reporting data with survey results from more than 1000 residential and commercial respondents a material flow model was constructed as a water balance for the city. The results include those living in informal housing and slums and shows that overall per capita water use in Bangalore is well below the published target of the central government except for those in the very largest homes.”

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Industrial Ecology Tools for Sustainability

Selecting Industrial Ecology tools: strengths and weaknesses for use in a decision support tool

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"This study gives an overview of selected Industrial Ecology (IE) tools in current use by industry and that could be used to assess the environmental performance. The tools selected are considered to be useful for a decision support tool (DST) that takes a company perspective while considering environmental and economic aspects on the decision-making process.

We define criteria for a first selection of IE tools. The criteria are related to the usefulness of a tool in an analysis that: 1) takes a company perspective 2) includes environmental and economic aspects of decision making 3) includes a complete coverage of the potential environmental impacts and 4) allows for an assessment of the consequences of pollution reduction strategies. Based on the purpose of our DST together with the criteria we identified twelve tools. These twelve tools are reviewed with respect to their purpose methodology final product strengths weaknesses and relevance for an environmental analysis taking a company perspective.

Next we present the characteristics of the DST. These characteristics allow for identifying the IE tools that are a promising basis for the DST. These seven characteristics are: the tool considers a gate-to-gate approach the tool considers the processes within the company that are relevant for the assessment of the environmental impact the tool uses company specific data easily available from the process owner the tool considers up-to-date and company specific pollution reduction options the tool provides information on the cost-effectiveness of the reduction options the tool can be used to express the company's environmental performance in one overall environmental indicator and lastly the tool can be used to explore possible user-defined pollution reduction strategies.

Finally a selection of the tools that are useful for our particular DST is made. We conclude that a combination of the following seven tools is most promising: Life Cycle Assessment, Substance Flow Analysis, Multi-Criteria Analysis, Technology Assessment, Sensitivity Analysis, Scenario Analysis, and Cost-Effectiveness Analysis."

Analysing the Sustainability of Wood-Based Bio-refinery and its Supply Chains

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"This research pursues a vision of sustainable production of wood-based bio-fuels in view of the triple dimensions of sustainability. Political leaders policy makers and the public demand detailed information about the environmental social and economic impacts of any emerging technology and how it compares with existing mature processes. Thus the need for assessing the environmental economic and social sustainability implications of promising technology and product systems over their life cycles are inevitable such as the production of forest-based bio-fuels.

Sustainability involves recognizing interconnections among ecological social and economic systems and competing views of acceptable tradeoffs among them. Criteria and indicators are used to operationalize the overarching principle of sustainable development. Majority of the existing systems models for analyzing the impacts of biofuels have not considered the triple dimensions of sustainability and failed to integrate the different tiers of biofuel supply chains. The current research focuses on the development of a prototype systems model for life cycle sustainability assessment of biofuel technologies. The primary use of this model is to analyze the life cycle and long term environmental emissions energy and other resource consumptions of the wood-based bio-refinery system. Nonetheless social and economic aspects such as population increase growth in economy and employment are taken into consideration.

Sustainability of biofuel supply chain is modeled using a holistic approach such as dynamic system modeling. The interrelationships of critical variables are modeled over a finite time horizon. A suite of interlinking models for technology assessment in biofuel industry is being developed to integrate the entire biomass-to-hydrocarbons process. When a valid working prototype is created scenario analysis is carried out to assess whether the development and use of novel biofuel technologies can really contribute towards meeting the sustainable development of biofuel supply chains."

Carbon Performance of US Electricity Producers under different US Carbon Market Scenarios

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“As a result of changes in the business environment such as regulatory efforts towards a low-carbon society and market pressures resulting from recent price increases for fossil fuels carbon constraints are emerging that call into question companies’ traditional production and consumption patterns. Consequently appropriate carbon management becomes increasingly relevant for companies. Previous research analyzing and comparing the carbon performance of companies (e.g. by measuring their GHG emissions) mostly pursues a static approach consisting of assessing the companies’ current contribution to global warming. However only a dynamic view of corporate carbon performance can provide a holistic picture that combines firm characteristics with concrete emission scenarios.

Hoffmann and Busch 2008 have proposed a consistent set of four carbon performance indicators: carbon intensity carbon dependency carbon exposure and carbon risk. Based on these four indicators we suggest a carbon performance assessment framework for the comparative analyses of companies. We exemplify this framework in detail by applying it to the 100 largest US electricity producers. Based on two market forecasts and two corporate carbon strategies (a path-dependent and a low-carbon strategy one) we derive three carbon scenarios.

Our results show that with a path-dependent carbon strategy only a marginal improvement the companies’ physical carbon performance can be observed in a constant (BAU) as well as constraint business environment (CACO). A significantly improved physical carbon performance can be observed in the RENEW scenario which assumes that the companies switch to a low-carbon strategy when faced with a carbon constrained business environment. Furthermore when taking into account monetary effects the carbon performance picture becomes much more heterogeneous. We will close our contribution with recommendations for strategic management and climate policy.”

Hoffmann V.H. Busch T. 2008: Corporate Carbon Performance Indicators: Carbon Intensity Dependency Exposure and Risk. Journal of Industrial Ecology 12 (4) 505-520

A Comprehensive Approach towards MFA and LCA

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“As environmental protection and sustainable development gained increasing attention a variety of methods for environmental management have been developed. Two widely applied tools are Life Cycle Assessment (LCA) and Material Flow Analysis (MFA).

Both tools differ in terms of scope data and application patterns. LCA models the complex interactions between a product system and the environment and is used to quantify and evaluate these mainly on the micro level. Based on this information the environmental impacts of products can be distinguished. MFA typically does not focus on individual products but on the circulation of materials in one “area of need” and is usually applied for macro level questions.

While LCA offers a procedure that leads to recommendations for decision making relating to environmentally friendlier products MFA provides information about all flows and stocks of a particular material within a system.

Both approaches have weaknesses: So far most LCAs focus on a single piece of product. The effects of the whole population of the product are not included. But the future accumulation or depletion of material stocks and resources in the whole economic system is an important aspect and should be considered for achieving environmental sustainability. In contrast MFAs do not directly address environmental impacts of the examined material flows and provide no conclusion about sustainable resource throughput.

This implies that sustainable consumption requires a comprehensive approach towards LCA and MFA that goes beyond the separate application of both tools.

In this work the characteristics of LCA and MFA are analysed and compared. Additionally a new approach to integrate these tools will be outlined. The central purpose is the improvement of decision making support with respect to the sustainability of human activities. This is achieved by combining the methodological strengths of LCA and MFA.”

A Review and Database of National Sustainable Development Indicators - toward the next generation of sustainable indicator system

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"This study reviewed sustainable development indicators (SDIs) set by national governments and international organizations and examined what types of indicators were being used. This review covered 1541 SDIs of 26 countries regions and international organizations and compiled a SDI database with categorization of four large groups - environment economy society and institution - and 76 subdivided categories such as poverty and dependence work climate change water quality ecosystem economic performance business and industry energy use transportation environmental management and policy. The database can give answers to questions such as what kinds of data are considered as elements of sustainable development? what kinds of indicators are developed in certain fields? in which field is a certain indicator being allocated?

Four major issues were identified relating to development of SDIs through the review process:.(1) how to measure the quality of development (2) how to measure trade-offs between phenomena and leakages to other countries (3) how and to what extent are future generations considered in the system of sustainability indicators and (4) how to bridge a gap between national social capital and individual real life of citizens. In order to promote developing SDIs as well as settle these issues we designed a framework for SDIs of dual hexagons with a yin and yang symbol Taiji in the center representing the balance between current and future generations. A hexagon represents the three pillars of sustainable development (environmental economic and social) and three combinations between them. Two hexagons represent individual and national necessities for sustainable development. Then criteria for the selection of and categorization of SDIs were examined. Since April 2008 we have been exploring alternative SDIs. Several topics and remaining issues relating to the ongoing examination will be presented with slight emphasis on the context of industrial ecology."

The CALCAS scientific framework for New LCA

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“Within the EU-FP6-funding scheme the CALCAS project has focused on three major elements of LCA development:

1) deepening LCA that is adding more realism and sophistication in the LCA model such as dynamics economic behavior spatial detail

2) broadening LCA that is adding issues that are currently not addressed in LCA such as economic aspects social aspects biodiversity

3) better founding LCA that is making it less an ad-hoc model but connecting it more to established disciplines such as decision theory economics ecology.

Following the establishment of the ISO-standards for LCA many developments have taken place to deepen broaden and provide a foundation for LCA. To mention just a few examples scenarios have been proposed for a broader validity of the goal and scope specification economic elasticities have been proposed to improve the inventory modelling social indicators have been proposed in connection to LCA and muti-criteria tools have been applied for life cycle interpretation. Despite the good intentions of all these inputs they together result in a confused picture because the coherence of the approaches gets lost. An important part of the CALCAS project is therefore to design a framework for New LCA which accommodates new developments in a coherent and is more flexible manner than the framework for ISO-LCA. This presentation will sketch the basic features of the framework for New LCA show how it builds on the framework for ISO-LCA as well as where it deviates from it.”

Technological change in Swiss thermal waste treatment - A socio-technical appraisal

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"Technology is generally seen as both the root cause of many environmental problems while also offering the means for reducing environmental impacts associated with fulfilling societal functions. Understanding the relationship between technological change and the environment is a critical issue for sustainable development.

Waste management is considered a typical example of a socio-technical system fulfilling the function "eco-efficient socially accepted and convenient processing of consumed materials and products". In Switzerland technological developments have led to a high standard in municipal solid waste management primarily relying on separate collections and incineration in grate-firings. Nevertheless the incineration residues still end up in landfills severely contradicting the guidelines because of their inadequacy for unproblematic final disposal. Despite extensive discussions on solving this problem no alternative technology that is expected to perform better in terms of residue quality has reached the market yet.

The aim of the paper is to better understand the mechanisms underlying technological change in order to provide fundamentals for the governance of innovation-based transformations. We present a comprehensive socio-technical analysis of technological change patterns based on a multi-stage elicitation and structuring of the knowledge of 18 leading experts. The analysis considered the three levels generally used to describe socio-technical transformations i.e. technology development regimes and context – and all phases of innovation processes i.e. from stimulus to diffusion. The study identified a set of system elements that significantly affects technological change in general. These general results were subsequently related to three specific technology options representing different transformation types in order to deepen the insights about drivers and barriers of technological change in Swiss thermal waste treatment. The analysis generally showed that Swiss thermal waste treatment is technologically locked-in i.e. drivers of change are not strong enough to overcome the manifold barriers (technical institutional etc.) associated with a fundamental technology shift."

Exergetic Evaluation of Sugar Cane Sub-Products as Fuels in Brazilian Cogeneration Systems

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“The sugar cane is known as one of the most important Brazilian agricultural crops. Besides being in relief as a feedstock in the production of ethanol the biomass from sugar cane has been outstanding in the Brazilian energy sector due to its potential for producing electricity and heat in sugar cane industries. As one of the key tools for environmental evaluation exergy analysis allows the quantification and evaluation of the quality of energy available in particular cases. The goal is to figure out the specific exergies of the main atmospheric emissions during the combustion of bagasse and sugarcane straw and indicate the relationship between these fuels commonly used in cogeneration systems. The calculation is performed by correlating the exergetic value of these solid fuels with the moisture. The results shows that straw even with 15% moisture lower than the bagasse which owns 50% denotes almost twice of energy potential. The exergies obtained were 10.25934 kJ/kg and 20.48545 kJ/kg for bagasse and sugarcane respectively which indicate the workability of using sugar cane straw as a better fuel for boilers. The difference among those biomass sources can be explained by their net calorific values since straw has 15.17349 kJ/kg and bagasse 7.655 kJ/kg which make evident its use as an energy input in cogeneration systems.”

Materials Flow Analysis and Dynamic Life-cycle Assessment of Lightweight Automotive Materials in the U.S. Passenger Vehicle Fleet

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"U.S. passenger vehicles are currently responsible for nearly 70% of the nation's liquid fuel use and emit 18% of U.S. greenhouse gas (GHG) emissions. These impact figures are increasing and motivate policy efforts intended to curb them such as defining higher vehicle fuel economy standards. To achieve better fuel economy automakers are considering vehicle weight and size reduction as a possible strategy. This includes using lighter-weight materials better vehicle design and offering smaller vehicle models.

To consider the effectiveness of lightweighting it is important to take into account the dynamic life-cycle energy and environmental impacts. For instance primary aluminum one of the light-weight material candidates requires almost four times as much energy to produce than steel. Expected efficiency improvements in material processing would modify this ratio over time. Examining the impact of lightweighting on the overall vehicle fleet-level as opposed to a single vehicle-level also reveals insights on the timing and degree of the impact reduction.

The research presented explores: (i) the degree of lightweighting that is likely to be employed to meet fuel economy targets set for year 2020 and (ii) given scenarios of evolving vehicle characteristics in terms of their weight size and material composition the corresponding fuel use and life-cycle GHG emission reductions achievable on the vehicle fleet level. Spreadsheet-based models of the vehicle stock automotive material use and the corresponding life-cycle energy use over time from 1975-2035 have been developed.

By applying a dynamic approach to LCA in combination with MFA and scenario analysis the effectiveness of vehicle weight and size reduction to reduce impacts on a vehicle fleet system level is better understood. Future work is committed to identifying factors in the material production and vehicle design stages that are most sensitive to reducing the overall energy and environmental impact of U.S. passenger vehicles."

Sustainable Value in Mineral Extractive Industry

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"Mineral extractive industry has been for a long time easily classified as a non sustainable activity because it not only leads to the natural resources depletion but also most of the times has non adequate environmental practices.

By supplying raw materials to several industrial activities it has an undeniable importance in the economical development of the country and therefore the mineral extractive industry must become sustainable by improving its performance not only at the economical level but also the environmental and the social ones.

The challenge to this industry is to manage in a more efficient way the resources it uses and on which its business is based according to Sustainability principles.

In order to improve the present situation in Portugal it was decided to implement a methodology in a target group of companies that could be representative of the sector being one of the objectives to maximize resource productivity.

The Sustainable Value methodology was used. It had already been tested with success in other companies from different industrial sectors. It consists in implementing in an integrated way the Cleaner Production (CP) and Value Analysis (VA) strategies in the companies' processes products and services. The objective of this approach is to improve Sustainable Value which means the relationship between economical environmental and social performance of the companies and the involved resources. It leads to the improvement of the companies' eco-efficiency and competitiveness based in an innovation entrepreneurial culture.

The eight companies involved are associated of a Technological Centre (CEVALOR) in the Alentejo region – natural marble. The project had one year duration with formal training where all the companies met together and discuss their problems and individual and tailor made application in each company.

At the end of the project each company had made the environmental diagnosis of its productive process found and evaluated potential improvements and established an action plan to implement the results.

Each company presented those results in a public session where the eight involved companies participated together with other from the mineral extractive industry which could be interested in a future application universities public and private entities."

Taking stock of the sustainability of the Oslo water and wastewater network

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“The water and wastewater network – an essential and critical component of urban infrastructure - is composed of pumping stations and treatment plants knitted together with the end-users by a network of pipelines. Maintaining and managing the water and wastewater network to provide the basic functions it is meant to provide entails the deployment of money materials and energy. The material and energy flows (and the associated monetary flows) necessary to enable and sustain the fulfilment of two primary functions – supplying clean and treated water to households and collecting and treating the used water (along with surface run-off during the monsoons) to prescribed standards prior to discharge back into water bodies – merits a comprehensive study. Sustainability of a water-wastewater network needs to be analysed on three fronts – social economic (or socio-economic) and environmental – and attaining to it would mean doing a very fine balancing act checking and re-checking and attempting to restore a kind of a dynamic equilibrium between the multiple sometimes- conflicting objectives. This paper looks into how the Oslo Water and Wastewater Department of the Oslo Municipal Corporation in Norway has performed over the years with an ageing network. An attempt is made to make the study as comprehensive as possible with the aid of industrial ecology tools – LCA, LCC and MFA - within the limits imposed by data availability.”

Greenhouse gas emissions from electricity consumption and conservation - perspectives and uncertainties

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“Unambiguous assessment of emissions from production of electricity required for certain purpose is difficult as emissions significantly depend on the technology the electricity is produced. Also it is very difficult to define what kind of technology or technology mix is used just for particular purpose under consideration. When grid-based electricity is used which is the most typical case system impacts due to market mechanisms have significant influence on the overall greenhouse gas impacts of the electricity consumption or conservation.

There is no generally accepted consensus on how the emissions from electricity production or conservation should be evaluated. It is very typical that the emissions of electricity consumption for a certain purpose is assumed in accordance with the average production mix of the market area under consideration. However this kind of approach is in conflict with the fundamental principle of the reference surface defined as it does not consider system impacts objectively (Soimakallio et al. 2008).

Decrease or increase in electricity consumption has direct impact on the marginal side of electricity production constructed by the most expensive production at the point of time. However it is also possible that the electricity required in the consumption point intentionally increases the use of renewable energy sources (or other type of energy sources) that would have not otherwise taken place.

In this study the emissions from production of electricity that is consumed for a certain purpose or from electricity conservation are analysed. The study provides perspective on the impact of selecting various goals and scope for the assessment procedure including time-dependent and equity issues. Significant attention is paid on uncertainties and sensitivities involved. Quantitative analysis is carried out by using market information from Nord Pool electricity markets.”

Comprehending Variation and Uncertainty in Streamlined Quantitative Life Cycle Assessment Methods

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“As environmental sustainability rises in prominence among both consumers and firms the role of life cycle assessment in strategic business decisions has grown. With this growth has come an increased awareness of the considerable data and resource requirements that most life cycle assessments require. The work presented here focuses on streamlining typical life cycle assessment methods while still yielding actionable results. These results can in turn be used to guide strategic decisions that can move firms towards more environmentally sustainable products and operations.

The streamlined quantitative life cycle assessment approach developed here involves a comprehension of both variation and uncertainty. While these issues are not new to the field of life cycle assessment the inclusion of such factors in streamlining the life cycle assessment namely in terms of determining what data – and what level detail of data – is collected is unique. In addition to streamlining the life cycle assessment process the inclusion of variation and uncertainty can also play a critical role in determining the range of possible strategic approaches available to a firm. Thus comprehending these factors is an important component of streamlining existing life cycle assessment methods.

This work will present a streamlined quantitative life cycle assessment method data on variation and uncertainty in a sampling of industrial processes and a case study showing how such streamlined life cycle assessment methods complete with variation and uncertainty data can guide strategic firm decisions around environmental sustainability. “

Towards Simulation of Transitions in Energy

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“In this paper we will report on the specication and application of a quantitative modelling and simulation framework for transitions in energy. Transitions emerge over time as fundamental change of large-scale socio-technical systems such as energy infrastructures that are the back-bone of society (Matthews et al. 1997 Rotmans et al. 2001 Loorbach 2007). Security of-supply and the climate crisis urge us to actively create shape and manage such transitions towards sustainability. To date however the body-of-knowledge on energy infrastructure transitions is largely descriptive while transition management has a prescriptive character not only can we understand transitions we can also shape them (Chappin and Dijkema 2008).

The body of literature on this topic is expanding and largely comprises qualitative analysis. In transition prescription for sustainability there is however also a need for quantitative analysis and prediction: do transition policies deliver? The specications of the simulation framework are derived from a discussion of transition and transition management literature which will include de nitions of societal and socio-technical transitions and an overview of transition management principles or tenets. In addition the diferences between radical incremental and fundamental change will be addressed and the implications of the multi-level perspective and the multi-phase perspective explored. Results from a case study on the impact of carbon policies on energy transition will be presented and discussed.”

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Life Cycle Greenhouse Gas Emissions Embodied in the Production Trade and Consumption of Primary Aluminum Ingot from 1990 – 2005

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“Temporal and regional variability in the technological characteristics of primary aluminum smelters affect life cycle greenhouse gas (GHG) emissions embodied not only in the production but also the trade and consumption of primary ingot. Existing life cycle inventory (LCI) reports and databases however provide limited detail on the impacts of these sources variation. LCI data are updated every few years and typically report a single global average GHG intensity of primary ingot production. With primary aluminum ingot being a globally-traded commodity the variation in life cycle GHG emissions may have implications for carbon leakage in the event of unilateral carbon regulation and the use of aluminum for product lightweighting.

A life cycle GHG emissions model is developed with the objective of quantifying the emissions embodied in the production trade and consumption of primary aluminum ingot in six world regions (Africa North America South America Asia Europe and Oceania) from 1990 to 2005. This dynamic model calculates emissions time series based on annual data for smelter electricity consumption electricity fuel mix carbon intensity of fossil fuel electricity generation and perfluorocarbon (PFC) emissions. Bilateral primary ingot trade data are used to calculate the GHG emissions embodied in imports exports and consumption.

Model results indicate that the production of primary aluminum ingot accounted for approximately 0.78% and 0.93% of global GHG emissions in 1990 and 2004 respectively. Most regions exhibited an increase in absolute GHG emissions over the period with the largest increase occurring in Asia. Concurrently efficiency improvements and PFC reduction programs have led to a decline in GHG emissions intensity of production for many of the regions. Analysis reveals that GHG emissions embodied in primary ingot trade constitute a significant fraction of the emissions associated with primary ingot for Africa Asia Latin America and Oceania.”

Hybrid Life Cycle Assessment of Advanced Biofuel Production and Consumption Scenarios in Scandinavia

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“In Norway and in many other regions greenhouse gas (GHG) emissions from land-based transport are increasing faster than any other source with sustained increases forecasted well into the mid-term time horizon. Low emission biofuels particularly those made from non-food feedstocks can serve to offset some of this growth. The life cycle GHG emission profiles of today’s biofuels including some “second generations” are increasingly being assessed using standard unit-process based life cycle assessment methods. However such assessments may be too narrow in scope failing to consider regional or even global consequential environmental effects associated with their production. Input-output models can be built to increase an understanding of the economy-wide effects resulting from the infusion of new technologies into a region such as biofuels and subsequently are well-suited to assess large-scale biofuel consumption and production scenarios allowing for better insight into any trade-offs or problem shifting that might arise which is associated with their production.

We develop detailed life cycle unit-process inventories of some of the more promising advanced biomass conversion technologies. We then assess the various ways biofuel production can be scaled up in a defined target region such as for example -- through centralized decentralized or synergetic production with existing process-industry -- which involves the identification and quantification of region-specific bioenergy potentials and other production factor endowments. We proceed by creating and assessing a series of biofuel production and consumption scenarios using an extended multi-region input-output model with detailed resolution of both the biofuel producing and consuming sectors. Our main objective is to assess the global warming mitigation potential of large-scale infusion of advanced biofuels across various regions and time frames.”

Visualization of Inter-industry Material Flow Based on Triangularization of Physical Input-Output Tables

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“The importance of the triangularization of input-output tables which has a long history is increasing recently. The triangularization of input-output tables was proposed in 1950s as a method for analyzing industrial structures (Chenery and Watanabe 1958 Econometrica). In the literature of the inter-industry material flow analysis a novel analytical framework waste input-output material flow analysis (WIO-MFA) was proposed (Nakamura et al. 2007 Journal of Industrial Ecology). \Materials\” are theoretically defined based on the triangular structure of an input coefficient matrix in WIO-MFA. This research proposes a method to visualize an industrial structure for inter-industry material flow analysis based on the triangularization of physical input-output tables and applies it to Japanese data. Triangulation problem is defined as a combinatorial optimization problem to find a permutation of industrial sectors which minimizes the sum of upper triangular components of an input-output table. Heuristic algorithms (Simpson and Tsukui 1965 Review of Economics and Statistics Korte and Oberhofer 1970 European Economic Review Fukui 1986 Econometrica) have been proposed because a triangulation problem has a huge number of feasible solutions and it has been almost impossible to solve the problem even in the case of a moderate number of industrial sectors. Recent development of digital computer being taken into account, however this research proposes a representation of the triangulation problem as a {01} integer program to which a general algorithm can be applied. The developed algorithm is applied to Japanese physical input-output tables (PIOT) estimated by the WIO-MFA approach to find triangularized PIOT the visualization of which can reveal inter-industry MFA.”

Dynamic LCA Approach for Decision Support on Sustainable Bio-electricity Development

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“In the drive to reduce net CO2 emissions from electricity production the use of biomass as a fuel has emerged as a possible means to offset the use of fossil fuels. Not all biomass is produced in the same way however and the danger exists that the focus on reducing CO2 emissions leads to other environmental degradation such as loss of biodiversity as illustrated by the recent controversy over palm oil production. To avoid this a Life Cycle Analysis (LCA) perspective is needed to assess the combined impact of all the steps from land-use production and harvest transportation conversion to fuel and/or electricity. The information thus generated could be used in decision-making by governments and companies alike. However an LCA gives us part of the sustainability picture. Not only is each of the technologies in bio-electricity systems subject to social and economic constraints that can limit its viability but also the bio-electricity supply-chain from land to socket is created by diverse actors that more often than not take one step at a time. To approach this we need a socio-technical systems perspective where we can examine the results from LCA for an evolving bio-electricity system. Therein aspects such as markets regulation and management decisions will effect the shape of the bio-electricity system. We are developing the combination of LCA and Agent Based Modeling (ABM) to eventually provide a \`corporate dashboard\”\’. Therein the ABM allows for the modeling of individual technologies and actors as autonomous agents who make decisions in response to actions taken by other actors in the system the market and the state of the surroundings. A model was developed to the explore the effect of different types of decision making on bio-electricity. Through the use of an LCA actors are given information on their environmental impact and can make decisions to mitigate this. Results from this model for bio-electricity will be given. Directions in which this modeling framework that combines system economics and dynamic LCA could be expanded will be further discussed.”

Integrated models versus the sequential application of individual models: an illustrative example

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“A mathematical programming decision support model for the optimization of the entire life cycle of products is presented. The model is designated by Life Cycle Activity Analysis (LCAA) and it is based on the integration of classical economic ’activity analysis’” originally developed by Koopmans with the environmental Life Cycle Assessment (LCA) methodology. LCAA is applied to an illustrative environmental problem aiming at describing the main features of LCAA in a practical way and evaluating the differences and similarities with other models currently employed to analyze material flows in the economy. A single hypothetical example of pollution problem is used which was previously proposed in an article (published in Ecological Economics: Bouman et al. 2000) to compare three types of models: substance flow analysis (SFA) environmental life cycle assessment (LCA) and economic partial equilibrium analysis (PEA). It is shown how Koopmans activity analysis can provide a common heritage to LCA and PEA models which can be exploited to provide formats of numerical calculation by mathematical programming thus establishing a basis for the conceptual integration of some of the approaches that Bouman et al. (2000) are calling for. To demonstrate their numerical example is reworked suitably adjusted and the various questions that they posed are discussed anew. Bouman et al. (2000) have concluded that the results of the three models are complementary rather than contradictory since each of them puts emphasis on different aspects of “the real world”. They believe that “a sequential application of a number of limited models may therefore be an approach that provides more useful information than the tedious construction and application of an encompassing model that integrates these models”. However the results presented in this paper demonstrate how a mathematical programming model integrating economic activity analysis with LCA appears to reduce the shortcomings of these models considered isolated or even sequentially.”

Global Resource Flows and Product Flows: Tracking Inter-Regional Pathways from Resource Extraction to Product Consumption

Faye Duchin, Stephen Levine

“Material flow analysis life cycle assessment and economic input-output models have all been used to quantify the flows of resources and products through an economy sometimes supplemented by graph theoretic methods that track individual paths through the system. In this paper we combine an input-output model of the world economy with an absorbing Markov chain representation of resource and product flows to characterize the paths followed by resources from their extraction to the consumption of goods in which they are embodied explicitly tracking the resource contents of both direct and indirect imports (i.e. imports that embody other imports). This paper focuses on the fundamental matrix of an absorbing chain and demonstrates its significance for addressing high-priority policy questions in the context of global production and consumption. In the process we make use of the graph-theoretic interpretation of this matrix to resolve some unsolved methodological problems in the analysis of resource and product flows.”

A Platinum Market Model to Examine the Risk of Increased Scarcity for Downstream Firms

Elisa Alonso, Frank Field, Rich Roth, Randolph Kirchain

"This paper examines the risk of materials scarcity and the benefits of addressing this risk for downstream firms in the supply chain. It is hypothesized that to reduce risk firms may take actions that lead to more sustainable resource use and improved environmental performance.

Using the platinum market as a case study we have developed a system dynamics simulation model as an experimental platform for examining the dynamics that could lead to scarcity. This model captures the delays and inefficiencies that can affect firms before market forces especially price lead to a balance between supply and demand. To explore the impact of changing market conditions on material scarcity over time the model represents the platinum market as a system of non-linear first order differential equations and numerically simulates the behavior of key material market actors. To build the model we used historical data describing platinum supply and demand for key industrial applications such as automotive catalysts petrochemical catalysts glass production hard disks and capacitors.

We apply our model to examine a number of hypothetical scarcity scenarios including one with a supply group shutdown and examine the statistical significance of the effect of different strategies in the face of limited supply. We find two strategies that can improve firm resilience: increased recycling and substitution. Because the delays involved in implementing these strategies may cause unprepared firms to lose market share to competitors who are more prepared to address these challenges these actions should be considered before price surges occur. Taking such actions may also lead to improved materials sustainability by reducing the firms' waste production energy consumption and resource use."

5th International Conference on Industrial Ecology

2009 ISIE Conference

Industrial Symbiosis

Complex patterns in industrial ecosystems

Shi Lei, Shi Haijia

“Industrial ecosystem is an interweaved system comprising many different types of enterprises at special temporal and spatial scales having hierarchical modular self-organizing and evolutionary features. How to reduce the complexity of industrial ecosystem? We present a conceptual framework with three encompassing concepts to structure this problem. The first concept is joint production referring to a reality of the physical world where feedstocks are transformed into products via chemical or physical processes. Under the guideline of joint production we can establish complex networks for industrial ecosystems. The second concept is industrial organization belonging to the world of economy and society including enterprise industrial cluster industrial park and global production network from micro-level to macro-level. The third concept is scaling by using multidimensional scaling and cluster analysis we can find complex patterns in industrial ecosystems.

Following the conceptual framework we found both local industrial symbiosis systems and some special industrial sectors (such as chemical industry and machinery industry) to be complex networks. For example we study the organic chemical supply chain in China and found it was a small-world network with three degrees of separation it was not a scale-free network but like food webs it was a hierarchically organized system with some motifs can be identified.”

Iron and Steel Industrial Symbiosis System from Thermodynamic Perspective: A Case Study of Handan City China

Yu Bing, Shi Lei

“Handan City 430 kilometers south to the Capital Beijing is an important iron and steel industrial base with capacity of 19000000 tons of iron 20600000 tons of steel and 14000000 tons of rolled steel. However all these iron and steel products are not produced from only large-scale companies but from more than 40 companies. Several categories of industrial symbiosis systems can be observed based on different combinations of coke iron steel and rolled steel. All these symbiosis systems are experiencing quick structural changes due to recent financial crisis raw material markets impact competitions among enterprises increasing resources and environmental pressure governmental policies and other issues.

Following the identification of industrial symbiosis systems exergy analysis is applied to examine the resource efficiency and environmental performance for each symbiosis system. The influence of topological structure and selection of boundaries on economic and environmental performance is also discussed.

Based on the discussion from thermodynamic perspective three scenarios are set up to be helpful in presenting suggestions. The first one is based on product structural change the second is based on enterprises recombination and the third is based on cleaner production efforts for each symbiosis system. Finally some suggestions are presented for iron and steel corporations to resist survive and develop in financial crisis. This research work is being carried out and some results are expected in April 2009. “

Zero Emission Park – developing industrial symbiosis towards sustainability: Theoretical framing upstream and conceptual specification downstream

Ralf Isenmann, Michael von Hauff, Georg Müller-Christ

" The contribution provides an ongoing case study on the industrial symbiosis project: "Zero Emission Park" currently conducted in Germany. Further to a mere project description and insights on how-we-did-it the contribution also offers input to theory build-ing in the field of industrial ecology.

While the underlying interest in the first perspective is a rather descriptive one the more promis-ing - but at the same time also challenging - focus in the second perspec-tive is on explanation i.e. the interest is also to contribute to theory building at least to a certain degree.

Hence the contribution is of relevance for researchers and scientists with academic interest at the one hand and decision-makers at different levels with practical interest on the other.

According to the goal and scope the contribution is structured into three parts:

- First (i) the case study: "Zero Emission Park" is presented. Zero Emission Park is an ongoing research project in Germany with the goal to develop existing industrial parks towards sustain-ability (http://www.zeroemissionpark.de). Among other stake-holders like chambers of commerce local authorities administration more than 600 enterprises are involved.

- Based on the outline of the "Zero Emission Park" project we further propose (ii) a theoretical framing upstream with links to economics and a (iii) conceptual specifica-tion downstream with links to management and organizational science. Both are thought useful for theory building in the field especially in terms of economics and management science.

In this contribution the research project: Zero Emission Park is described and early insights are presented. Further to a mere project description the contribution is em-bedded into an effort of contributing to theory building in the field: The proposed theo-retical framing upstream – with links to economics – and the conceptual specification downstream – with links to management and organizational science – may have the potential to contribute to a more solid body of theory especially from the point of eco-nomics (upstream) and management and organizational sciences (downstream)."

Is there cash in that trash? Exploring industrial symbiosis through a strategic management lens

Raymond Paquin, Suzanne Tilleman, Jennifer Howard-Grenville

"Industrial symbiosis has gained a following among practitioners and academics interested in understanding how such an interfirm approach to waste reduction can be encouraged and sustained. Critical to successful industrial symbiosis however is the recognition by managers of the potential opportunities to make productive use of otherwise un- or under-valued resources or by-products. In this paper we draw on the resource-based view of the firm (RBV) a well-established perspective in the strategic management literature to explore the conditions under which waste material resources become regarded as valuable by firms sourcing and receiving such resources.

We explore the formation and development of 1068 IS projects among 6881 firms who have expressed interest or actively engaged in developing IS projects in the UK between 2005 to 2007. We empirically test two commonly held yet largely untested assertions within the industrial symbiosis literature – first that firms from diverse industries are more likely to undertake industrial symbiosis because they are able to find unexpected opportunity and value in another firm's wastes and second that firms engage repeatedly in industrial symbiosis once they have experienced a successful project. In the first test we find firms are more likely to engage in industrial symbiosis with firms in the same industry or with firms that are in downstream industries rather than with firms in more dissimilar industries. This may indicate the importance of local search which does not necessarily counter the logic of unrelated industries finding new value in novel waste. For the second test we find that firms successfully involved in industrial symbiosis projects tend to successfully complete additional IS projects over time. These findings provide interesting and important implications for RBV researchers industrial symbiosis practitioners and public policy makers."

Resource relevance of Eco-Industrial Networking in Germany

Susanne Hartard

" Eco-Industrial networks in Germany can be characterized by their different background and history. The focus of networking companies is not limited on material exchange best known from the traditional Eco-Industrial Park Kalundborg. German networks can be characterized as follows:

• combined production (chemical industry)

• supply chain (automotive industry)

• economic promotion (Green industrial parks)

• sustainability (Agenda21eco-profitPIUS) waste management (eco-industrial recycling parks networks)

• energy supply (zero-emission networkscluster)

• efficiency (material efficiency networks energy efficiency tables).

Main motivation of actual industrial cooperation are rising energy and raw materials prices and a general change towards renewable energy technologies. German enterprises join new forms of cooperation in order to achieve material and energy efficiency. Small and medium sized companies could save money with energy efficiency networking activities up to 150.000 EURO per year.

The actual fast growing amount of local energy efficiency table networks might have effects in future local energy supply cooperation.

The focus of efficiency networks goes towards information exchange by convoy consulting. Enterprises meet regularly exchanging ideas of their individual best practice and inviting energy consultants. The information transfer leads to technology change and implementation of new energy management systems.

The presentation will give examples of German eco-industrial networks and their resource relevance. Zero emission networks will have an important future function of an exchange of materials and combined production on a renewable material based industrial society. It will be discussed if local energy efficiency tables might have a future function as local energy supplying units. Resource autarkic networks will increase in importance against the risk future word-wide resource competitions and conflicts on energy and raw materials."

Potential of urban and regional symbiosis among sewage sludge treatment plants and industrial factories through sludge-to-liquid conversion technology

Noboru Yoshida, Yugo Yamamoto,Tohru Morioka,Takayuki Ihara, Masayuki Kai, Hirotaka Mabuse

“For recent years increasing attention has been paid to waste biomass as one of renewable energy resources. Regarding sewage sludge Japan government set up a target of utilizing sewage sludge as energy up to 29% by 2012 in the plan for achievement of the goals of the Kyoto Protocol.

In our research project potential and the environmental effect of urban and region wide symbiotic networks among sewage sludge treatment plants and various kinds of heavy-oil-using industries were examined through biomass fuel utilization based on material and energy flow life cycle inventory GIS and input-output analyses.

First an attempt was made to convert dewatered sewage sludge to liquid fuel using fast pyrolysis one of recently developed thermochemical conversion technologies. As a result of bench and pilot scale experiments the material and energy flow was estimated and it revealed that: i) sludge-derived pyrolysis oil could be produced using their own calorific values with no additional energy supply from outside and ii) characteristic of the pyrolysis oil is similar with that of heavy oil and could be used as fuel.

Secondly the fast pyrolysis oil conversion was compared with various energy utilization technologies of sewage sludge using life cycle inventory analysis. The result showed that the fast pyrolysis oil conversion could reduce more carbon dioxide than other technologies including methane fermentation and gasification.

Thirdly transport distance of pyrolysis oil from sewage plants to industrial factories was analyzed by using GIS. As a result we found that the distance could be affected by renovation schedule of the plants.

Furthermore input-output analysis was applied to estimate the macroscopic effects due to expansion of pyrolysis oil utilization by industrial sectors. The result indicates reduction of carbon dioxide emission directly and indirectly beyond increased emission due to the oil transportation.”

Industrial Ecology Applied To Industrial Parks in The French Context

Sabrina Brullot, Paul Schalchli, Dimitri Coulon

“In France it exists between 24 000 and 50 000 industrial parks (also called industrial estates or business areas). Meeting point for companies local authorities civilian organisations and park managers industrial parks represent a vast “laboratory” for the implementation of sustainable development strategies: collective waste and sewage management transportation issues and accessibility risk management services development consultations and stakeholders participation etc.

Integrating so many complex issues is a real challenge for local public authorities and firms. In addition there is an urgent need to develop stronger methodological and technical tools to lead the decision-making process with the most reliable elements in order to achieve local sustainable development objectives.

Since 2008 Orée leads the COMETHE* project laureate of the French Programme for Research into Eco-Technologies and Sustainable Development launched by the French National Research Agency. This project started in 2008 and lasts 3 years.

COMETHE is based on the joint effort of 15 partners: universities research centres environmental protection organisations planning offices and experts local authorities and companies. Concretely this project follows four main objectives:

- The production of knowledge in the technological and technical domains as well as in social and economical sciences

- The creation of a methodological handbook for the implementation of industrial ecology applied to industrial parks

- The elaboration of an integrated tool articulating four specific modules

- The realization of diagnosis and feasibility studies for the 7 territories involved in the project (located in 4 different French Regions and involving more than 30 local partners).

Finally more than 1000 firms could benefit of the results of this very first research program at a national level.”

* Conception of Methodological and Assessment Tools for Industrial Ecology [www.comethe.org]

Detecting industrial symbiosis using a GIS based tool

Guillaume Massard, Albin Viquerat, Suren Erkman

“Cycling the use of material in product manufacturing is the conceptual framework of industrial ecology (EI). Within this context industrial symbiosis creates physical exchanges of materials energy water and/or by-products among economic activities that are collocated or spread though a state or region.

Detecting and analysing potential symbioses on a multifunctional territory first requests physical input-output data collection from economic activities. Secondly the information needs to be stored in a way that allows data treatment for symbioses detection and feasibility analyses. A database is used to store manufacturing processes and related flows information. A clearly defined terminology allows application of algorithms for treatment and retrieval of information. In addition a geographic information system (GIS) interface is developed as technical and decision support for experts. It allows among other things the visualisation of detected symbioses the evaluation of technical and geographical feasibility the detection of new potential partners within the manufacturing activities and the identification of optimal location for new economic activities based on material flows consideration. Interactions with other spatial layers extend the symbiosis detection to other economic activities such as agriculture housing or services.

The methodology and the tool developed aim at providing useful information for a more efficient use of resources that may be used to advise decision makers involved in economic and industrial planning. It may be a valuable instrument in the hands of public and private institutions seeking information on manufactures and their organisation.

This paper is centred on the experience initiated by the state and republic of Geneva (Switzerland). Since 2004 the state’s Agenda 21 supports a project aiming at detecting and implementing industrial symbiosis on its territory.”

Interplay between industrial ecosystems and environmental governance at different spatial scales: The case of the Gulf of Bothnia heavy industries in Finland and Sweden

Olli Salmi, Jyrki Heino, Janne Hukkinen, Mari Pajunen, Maaria Wierink

“Many scholars of industrial ecology have focused on the institutional and organizational challenges of building and maintaining regional industrial ecosystems through the synergistic integration of material and energy flows. Despite the promise that these intellectual developments hold for the future dematerialization of industrial production they suffer from a blind spot namely the challenge of trans-national governance of material flows. In this presentation we introduce some of the issues of trans-national governance of a cross-border industrial ecosystem by way of a case study the Gulf of Bothnia industrial region in Finland and Sweden.

To illustrate the technological and regulatory bottlenecks in creating regional industrial ecosystems we create three technological scenarios at different geographical scales. These scenarios describe innovative uses of waste material flows for novel products among the industrial parks of the Gulf of Bothnia. The first scenario Bothnian Arc Joint Steel Works describes the utilization of steelmaking dusts and scales from Sweden and Finland for new steel products. Second the Nickel substitution scenario describes the use of manganese waste from Kokkola Finland as a nickel substitute in steelmaking in Tornio Finland. Finally the Zink sink scenario describes a zink clinker production in Rönnskär Sweden from numerous small dispersed sources in Finland and Sweden. We conclude the article by analyzing the key technological bottlenecks in need of engineering intervention and governance bottlenecks in need of policy intervention to facilitate the emergence of industrial ecosystems along the chosen scenarios.”

Policy and legislative framework on waste management in the European Union: a key issue of industrial symbiosis

Inês Costa, Guillaume Massard, Abhishek Agarwal

"A recurrent theme across industrial symbiosis (IS) research relates to which structures - institutional legal and/or economic - are required to facilitate its emergence. However two decades of research later some European countries still present no widespread achievements on IS despite "neighbour successes" of Austria or the UK. This encouraged researchers to focus on European Union (EU) legal structures (policies/legislation) and its impact on realizing IS as a resource and waste management tool. The research gains additional significance when considering the recent EU Waste Directive which aims to promote the use of waste as a secondary resource.

By taking Denmark Portugal Switzerland and UK as case studies this paper aims to: 1. critically appraise EU waste legislation on its IS impact 2. explore the existing IS practices and the associated legislative framework and 3. explore the extent to which IS concept can become a tool for future EU resource / waste legislation development."

Life and death in industrial ecosystems

Weslynne Ashton, Marian Chertow

“Industrial symbiosis is held as the embodiment of industrial ecology in practice characterized by collaborative resource management among firms and significant environmental benefit to the region where the firms are located. At least initially these partnerships develop for economic reasons with firms generally unaware of the spillover benefits beyond their own facilities while other benefits come into play later on. Kalundborg Denmark has had the longest-term success in that the actors after they became aware of their industrial ecosystem continue to adapt to changing conditions. While most partnerships are economically justified the presence of a culture of cooperation suggests that other considerations also come to bare in perpetuating industrial symbiosis activities among firms. In contrast the industrial symbiosis activities in Barceloneta Puerto Rico lasted for a finite period and collapsed when the partnerships no longer met the needs of the companies there. This paper examines the role of consciousness about environmental benefit and the importance of recognition as part of a broader industrial ecosystem on the long-term sustainability of these industrial regions. It compares Kalundborg and Barceloneta as the main cases drawing on other examples of failed systems and considering the role of a \dormancy stage\” project as a link between failure and rebirth.”

MgMetallic - a concise serious game

Gerard P.J. Dijkema

“Mainstream Industrial Ecology focuses on material and energy flows. A much advocated strategy to reduce unsustainability is to foster by-product exchange and establish eco-industrial parks which can be viewed as industrial networks on a single integrated industrial site. An active co-siting strategy would then involve attracting industry to existing sites that would lead to more exchange between its industrial facilities. Creating sustainable business not only requires an acceptable ecological footprint however but also solid business economics and stakeholder acceptance. Any investment can be viewed as a business proposition that must be approved by senior management conform to appropriate standards and regulation be acceptable to local government and community and overcome any opposition from interest groups NGO\’s and other stakeholders.

Using a real case of industrial development a worldscale magnesium producion facility we have created a paper based game to illustrate the intricacies resulting from the socio-technical complexities involved in growing an eco-industrial park. MgMetallic is a company that endeavours to exploit a unique local resource pure magnesium chloride MgCl2. The company has a shortlist of two \’equivalent\’ industrial sites with suitable location factors. Apart from pure metallic magnesium the facility will produce chlorine the use of which to produce chlorinated hydrocarbons is technically complex and controversial while converting the chlorine to sodium chloride would imply a huge loss of exergy. Transport of the chlorine is banned because of transport safety regulations. By assigning participants to groups that each are given a key stakeholder role - companies national government local agencies interest groups etc. the complexities in reaching a decision how to attract or where to locate the magnesium plant are explored. The game has been succesfully played with academics management civil servants and citizens participating. At the conference the game can be played.”

Evaluation of symbiosis effects in eco-industrial parks in Japan

Tsuyoshi Fujita, Shizuka Hashimoto

“Industrial symbiosis is concerned with the recovery and reuse of wastes from one facility as alternative input in neighboring facilities. The Eco-Town Program in Japan is a program to extend Industrial Symbiosis into geographic proximity of industrial areas by using previously discarded waste materials for industrial applications. The program established 26 Eco-Towns and 1.65 billion USD was invested in 61 innovative recycling projects. In 16 Eco-Towns the private sector was the most important actor supporting local government in realization whilst in 9 Eco-Towns this was civil society. Firstly qualitative comparison of different eco towns are provided and the development of policy targets of eco-town projects are also identified namely from accumulation of recycling facilities into urban platforms for circular regions. Secondly taking a Kawasaki eco-town as a frontrunner current symbiotic networks are identified and extensive future policy options are designed. Symbiotic network development among urban sectors such as households and shops spatial extension of circular boundary beyond single municipal government are contemplated for the scenario design. Finally quantitative evaluation procedure of environmental effects are developed as well as core indicators and several numerical evaluation are provided. Evaluation process is developed to apply the technology inventory data with their locational information for the regional GIS data base. Disaggregated area-scale database is established on GIS are used by integrating the socio-economic statistical data with basic geographical information such as municipal borders transportation networks and environmental resources such as rivers and oceans. Circular technologies are formulated by quantifying material and energy input and product output of representative plants in eco-towns.”

Cooperation in a proposed syngas industrial cluster

Andreas Ligtvoet

“Current use of fossil fuels and feedstocks increasingly faces uncertainty of supply due to geological, financial, organisational and environmental constraints. In the last years, the price of oil has sky-rocketed and dropped, and gas supplies are threatened due to geopolitical interventions. At the same time, industries willing to use coal as a substitute for natural gas need to prepare for carbon capture and storage (CCS) technologies becoming mandatory in the future.

A possible solution to cope with these challenges is the creation of a synthetic gas (syngas) cluster in the Port of Rotterdam. Syngas could be used as a general fuel/feedstock for the generation of electricity, the production of transport fuels, the direct reduction of iron, and the manufacture of a wide variety of chemical products such as ammonia and methanol. These processes are already taking place in different sites around the world and thus constitute proven technology. However, connecting such plants to a shared syngas grid would offer the participating firms flexibility in the use of feedstock. Furthermore, during the process of gasification, CO2 can be separated in a more efficient manner as compared with other technologies for capturing carbon dioxide.

At the moment, the design of such a syngas cluster is still in an exploratory phase. Our research focuses on investigating the willingness of firms to cooperate and how such cooperation could take place.

Theoretical concepts of cooperation are matched with (possible) stakeholder opinions and tested in simulations of the development of syngas infrastructure formation. We aim to present a range of possible pathways (scenarios) in which cooperation leads to the formation of a cluster and conditions that determine success or failure.”

Valuing Diversity in Industrial Ecosystems

Randolph Kirchain, Frank Field

"The notion that industrial systems should mimic ecological ones is a foundational concept within the field of industrial ecology. In exploring the implications and importance of this, the IE literature identifies a broad range of traits that characterize successful biological ecosystems which may be important to realizing sustainable industrial activity. Three that seem to have achieved broad consensus are efficiency, waste recirculation, and actor (and resource flow) diversity. Although a significant literature has emerged that provides an economic foundation for the practices of industrial ecology, this literature has largely focused on motivations that derive from the former two characteristics: efficiency and waste. Although the benefits of diversity would seem intuitive, analytical demonstrations of its value have been elusive and few. This presentation will discuss economic motivations for IE activities that derive from diversification.

Specifically, this presentation will briefly discuss three micro-scale (inter-firm or small collection of firms) examples, where analytic and numeric models can be used to demonstrate that cases exist where sourcing diversification improves the economics of production and the incentive to use secondary resources. These examples will be built around both static and dynamic models that demonstrate the inherent value of source diversification, particularly for secondary resources, under conditions where production is subject to uncertain i) product demand, ii) raw material quality, and iii) supply availability.

Obviously, almost all real-world producers and productions systems confront each of these issues. As such, the value of diversification emerges not from particularly unique case characteristics, but rather from a proper framing of the industrial decision problem. Nevertheless, for each case, this presentation will summarize the characteristics of a production context that amplifies or mutes the economic and environmental gains associated with diversification."

5th International Conference on Industrial Ecology

2009 ISIE Conference

Managing End-of-Life Products

E-waste assessment in Minas Gerais/Brazil

Martin Streicher-Porte

“Brazil is considered the fifth largest market for personal computers worldwide. According to International Data Cooperation there were 10.7 million computers sold in Brazil in 2007 and the country is expected to reach third place in terms of installed PC base by 2010 -the United States ranks first with 64 million installed units followed by China Japan and the United Kingdom. In addition to this with roughly 35% of the region’s revenues Brazil remains Latin America’s largest telecom market.

As yet the end-of-life management of obsolete Information and Communication Technology (ICT) equipment in Brazil seems not to have entered into the dire practice of providing waste material to a largely uncontrolled informal recycling sector -as is the case in India and China. It is therefore essential that knowledge of the ICT consumption and waste generation be gained in order to plan a comprehensive e-waste management system. The State Government of Minas Gerais and Empa are conducting an e-waste assessment in Minas Gerais with the intention of integrating e-waste into the existing waste management system of the major cities in Minas Gerais. The assessment will collect data on saturation levels of ICT equipment in households and businesses as well as data on sales numbers and will estimate the average life span of ICT appliances. With simple cohort-models the waste volumes can be calculated assuming the fall out of equipment after their usage period. Based on the quantitative data the study will also evaluate how the existing informal or semiformal waste sector can be trained and guided to collect and pre-treat e-waste from ICT equipment. The goal is to establish a business model which enables underprivileged strata of society to profit from the waste of ICT equipment by producing tradable waste fractions whilst still preventing polluting emissions from entering into the environment.”

Assessing the management of small waste electrical and electronic equipment through substance flow analysis – The example of gold in Germany and the USA

Perrine Chancerel, Vera Susanne Rotter

"The demand for precious metals by manufacturers of electrical and electronic equipment has increased significantly over the past few years. Although precious metal concentrations in appliances are very low these metals have a high economic and environmental relevance compared to other substances present in much higher quantity (e.g. iron copper plastics). In the current context of resource scarcity and high prices more research is needed for a better understanding and management of these metal flows.

This research project aims at describing and quantifying the flows of small waste electrical and electronic equipment (SWEEE) in Germany and in the USA for the year 2007. The term 'SWEEE' refers to small household appliances IT and telecommunication equipment consumer electronic tools and toys. Although collection systems were set-up for SWEEE in many cases SWEEE is not collected separately for recycling but rather disposed of. Regarding treatment of SWEEE the model differentiates between reuse and treatments carried out by the formal and informal sector (including illegal export of SWEEE).

The material flows of SWEEE in Germany and in the USA and the flows of gold and palladium related to SWEE were quantified based on a combination of expansive experimental investigations carried out at TU Berlin and a review of the relevant literature. The results revealed that in 2007 only around 5% of the gold contained in mobile phones was recovered in Germany and over 90% was lost for the cycling economy. From mobile phones alone 393 kg of gold was lost in one year. The investigation revealed similarly low recovery rates for the USA.

In conclusion the current infrastructure seems inadequate to recover gold efficiently from SWEEE with collection being the main weakness of the system. More efforts are needed to reduce the losses of precious metals in electronic waste management."

Development of Integrated Framework for Sustainability Evaluation of Sanitation Systems in Small Towns of Vietnam

Pham Ngoc Bao, Keisuke Hanaki, Toshiya Aramaki

"Decision making in sanitation planning is often complex mainly because of the inherent trade-off between sociopolitical environmental ecological and economic factors. Selection of appropriate and sustainable sanitation system for domestic wastewater treatment often involves multiple criteria with conflicting preferences from different stakeholder groups. In order to fulfill conflicting while complementary objectives a systematic approach called the "analytic hierarchy process" has been utilized to develop an integrated framework for comprehensive evaluation comparison and selection of wastewater treatment scenario with regard to sustainability. This study presents analytic hierarchy process (AHP) technique in combination with life cycle assessment (LCA) and a proposed set of sustainability criteria as effective decision support tools for the sustainability evaluation of wastewater treatment systems through a case study in Toan Thang small town in Vietnam. A short-listed of three selected scenarios and a set of impact categories have created a complex decision making process. Characterization of each scenario is based on a series of impact categories and life cycle assessment addressing environmental social economic health and technical aspects. Results from this process revealed that the proposed scenario with a combination between decentralised sanitation solution with household septic tank and centralised sanitation option with waste stabilization ponds is ranked as the first priority from all stakeholder groups with 64% support compared to the other alternatives with 13% and 23%. This seems to be the most promising and sustainable choice for the town as it brings about positive impacts in term of environmental socio-economic health related technical and functional aspects including low capital O&M costs resulting low user costs high treatment efficiency possibility of nutrient recovery and safe wastewater reuse especially minimizing the health risk from effluent which may pose to the local resident. Moreover this scenario offers equally contribution among dimensions of sustainability. The overall results obtained from this study shown that this approach is a viable tool and offer good communication among different stakeholder groups."

A knowledge-based transition of managing end-of-life products towards a recycling society

Henning Wilts

“The global competition for resources accompanied by increasing prices of raw materials has called attention to waste not just being a disposal problem but also an „urban mine“for the extraction of secondary raw materials. Also concerns about security of supply with scare metals and lower CO2 emissions in comparison to primary raw materials have spotlighted the accumulated stocks in the anthroposphere. Recent studies underline their relevance. In the EU political initiatives like the „Thematic Strategy on the sustainable use of natural resources“ are undertaken but still the majority of waste is incinerated or dumped and consequently not available for a high-quality recovery.

Especially materials beyond the main waste streams like PGM in consumer goods show very low recycling quota. They represent only a small percentage share but because of their huge environmental rucksack they contribute significantly to the eco balance of products.

According to our approach the aim of the „recycling society“ is primarily an information problem. A real transition towards a sustainable resource management presupposes knowledge generating institutions which are actually lacking at the crucial points of intersection along the life cycle of products. Required institutions must principally differentiate between mobile and immobile goods. Based on empirical data this hypothesis is supported by an institutional-economic comparison between recycling strategies for copper in public infrastructures and PGM in catalytic car converters. The analysis provides evidence that previous incentives for a sustainable resource management are minimized by inconsistent legal and economical systems of regulation. They are even distorted by fostering a burden shifting into regions with lower environmental standards.

Proposals for solution are discussed for mobile and immobile goods which aim at an increase of consistency and efficiency of existing regulation systems and hence make a contribution towards a boost of resource efficiency.”

Development of a tool for optimizing industrial ecology processes in WEEE treatment

Eduardo Santos, Sandro Vicente, Pedro Nazareth, Fernanda Margarido, Paulo Ferrão, Carlos Nogueira

"Producers and importers of electrical and electronic equipments (EEE) have to ensure the management of the respective waste electrical and electronic equipment (WEEE) by promoting its collection and recovery. In Portugal there are two WEEE take back systems that have to fulfill legally binding collection and recovery targets.

To meet recovery targets of WEEE at an economically optimized cost is one of the major challenges of managing entities. This will be possible if the management entities choose the adequate technologies to treat WEEE considering not only the present but also the future technological specifications (e.g. amounts and material characteristics of the waste being generated future recovery targets etc.).

This paper presents the methodology used to develop a tool for assisting the selection of technologies to treat WEEE. The method involves the modeling of the unit processes constituting the flowsheet which will be tested by simulation to assess its technical and economical performance based on data obtained from empirical tests in a set of operating ranges. A factorial analysis to determine the relevant variables of each unit process will be applied for the purpose of modeling it into the tool.

In the factorial experiment the effects of a number of different variables (factors) are investigated simultaneously. The treatments consist of all combinations that can be formed from the different factors. In that sense it is analyzed not only the influence of each variable individually on the process but also the possible interaction between them.

Results were complemented with bibliographical data concerning the specifications of the equipments of each unit process. The developed tool allows obtaining a set of important results for the selection of WEEE treatment technologies namely cost and efficiency."

A comprehensive methodology to calculate WEEE recycling and recovery rates in Portugal

Mónica Luízio, Susana Ferreira, Eduardo Santos, Paulo Ribeiro

"One main challenge for Amb3E the main WEEE collective take back system in Portugal is to measure the effective performance obtained in WEEE recycling and recovery by its recovery operators in order to calculate and compare the system's overall results against the legally binding recycling and recovery targets.

To that extend Amb3E developed a "Procedure for WEEE Treatment Tests" based on the material flow analysis methodology and the WEEE Forum Guidelines and Checklists. The procedure was carried out in 2007 and 2008 and tests were performed for the WEEE treatment categories and Amb3E operators.

Given the European dimension of the WEEE management a question that arises is the comparability between different systems and countries. Therefore in order to have a standardized classification of components fractions and technologies Amb3E tests data were inputted to the WEEE Forum tool – Reptool.

This paper presents the treatment tests methodology and results namely in the context of the environmental results obtained and in particular of hazardous substances removed. Additionally the technologies used by the recovery operators and the input and output fractions obtained are characterized quantitatively and qualitatively and the European method to ensure comparability of results (Reptool) is analyzed.

Furthermore the technical limitations of Amb3E's method are identified and discussed and possible solutions are suggested namely in the context of the Amb3E legal boundary and its relation with the entire WEEE value chain from the waste collection until the moment where WEEE materials are effectively reincorporated in new products."

Importation and end-of-life processing of computers in developing countries: Peru's case study

Ramzy Kahhat, Eric Williams

"This paper considers the import of used personal computers (PCs) to Peru and the forward and reserve supply chain vis-a-vis development and environment. The empirical pillars of this study are 1) Analysis of government trade data on the importation of used and new computers, and 2) Surveys and interviews with households computer refurbishers recyclers and sellers in Lima. Results show that the United States is the primary source of used PCs imported to Peru. Analysis of shipment value shows that 83-86 percent of all imported computers used had a price higher than the value of recyclable materials. The main motivation for trade is thus reuse as opposed to recycling. The reverse supply chain of PCs was found to be efficient with extensive reuse and recycling. The main environmental problem found is open burning of copper-bearing wires to remove insulation. Distinct from informal recycling practices in China and India printed circuit boards are usually not recycled domestically but exported to Europe for advanced recycling or to China for (presumably) informal recycling. It is notable that purely economic considerations lead to circuit boards being exported to Europe where environmental standards are stringent presumably due to higher material recovery rates attained by modern smelters."

Artery-Vein Cooperation in Material Cycles

Rokuta Inaba, Minoru Fujii, Keisuke Nansai, Masahiro Osako

“The material cycles of human society has been often compared to the blood circulation of human body so the recycling system is often called as venous system. The venous system has presented some problems related to energy and cost. However when coupled with an arterial system it presents an efficient system for energy and cost reduction. We therefore propose an artery-vein cooperation (AVC) by which the vein and artery systems represent the mutual use of substance and energy or sharing of various processes and by which reduction of energy consumption costs and environmental burdens are achieved. First in this study the patterns of combinations were classified. Then a life cycle assessment (LCA) of greenhouse gases (GHG) was conducted to alternatives of waste management system as effects of AVCs. The alternatives include factors of AVC.”

Is Economic Value an Effective Proxy for Embodied Energy and Environmental Impact in Material Systems?

Jeremy Gregory, Susan Fredholm, Randolph Kirchain

"Life-cycle assessment (LCA) has proven to be a valuable tool for evaluating embodied energy and environmental impact in products and material systems. However LCA is complex expensive and time-consuming making it inaccessible to many stakeholders making important decisions in material recovery systems. Unlike product design cycles which can last several years and afford time to do detailed LCA studies decision-makers in material recovery systems must deal with constant variation in incoming end-of-life (EoL) products and market demand for secondary materials and products. They have few practical methods available to evaluate the expected performance of the many different strategies to materials recovery (e.g. should recyclers focus on bulk materials like plastics or scarce materials like platinum group metals).

In light of this need two key research questions emerge: Is there information that is accessible to these stakeholders that could serve as a proxy for LCA to better inform their decisions and when would it be appropriate to apply this proxy?

Economic value is clearly information that is readily available for materials recovery stakeholders. Furthermore economic value of materials reflects quality the cost of production or use (including energy consumption) and scarcity rents for current use of that resource. Thus EoL material recovery metrics that include value provide significant information about the effectiveness with which resources are reclaimed and returned to productive use providing an indicator of both retained quality and environmental impact.

This paper uses economic value metrics to evaluate the retention of value of secondary materials and provides a framework for characterizing value throughout a material and product life-cycle. These economic value metrics are compared with analogous LCA metrics in order to determine the conditions under which economic value effectively represents environmental impact for EoL material recovery decision-makers.

The broader research agenda is to explore whether readily available information can direct environmental decisions and whether market behaviors lead to lower environmental impact. The specific research question addressed here is: Can the use of economic value metrics lead to environmentally informed decisions?"

The Role of Displaced Production for Reuse and Recycling

Roland Geyer, Vered Doctori Blass

“Recycling of materials and reuse of products or their components is central to the theory and practice of industrial ecology. The idea of turning the wastes of a product system into resources for others lies at the heart of the industrial ecology metaphor. The need to ‘close the loops’ of an industrial society’s metabolism is frequently taken for granted or demonstrated by assessing the environmental benefits of reuse and recycling. Such assessments frequently show that the environmental benefits of displacing primary production processes, e.g. of virgin material, are substantially larger than the benefits of avoided landfill or incineration. However, environmental assessments of reuse and recycling, whether based on models or empirical data, all share one fundamental problem: How do we know that reuse and recycling activities displace other production processes, and how do we determine which processes are displaced and to what extent? This is not a trivial matter since any proof of displacement needs to be grounded in counterfactual reasoning. An example would be: ‘Virgin paper production would have been x tons higher if y tons of paper had not been recycled.’ This presentation gives an account of the current theories of displacement in industrial ecology and reviews the existing efforts to substantiate these theories with empirical evidence. It is surprising and troublesome how little empirical work exists to date, given the importance of reuse and recycling in industrial ecology. The second part of the talk presents an empirical analysis framework of displacement and its application to several case studies.”

Product End-of-Life Management Networks

Vered Doctori Blass, Roland Geyer

“Interest in product end-of-life management (EoL), from industry, government and academia alike, has grown tremendously in the last decade. Although theoretically promising, relatively few circular production structures are in practice self-sustaining without government intervention. While reuse and recycling activities are usually studied as circular material and process flows, a closer look at the involved agents reveals more complex product end-of-life management networks. Using the example of EoL cell phones, we introduce an analytical framework for studying EoL management networks. This framework is part of our ongoing research to better understand the relationship between EoL processes, agents, decisions, information, and the resulting environmental and economic performance of reuse and recycling. We seek to understand how EoL networks evolve and adapt to regulations and market conditions, and evaluate these changes based on their impact on economic and environmental performance of reuse and recycling. Understanding how networks of EoL agents and processes evolve and adapt to prevailing and changing regulations and market conditions will help to identify, understand, and ultimately remove existing barriers to reuse and recycling. We first discuss previous research on EoL management and the different dimensions of EoL networks. We specifically explore product characteristics, EoL processes, agents, decisions, and information availability. Then, using the example of EoL cell phones, we illustrate EoL network dynamics.”

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Sustainable Consumption

Understanding the Meaning Behind Sustainable Household Consumption Patterns in Metro Manila by Bridging the Gap Between Social and Environmental Science.

Marlyne Sahakian, Anthony SF Chiu

“The proposed paper is based on a concern for the environmental impact of certain forms of consumption in so-called developing countries and specifically the National Capital Region (NCR) of the Republic of the Philippines with its 10 million residents. It proposes to address the main question: In what way can an understanding of household consumption in the NCR help identify opportunities for more environmentally friendly consumption? Household consumption is analyzed in relation to priority areas in terms of resource efficiency: infrastructure development food consumption household electricity usage and transportation.

There is an idea that developing countries might be able to leapfrog over the errors of more industrialized countries by choosing sustainable modes of development (Chiu 2004 Tukker 2005). But how do we chart the transition? We know what forms of consumption tend to have a higher negative impact on the environment (from material flow accounting life cycle analysis ecological footprint calculations etc.) but we know little to nothing about consumption and consumers in specific contexts (beyond the wealth of information that exists in the private sector from marketing agencies). Industrial ecology and the broader area of environmental science may benefit from theoretical approaches and findings drawn from anthropology that see consumption as socially-embedded thus debunking more conventional views of consumption as a rational individual act based solely on freedom of choice.

Understanding the consumer could be an important element towards achieving more sustainable environmentally friendly consumption in so-called developing countries or what is being called the “new consumer” by authors such as Juliet Schor (1999) as well as Norman Myers and Jennifer Kent (2004). By looking at Metro Manila as an emerging Southeast Asian economy and highly urbanized city with vast socio-economic differences research on consumption patterns reveals the meaning behind the action and discourse of consumers in relation to energy efficiency in the hopes of building one small bridge between environmental science and anthropology.”

Economic and Greenhouse Gas Implications of Delivering Canadian Oil Sands in the United States

Aweewan Mangmeechai, H. Scott Matthews, Chris T. Hendrickson, Michael Griffin, Paulina Jaramillo

“Canada is the largest supplier of crude oil to the U.S. A large investment in emerging Alberta oil sands production could further support U.S. fuel demand. We developed a life-cycle based capital cost and greenhouse gas (GHG) emissions comparison between synthetic crude oil (SCO) derived from Canadian oil sands and existing U.S. crude oil consumption (including imports). The life-cycle boundary includes the extraction transportation refining and fuel combustion. The results show that imported light crude oil shipped long distances could have lower life-cycle emissions than conventional heavy crude oil imported from neighboring countries due to the high production emissions of heavy crude oil and the difference in transportation emissions by mode (i.e. tanker emissions are less than pipelines). Thus importing light crude oil from Norway UK Colombia or the Middle East generates lower life-cycle emissions than importing conventional heavy crude oil from Canada Venezuela Mexico and Ecuador. Across all options the life-cycle emissions of Canadian SCO are distinctively a worst case. The life-cycle GHG emissions of Canadian SCO are 5-20% higher (per MMBtu of crude oil) than the status quo of U.S. domestic and imported crude oil. If the U.S. imports 2 million barrels per day of Canadian SCO of which 1 Million barrels are heavy crude oil we estimated the overall life-cycle GHG emissions of U.S. petroleum will increase by 5 lbs CO2 equiv/million Btu crude oil. The additional domestic capital costs for energy infrastructure will be $4-14 billion (2006 dollars). The levelized costs of producing and transporting Canadian SCO to a U.S. refinery are $0.80-$1.02 per gallon.“

Green procurement of construction materials and products: from Life Cycle Thinking to environmental procurement criteria definition.

Mario Tarantini, Arianna Dominici

"Green Public Procurement (GPP) has been repeatedly acknowledged by European Commission as an important tool within Sustainable Consumption and Production policies to increase innovation and efficiency of use of energy and materials. GPP can be supported by a public procurement market that accounts for about 16% of Community Gross Domestic Product. Anyway to make effective this potential scientifically sounded shared and easily verifiable environmental criteria should be developed and used within procurement procedures.

The paper describes a case study for the GPP of construction materials and products one of the product categories to which the Italian National Action Plan (NAP) gives priority.

Despite the diffusion of some building certification schemes and the availability of some Type III eco-labels (EPDs) of construction materials only limited activities have been since now undertaken in Italy on construction products GPP.

After a description of the general context the paper presents the adopted methodology. The environmental objectives to be met via GPP are defined in the NAP: efficiency and savings in the utilization of resources in particular energy and the consequent reduction of CO2 emissions reduction in the use of hazardous or polluting substances lower levels of waste generation.

LCA has been used to identify the key environmental impacts and the responsible processes along with a literature review of the existing eco-labels and standards and an analysis of the European GPP practices. The product technical characteristics which influence the specific process environmental impact were then defined. Among the possible mitigation measures the ones which show synergies with other economic policies and are in compliance with future as well as current legislation were selected.

The windows case study suggested to adopt a methodology to aggregate the GPP criteria at different construction product scales (materials products components assembly elements). This methodology seems suitable to make a rationale connection among the building and the construction materials environmental performances."

Munich 2058 – Pathways to a Carbon Free City

Stefan Lechtenböhmer, Dieter Seifried, Kora Kristof, Clemens Schneider

“Given the necessity to reduce GHG emissions in industrialised countries 80 to 95% by 2050 it is obvious that our cities – as nodal points of industrialised economies and core emitters of greenhouse gases – have to become virtually “carbon free” soon after the mid of the century. This re-shaping of cities to carbon free ecosystems will not only be a must to prevent climate change but also a major factor of success for their economic perspective. However hardly any larger city has yet made up its mind for this challenge which definitely has consequences for today’s policies and development strategies.

Commissioned by Siemens AG we have analysed two scenarios “Target” and “Bridge” on technological options and necessary paradigm shifts to set Munich the third largest and fastest growing German city on the path to become almost carbon free by its 900th anniversary in 2058. By using the example of a planned combined existing and new quarter for 30000 inhabitants we demonstrate how to realise carbon free city quarters in the near future as a part of the strategy to convert the whole city.

The conclusion of our analysis in which several core stakeholders were engaged is in brief: Technologically an almost carbon free city will be available. However taking this track means significant investment in the restructuring of the urban (infra)structure. But this investment will most probably pay off e.g. by reducing energy costs and by mitigating climate risks. And finally it was recognized by the stakeholders that such a restructuring of the city will not only set an example for others but also offer the city a strong economic perspective profiling it as a leader in developing sustainable urban structures and creating business opportunities in the emerging mega-market of making cities and societies carbon free.”

Developing local Carbon Footprint based indicators using Input-Output Analysis

Hogne Nersund Larsen

“Cities and local communities are asked to respond to the urgent agenda of reducing emissions of greenhouse gases (GHG). Many municipalities have adopted mitigation targets and even developed action plans however these commitments have not always been followed up with sufficient actions to mitigate GHG emissions. Local authorities have often faced a conflict between economic and environmental objectives and part of this conflict arises out of how the causality of emissions is addressed in current emission inventories. It is still common to inventory emissions on a territorial basis so that a city would be responsible for the emissions inside its municipal boundaries. The location of large point sources such as industrial establishments or heat and power plants hence plays an important role in determining the emission level of a municipality. Because large point sources usually produce for a larger set of customers than the local municipality it is sensible to distribute the emissions among all these customers. The Carbon Footprint (CF) has been produced precisely for this purpose. CF methodology focuses on consumption rather than production and is therefore not influenced by fluctuation in production activities. This implies a stronger focus on the environmental impacts resulting from both private and public consumption and investments. The development of Environmentally Extended Input-Output Analysis (EE-IOA) has proven valuable in improving the footprint methodology especially in linking consumption to environmental impacts standardization of the methodology and to avoid cut-off errors. Still improvements have to be performed regarding improving the detail level e.g. introducing more specific Life Cycle Inventory data. Using some of the improvements identified we investigate how an EE-IOA based CF model performs as an indicator of local sustainability in a selection of Norwegian cities.”

The bare necessities: how much household carbon do we really need?

Angela Druckman, Tim Jackson

"An extensive body of literature exists concerning the relationship between the consumption of goods and human well-being. It is largely agreed that in developed countries material needs such as those for food and shelter were basically met in 1950s and since then increased consumption can be construed as attempts to satisfy non-material needs through material goods and services. However there is little evidence to support the theory that increased consumption has led to increased well-being. The reasons behind this are complex and must include scrutiny of the structural environment within which citizens live in addition to aspects of personal choice. In this paper we use a quasi-multi-regional environmentally extended input-output framework of the UK to estimate greenhouse gas (GHG) emissions that arise from the production and distribution of goods and services purchased by UK households. In the framework emissions are attributed to functional uses such as those for housing food and recreation. The framework is used as a basis for investigating GHG emissions ascribable to the attempted satisfaction of non-material needs through the purchase of material goods and also to look at emissions due to the purchase of 'non-essential' goods and services. We explore the extent to which consumers are 'locked-in' to consuming material resources in order to meet non-material needs such as those for participation in society and identity. We also consider what potential there is for reducing material consumption and the associated GHG emissions to a minimal level without compromising basic well-being. The paper concludes with an estimation of the impact this could have for UK GHG emissions into the future and relates this to the legally binding targets set out in the UK's Climate Change Act."

System innovation for Mobility

Theo Geerken, An Vercalsteren, Mads Borup

“The mobility system is an enabling system that allows human activities which are driven or influenced by many other societal systems (labour education production spatial planning tax etc.). Main sustainability problems are the high and still rising contribution to global warming the increase of congestion and the still far too high number of road fatalities.

Results will be presented from the EU funded SCORE! (Sustainable Consumption Research Exchanges) project regarding the need area Mobility. Within the first phase of SCORE! different perspectives (business development (sustainable) solution design consumer behaviour and system innovation policy) were combined to analyse changes towards sustainable consumption in general. In a second phase three need areas (Mobility Agro-Food Housing/energy/ electronics) were analysed from a system innovation perspective based on a number of real implemented cases of SCP.

Changes towards sustainability within the mobility system can happen in three main dimensions: human behaviour vehicle technology and infrastructure. For Mobility the three main strategies are reduction of needs and wants promoting the shift to more sustainable (collective) modes of mobility and promotion of the sustainability performance of all modes of mobility.

A system perspective will be presented including Meta trends and context factors the mobility landscape stabilising factors that hinder rapid change destabilising factors that call for a change windows of opportunity for different actors in the system. A number of concrete cases will be presented and their success and failure factors will be given. Within the Mobility system many lock-in situations exist and these should be taken into account for any effective change. The role of public authorities within the mobility system is very pluralistic as a regulator as an operator as a consumer as a cashier of taxes and many more.”

Lifestyles Consumption and Resource Use in Australia

Heinz Schandl

"Lifestyles household consumption and time use in Australia have fundamentally changed since the 1950s and these changes have contributed to increasing resource use and related environmental impacts. The Australia of the 1950s appeared to be a laid back society however growth in incomes increased interconnectedness with the rest of the world and changes in values have contributed to a convergence of consumption and time use between Australia and other OECD countries. Australia's urban lifestyles and related consumption activities have resulted in growing environmental pressures in Australia and elsewhere.

We present a conceptual framework and empirical analysis of Australia's consumer culture consumption activities and time use patterns resource use and waste and emission consequences. By employing a social science approach we identify household types that share lifestyle and behavioural characteristics and consumption and time use characteristics. The household typology has been established by combining quantitative and qualitative social science methods. The resulting household types and their consumption vectors have been linked to overall resource use by using material and energy flow accounting methods and input-output economics. We discuss how consumption activities and time use patterns have changed since the 1950s and link those trends to patterns and dynamics of natural resource use waste and emissions. We particularly focus on clusters of services in the areas of food and nutrition building and housing transport and mobility because as previous research has shown these are responsible for about 70% of resource use energy use and land use.

We discuss how lifestyles and consumption behaviour may eventually change in the future and show entry points for sustainable consumption in Australia. This research aims to inform policies that create conditions enabling sustainable consumption in Australia."

From Consumer to Prosumer – Development of new trading and auction cultures to promote sustainable consumption

Lorenz Erdmann, Christine Henseling

"With electronic markets and trading platforms in the internet consumer behaviour is changing fundamentally. The user operates not only as consumer at the same time he acts as provider of products and services (e.g. in second hand markets). This offers opportunities for sustainable consumption such as the extension of products' lifespan. Furthermore electronic markets change the attitude towards consumption and possession: from the idea of accumulation of goods towards the idea of auction culture temporary ownership and reselling.

The unique project led by the Institute for Futures Studies and Technology Assessment Berlin is carried out in co-operation with eBay and involves the University of Frankfurt and the Borderstep Institute as research partners. It is funded by the German Ministry of Education and Research (duration: 2008-2010).

An extensive online-survey comprising roughly 3.000 responding eBay vendors and buyers of used products has been finished recently. The interpretation unveils 'hard' behaviour of the users as well as motives and attitudes towards sustainable consumption patterns.

These data provide the empirical input into a quantitative reference model which will be completed by April 2009. The model reflects direct environmental effects (e.g. electricity consumption of being online) indirect effects (e.g. reduced private car traffic for shopping) as well as systemic effects (e.g. additional consumption due to lower prices for single products). The integrated model allows to link lifestyles to environmental impacts.

We have started to develop concrete measures to support sustainable consumption such as climate neutral packaging services regional trading schemes and concepts for a better mobilisation of used products. Whereas the innovation strategies are developed and tested in co-operation with eBay the results of the project address a wide range of actors especially research and consumer organisations."

Material intensity of household products and leisure activities – how to achieve dematerialisation?

Michael Lettenmeier, Sini Veuro, Satu Lähteenoja

"Products are often called resource-intensive services and leisure activities immaterial and thus resource-efficient. However a detailed study on the resource-intensity of 27 Finnish households shows that this assumption may not stand.

During a research project called FIN-MIPS Household the participating households monitored their consumption during a period of six weeks. Using detailed diaries for several consumption areas the total material requirement (TMR) of the households was calculated on the basis of the MIPS concept (material input per service unit). Housing tourism mobility and foodstuffs turned out to be the most resource-consuming consumption areas whereas leisure time activities and household goods and appliances were found to be of smaller relevance.

The paper presents the material intensity of different household products and leisure activities and their influence on the TMR of households studied. The difference between the least- and the most-consuming household was factor 27 with leisure time activities (from 600 kg to 16000 kg per person per year) and factor 10 for the household goods and appliances (from 600 kg to 5900 kg). Leisure time activities include many activities that can be seen as services like visiting a theatre or going to a fitness club or gym. The paper discusses the factors influencing the material intensities and options for decreasing resource consumption. It is pointed out that the material intensity of both consumption fields is a question of lifestyle and the idea of immaterial services vs. resource-intensive products cannot sufficiently address dematerialisation."

How can the consumers' action space be enlarged towards sustainable consumption

Satu Lähteenoja, Elli Kotakorpi, Michael Lettenmeier, Burcu Tunçer

"Moving towards sustainable consumption is a challenge that requires actions from all parts of the society. Even if the consumption choice is considered an individual decision there are many social and structural factors affecting it. When the context of consumption choices is taken into account it becomes clear that information dissemination about better choices is not enough. The paper proposed for presentation discusses the concept of consumers' action space and gives examples on how it can be enlarged. Action space consists of social structural and historical factors that limit or enable sustainable choices.

The paper is based on the conclusions of a research project called FIN-MIPS Household where the ecological backpacks of 27 Finnish households were analysed. The most important con-sumption areas are mobility housing tourism and food. The factors affecting sustainable con-sumption choices were studied by focus group interviews with the households. It was found out that social norms affect consumption choices significantly. This is one reason why consumption choices are not becoming more sustainable although their environmental impacts are obvious. For example as long as travelling is seen as variety widening one's picture of the world travel-ling abroad is unlikely to decrease. Still it is possible for these norms to change. Examples for this are given in the paper.

Civil society organisations (CSOs) can play a major role in the process of changing social norms in order to facilitate sustainable choices. However more dialogue and partnering between civil society and other stakeholders are needed. The last part of the paper introduces a dialogue platform that offers space for creating new solutions to facilitate change towards sustainable lifestyles especially in the fields of mobility housing and food."

Diversifying options for household mobility: Reducing vehicle energy consumption with capacity matching strategies

Kevin Bolon, Greg Keoleian, Lidia Kostyniuk

"Personal transportation accounts for 17 percent of total greenhouse gas emissions in the United States and must be a major component of any climate change mitigation plan. While technological advancements hold promise for improving efficiency and reducing energy consumption uniformly applying the most advanced technology to all vehicles is not cost-effective. A transformational change can be achieved more quickly and at lower cost if the fluctuating and diverse patterns of users' mobility needs are more closely coupled to the capabilities of available vehicles and fleets. Because requirements for passenger and cargo capacity vary from day to day individuals who rely on a single vehicle typically operate with underutilized capacity leading to higher energy consumption and potentially higher costs. The extent to which the set of options is diversified beyond a single vehicle provides an opportunity for more closely matching trip capacity requirements with vehicle capability.

Using data from the National Household Travel Survey for over 60000 U.S. households an optimization model was applied to analyze two different strategies for reducing energy consumption through capacity matching. With the first strategy vehicles in existing U.S. household fleets were optimally assigned to trips. Average fuel savings in the range from 5 to 23 percent was achieved depending on fleet size and composition. Households with more vehicles in the fleet and a more diverse range of vehicles to choose from are able to achieve higher savings than those with more homogeneous fleets. The second strategy of diversifying vehicle choice sets results in even more significant savings. The extent of savings depends on whether diversification is achieved by changing the composition of existing household fleets adding vehicles to fleets or accessing vehicles outside of the fleet on a temporary basis."

Information source and environmentally friendly consumption in the East Asian perspectives

Midori Aoyagi-Usui

"We sought how people perceive and understand the climate change issues and what the motivation for taking actions are. We carried out nation-wide public opinion surveys in 2006 2007 and 2008 in Japan and also three Chinese east coast cities 2005 in Shanghai 2006 in Hong Kong and 2007 in Shenyang. Those surveys are intended to investigate 1) The status of people's information gathering about the environmental issues and people's understanding and perception on climate change risks and 2) the effects of social capital on the actions for reducing environmental impacts from everyday lives. Our results are: 1) People\'s climate change risk perception is categorized into three groups: disasters bio-diversity loss and threatening to people\'s everyday lives 2) Almost of all people felt "world climate is changing" but they know governmental campaign for tackling climate change. People could not feel the "reality" of Climate Change and feelings got people distracted to take actions. 3) Social capital has significant effects on people's actions especially "organizational membership". Also we confirmed the results from the focus group interviews: people's misunderstanding climate change issues: both causes and effects but differently in regions we surveyed.

People's perception on the climate change issues are affected by existing knowledge of air-related environmental issues such as air pollution and depletion of ozone layer. Those misunderstandings are very popular in whole population of the public according to our research results. Although people are realizing "world's climate is changing" they have no clue or can't have appropriate clue for taking actions against it. People are "exposed" those information from TV programs TV commercials or newspaper articles newspaper advertisements by government or private companies but people just "see" them but not "look" at hem or "examine" them carefully. Or even they misunderstood them."

Intensity of resource consumption at district level

Joana Abreu, Daniel Wiesmann, John E. Fernandez, Nuno Clímaco, Tiago Domingos

“Studies have shown that since 2007 most of the human population is living in cities. From a systems point of view urban concentration may provide the means for the delivery and consumption of resources more efficiently but may also generate new complex consequences. Motivated by this context we are developing a method which intends to capture the dynamics of resource consumption in cities.

To define the boundary of analysis regarding the dynamics of material and energy flows in a city is often a challenging task because large gravitational centers are influenced by nearby regions. As a consequence it is not sufficient to analyze only individual cities. Therefore the goal of the authors is to model the material and energy consumption for the Metropolitan Area of Lisbon (AML) on a district level (freguesias) using System Dynamics.

In this paper we will present an aspect of this model which is the characterization of districts in terms of intensity for transportation and electricity consumption. In order to understand the improvement that can be achieved by policies and incentives intended to influence consumer behavior the consumption patterns will be decomposed into structural and behavioral components. Feedback loops will be explored to describe the trade-offs and unintended consequences of these potential measures.

The structural component is the part of the resource consumption that is independent from the consumption patterns and has its roots in the physical structures of the area such as size and age of buildings roads and distance to the center. By normalizing the estimated overall consumption of resources with the structural component we try to obtain a measure for potential savings on the behavioral side of consumption.”

Global patterns of material use: The impact of economic development population and technology on cross country differences of material consumption.

Julia Steinberger, Fridolin Krausmann

“Global human use of materials at the beginning of the 21st century has been estimated to range between 48 and 58 Pg per year corresponding to 8 - 10 tons per capita. The use of these materials is by no means equally distributed around the globe. In the year 2000 industrialized countries although inhabited by only 15% of the world population benefited from 79% of the global GDP while using 33% of all extracted materials in contrast the 11% of global population living in the world\’s least developed countries used only 4% of globally extracted materials. Across countries global per capita material consumption varies by a factor 20: ranging between 2 and 40 tons/cap/yr.

This paper presents a new global dataset for material use for 175 countries for the year 2000 containing information on domestic extraction imports exports and domestic consumption of biomass fossil energy carriers ores and industrial minerals and construction minerals. It explores the differences in the size structure and scale of material use across countries and analyses the socio-economic and bio-geographic patterns underlying these differences. We used multivariate regression analysis to identify the socio-economic factors (population income technology) and bio-physical factors (population density climate) correlated with material consumption imports and exports. The comparison of the four major material categories shows striking differences in global consumption patterns. Our analysis reveals stark distinctions between vital or common materials (biomass and construction minerals) on one hand and economically-driven limited materials (fossils industrial minerals and ores) on the other. We further identify the drivers correlated with specific materials. We discuss the implications of these results for future development and dematerialization.”

Evaluation of Environmental Impact of Different Consumption Patterns based on Input-output LCA and Uncertainty Analysis

Hwong-wen Ma, Ming-Lung Hung, Chia-Wei Chao, Chun-Chieh Wang

“Traditional environmental assessments only focus their evaluations on the supply side and place the environmental responsibilities on the producers. However by ignoring the fact that production is largely driven by consumption the traditional approach disregards the assessments on the consumer side and fails to address issues associated with consumption. Contrary to the traditional environmental assessments on emissions this study utilized the input-output life-cycle assessment approach to examine the direct and indirect environmental load caused by demands and rectify the myth of “no chimneys no emissions”. The demand-side analysis on environmental impacts shows that 20.52%-34.59% of total burden comes from industrial activities to meet household demands and 43.57%-65.91% originates from export activities. This clearly demonstrates that the main environmental burden issues from export activities. This study also combines the scenarios on consumption activities with uncertainty and sensitivity analysis to examine the environmental impacts issuing from different consumer spending and consumption patterns. The differences of consumption patterns of various cities and counties cause the environmental impact to vary as much as 82.82~92.66% of the average values for various impact categories indicating the clear influence of consumption patterns. The results show that while consumer spending has a greater effect on environment impact electricity agricultural and transport and storage needs are also major factors impacting environmental changes.”

The Economic and Environmental Implications of Technological Transitions: Moving towards a low carbon society in Iceland

Brynhildur Davidsdottir, Maria Maack, Elisabeth Unger, Rosa Gudmundsdottir

"The environmental economic and social implications of technological transitions which are required to push the world economy towards a low carbon future and towards SED all need to be assessed. Without such analysis environmentally or economically inferior pathways might become locked in creating both or either economic and environmental inefficiency in the system a result that could be prevented. The research project SMART H2 ongoing in Iceland aims at assessing the environmental social and economic implications of transforming the Icelandic economy towards running 100% on renewable energy comparing the physical potential and environmental/economic/social implications of transitioning the Icelandic transportation sector towards hydrogen biofuels or electric vehicles or something in-between such as plug in hybrids. The overall goal of the project is to build a total impact assessment of transforming to a low(er) carbon society in Iceland with a focus on hydrogen or alternative fuels in addition to alternative motor technologies and measuring the impact through implications for natural social and man-made capital. The motivation is to build a framework that enables comparative multi-dimensional assessment of technological trajectories of different options. This paper presents the analysis of the potential pathways towards a low-carbon future in Iceland in addition to a Well to Tank to Wheel Assessment of the environmental and economic implications of transforming the Icelandic energy system to a low-carbon-system wholly reliant on domestically produced renewable energy."

How to deal with the rebound effect? A conceptual model for a household environmental management system

Pedro Baptista, Nuno Videira

"The rebound effect is a major concern of environmental policy and for the pursuit of sustainability. The real benefits of environmental policies are lower or can even backfire the estimations due to the micro (substitution and income) and macro (input-output economy-wide and transformational) rebound effects.

Conventionally the analyses of Sustainable Consumption and Production have a static vision of the economy leading to the aforementioned effect. Therefore it is necessary to create a new framework for decision making to deal with the natural trend of growth of the economic system. On this line of thought the use of indicators of environmental impacts per euro (EI/€) has a great potential to explore. This approach gives three main guidelines to environmental policy: reduction of working hours redirection of consumption and reduction of the EI/€ of products. In this paper we present a framework for a household environmental management system based on the use of this type of indicators.

Unlike conventional simulators of environmental impacts of private consumption the proposed framework considers all consumption and not only priority categories. In this way the rebound effect is considered which promotes the environmental optimization of the application of disposable income as opposed to a simple "reduction of consumption" policy. The environmental management system receives input data on expenditures and household activities and then generates an environmental profile and personalized measures for improving household environmental performance."

Carbon Saving and Cost-Effectiveness from Efficiency Measures:Improving Decision Making Under Uncertainty

Inês Lima Azevedo, Constantine Samaras

"The US residential buildings sector accounted for nearly 35% of US greenhouse gases emissions (GHG) in 2006. While energy efficiency options are currently being deployed or considered as means of reducing GHG emissions there is still a large uncertainty on the effect of such measures on the overall GHG savings. One major source of uncertainty is determining the baseline emissions displaced via specific efficiency measures. The main objective of our work is to explore the uncertainty in cost-effectiveness (in $/tonCO2 avoided) and in GHG reduction potential of different electricity-related residential energy efficiency strategies accounting for different plausible carbon and energy use factors. We provide ranges of estimates for the cost-effectiveness metrics and GHG savings assuming carbon factors at national census division level Independent System Operator (ISO) areas state time of day and assuming different marginal power plants. For the residential efficiency measures the detailed technology characterization includes annual electricity use number of hours of operation investment cost and lifetime of the technology/appliance. Detailed data on residential technology choice market shares and energy use was adapted from the Annual Energy Outlook (AEO) 2008 underlying data from the Energy Information Administration (EIA). Data on carbon factors came from the E-Grid database from the Environmental Protection Agency (EPA) and from the AEO 2008 underlying data. This study allows decision makers to develop successful residential energy efficiency strategies under uncertainty."

Humanitarian aid and ecological sustainability. The Nicobar Islands in the aftermath of the tsunami

Simron Jit Singh, Willibald Haas

“The paper highlights the role of humanitarian aid in the aftermath of the tsunami in contributing to substantial changes in both qualitatively and quantitatively the social metabolism of the indigenous population of the Nicobar islands. Located in the Bay of Bengal some 1200 km off the East coast of India the Nicobar islands were subject to enormous devastation by the tsunami. Following the catastrophe was another wave in the form of national and international humanitarian aid. Driven by its own logic at helping the Nicobarese were very soon overwhelmed by huge amounts of money and material goods thus increasing consumption levels and causing changes in lifestyle of the population within a very short time. At the same time crucial parts of the pre-tsunami means of production or supply system were made dysfunctional while increasing dependency on aid. The new metabolic profile brings in a high potential for social conflicts in terms of access to resources land leadership social coherence family structure and continued access to aid flows. While introducing the notion of ‘complex disaster’ the presentation will compare the pre-tsunami metabolic profile with that of the present one through the use of indicators such as material use energy use land-use and time-use. Finally the presentation will draw linkages between existing humanitarian aid structures with that of sustainable development and argue for ‘green aid’ in support of sustainable consumption and resource use.”

Industrial Ecology and Systems of Provision

Stefan Goessling-Reisemann, Arnim von Gleich

“Industrial Ecology (IE) is strongly influenced by thinking in nature analogies and metaphors especially with respect to the functionality of eco-systems. Natural material flow systems are seen as role models for designing industrial systems. In the past this has mainly resulted in describing and analyzing the industrial metabolism. The frame of analysis was usually based on product life cycles i.e. from cradle to grave including the use phase. However consumers and their behavior have so far only played a minor role in these analyses. Only recently has the IE community opened up to discussing the topic of \sustainable consumption\” and the role of the consumer. The frame of analysis has thus broadened to include not only the system but also the actors within the system. In the environmental social sciences so far mainly focusing on the consumer a parallel development has taken place which opened up to the embedment of consumers in production and consumption systems the so called “systems of provision” (SOP). While this has extended the frame of analysis from subject to system it has not yet led to the inclusion of material flows or an analysis of their dependence on consumer behavior. The focus has been on quantitative aspects (social actors infrastructures of provision environmental innovations social practices daily routines and environmental heuristics). Here we present an overview of the contact points of the two approaches (SOP and IE) their scientific background and their potential for mutual fertilization. We believe there is some explanatory potential for a combined approach using the scientific rationale from both disciplines. The approach could be facilitated along three different axes:”SOP in IE”□ ”IE in SOP”□ and ”Design by IE and SOP”□. We will support our argument with practical examples and try to lay out a path for a potential research agenda.”

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Sustainable Resource Management

A Scaling Factor for the Timing of GHG Emissions in LCA

Alissa Kendall

"Recent studies have shown the importance of including greenhouse gas (GHG) emissions from land use change induced by biofuel feedstock cultivation in life cycle calculations for biofuels. Land use change GHG emissions occur at the outset of production. When incorporated in life cycle GHG emissions calculations land use change emissions are typically allocated over some assumed time horizon of feedstock cultivation by simply dividing the land use change emissions equally over that time horizon. This method of allocating emissions that occur at the outset of biofuels production underestimates their true climate impact since the impact of GHG emissions scales with the time they reside in the atmosphere.

To address this underestimation a time correction factor (TCF) is proposed that accounts for the climate change impact of emissions that occur at the outset of production relative to their impact when allocated over the production period. The TCF is calculated using a methodology analogous to the calculation of global warming potentials based on the relative cumulative radiative forcing between GHGs emitted at the outset of biofuels production to emissions allocated over the time horizon. Application of the TCF to allocated emissions ensures that by the end of the allocation time horizon the cumulative radiative forcing from the allocated emissions is equal to the cumulative radiative forcing of the actual land use change emissions. For time horizons between 10 and 50 years the TCF falls between 1.7 and 1.8.

The TCF has application to other life cycle assessments (LCAs) particularly those where capital investments in facilities materials or goods significantly influence life cycle GHG emissions intensity. For example the TCF may have particular application in the LCA of photovoltaic"

Ecological assessment of agricultural modernization with ecological footprint in Japan, Korea and China

Tomoyo Toyota, Daisaku Goto, Shinji Kaneko

“Capital intensive agriculture contributes to improvements in land productivity, as lesser land input and more production, while production and use of the capital causes environmental pollution and burden. Ecological footprint (EF) is an accounting framework of the land which is required for assimilating environmental burden. For measuring ecological footprint as required indirect lands, one might consider environmental pollutions discharged from production processes of agricultural machinery and chemical fertilizer and pesticide, carbon dioxide emissions in use of agricultural machinery, water catchments for irrigation water and etc. The EF enables to translate the impacts of various different environmental burdens into the area of land, as a size of environmental externalities. In the process of agricultural modernization, the trade-off between increases in land productivity and ecological footprint can be observed in such a way that harvested land to produce one unit of agricultural product (land input) is declining, whereas the EF is increasing. The study focuses on the optimal ratio between land input and ecological footprint.

First, ecological footprint of non-modernized and modernized grain production in Japan (1930-1954, 1956-1975), Korea (1961-1971, 1972-2002), and China (1961-1978, 1979-2003) are empirically estimated. Second, production functions with two inputs, namely direct land input and indirect land input are specified. Under the several assumptions including that prices of direct and indirect land inputs are same, farmers behave with profit maximization principle and perfect competition of the market, optimal combinations of direct and indirect land inputs are empirically identified for each period. Third, the gaps of annual combinations of these land inputs from the optimal combination are measured.

The study found that relative significance of direct land inputs in the optimal combinations is increased with agricultural modernization. The gaps of annual actual combinations of these land inputs from the optimal are increasing over time for those three countries.”

Case Study: Multi Life Cycle Center

Bernd Kopacek

“This case study shows the implementation of a highly innovative re-use and recycling system for waste of electric and electronic equipment (WEEE). This so called Multi Life Cycle Center will make use of the latest development in automation and information technology in order to obtain an efficient economical and ecological process. In this Center implemented as pilot plant in Vienna Austria WEEE will be transformed back into valuable products. The product groups treated for re-use include IT (information technology) and telecommunication equipment consumer electronics electrical and electronic tools toys and leisure equipment. Regarding all other product groups the collection and recycling will be organized. The management of the reverse logistic system is based on RFID technology (radio frequency identification). The Multi Life Cycle Center follows the philosophy to recover WEEE at the highest possible level starting with re-use of the whole product down to the subassembly and component level and finally to the recycling of materials. This approach is unique in the world and we are going to prove that an eco-efficient re-use of WEEE on a large scale can be feasible by using highly sophisticated technologies. The presented paper gives an overview of the various functions of the Multi Life Cycle Center and highlights two key technologies: semi automatic disassembling and reverse logistic based on RFIDs.”

Evaluation method for Metal Resource Recyclability based on Thermodynamic Analysis.

Kenichi Nakajima, Osamu Takeda, Takahiro Miki, Kazuyo Matsubae-Yokoyama, Tetsuya Nagasaka

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“In both ferrous and nonferrous metallurgical processes ores of natural resources are used as raw materials to produce metals these processes also use secondary resources such as by-products and waste materials. In the case of using natural resources the relationship between the desired elements and accompanying elements is relatively clear. Using metal wheel charts Verhoef et al. [2004] showed metal linkages in natural resource processing and pointed out the importance of consideration of relationships between base metal and its accompanying elements.

On the other hand the combinations of elements in secondary resources are often different from those in natural resources. There are even combinations that are not present in natural resources. Conventional metallurgical processes have been optimized for economical and efficient extraction of desired elements only from large amount of ores under constant grade. Therefore in order to extract metals from secondary resources by the conventional metallurgical process it is necessary to estimate the recoverability of the constituent elements by taking into account their chemical properties well in advance.

In this study we developed the evaluation method of metal resources recyclability based on thermodynamic analysis and made clear the element distribution among gas slag and metal phases during metal recovery based on thermodynamic analysis. In an application of the method shows that Cu and precious metals (Ag Au Pt Pd) present in mobile phones can be recovered as metals in the pyrometallurgy process of Cu in a converter while Pb and Zn can be recovered as vapor. Other elements distributed in the slag phase are difficult to recover. The result of our analysis reflects the trends observed in the distribution of metals in copper metallurgy thereby indicating the validity of our proposed evaluation method.”

Global mapping of in-use stocks of Fe, Al, Zn and Cu

Jason Rauch

"With increasing consumption of metal resources humanity is causing a significant reallocation of metal from in-ground ore deposits to human-built infrastructure. This human-built infrastructure is comprised of material dubbed "in-use stocks" or that amount required to provide various services of which metal comprises an important part. In-use metal stock deposits are growing in size the discards from which feed the recycling stream as a secondary resource of metal. As the world trends towards the principles of sustainability more emphasis is being placed on understanding in-use metals stocks as a sink for mined material and as a source of mineral resources. This study addresses two basic questions at the global scale: where are in-use metal stocks and how much is there?

In-use stocks of Fe Al Cu and Zn representing >95% of the metal mass consumed by society are mapped globally at 1 km resolution for the year 2000. The method relies upon the observed high correlation between in-use stock magnitudes and Gross Domestic Product (GDP) and GDP and the Nighttime Lights of the World. Global maps of in-use metal stocks reveal that a full 25% of the world's Fe Al Cu and Zn deposits are concentrated in three bands: 1) the US Eastern seaboard from Washington D.C. to Boston 2) England Benelux into Germany and Northern Italy and 3) South Korea and Japan. This pattern is consistent across all metals investigated. This contrasts with the ultimate source of these metals in-ground deposits which are more evenly distributed between the developed and developing world. This method provides a fast estimation technique for in-use metal stocks from which the total quantity of in-use metal stocks of any specified geographic region (state/province country world region) can be generated."

Implications of ethanol and climate change on future water environment

Yi-Wen Chiu

“The extensive water consumption associated with the US bioethanol industry has drawn considerable attention since the biofuel boom in 2001. Discrete incidents of local water shortages triggered by individual ethanol facility and irrigation of corn attracted substantial media attention and National Research Council (NRC) of the United States warned about the potential adverse impact of biofuel on water resources. Previous studies by the current authors highlighted the wide spectrum of spatial variations in life-cycle water consumption by ethanol. However given the rapid dynamics of ethanol industry we found that static analysis falls short in providing adequate supports for policy makers on ethanol-water issues. We therefore incorporated a spatially-explicit dynamic modeling to better understand the interaction between the future ethanol development and the water environment.

This study aims to better understand the water stock-and-flow dynamics under various scenarios of the elevated ethanol production. We used system-dynamic model combined with geographical information system in the context of water stock-and-flow model while we had to limit our analysis within Minnesota to maintain high spatial resolution under the current data availability situation. Regional agricultural practices land use demographic changes and climate factors – particularly precipitation and temperature – are taken into account in the model. We expect to deliver the spatially and temporally explicit results of water stress and public water competition in association with the sharp increase of ethanol production. Moreover by translating water stress information into crop water stress index established by Jackson et al. (1981) the potential feedstock production for biofuel will be estimated. The methods and study results will provide critical information in supporting decision-making processes addressing 1) site selection for ethanol facility considering local water availability 2) optimization of ethanol production without compromising water supply to other users and 3) development of local agricultural water conservation plan considering ethanol production.”

Environmental and economic conditions for landfill mining

Joakim Krook, Mats Eklund, Niclas Svensson

“At the conference we would like to present selected results from an ongoing research project aiming to address the environmental and economic potentials of landfill mining (LFM) in Sweden. LFM means the excavation processing treatment or recycling of waste that over the years have been dumped in waste deposits. In the first part of the presentation the environmental potential of LFM on the national scale of Sweden will be quantified in terms of selected impact categories (global warming potential material and energy resource flows etc.). Preliminary results show that this overall potential is huge and could for instance lead to avoided climate gas emissions corresponding to 4–5 times the annual Swedish emissions. Critical factors (efficiency of waste technology transportation distances etc.) determining to what extent such potentials can be realised in practice i.e. in specific LFM–projects will then be discussed. The second and final part of the presentation will solely focus on conditions for realisation. Here we will discuss under what circumstances LFM is profitable and contributes to economic growth. Our ongoing research show that only the raw material value of Swedish waste deposits is beyond 10 billion Euros (€). However no matter how large the economic potential appears on the national scale the realisation of LFM will always be done by actors on the project level. For these individual companies benefits must simply outweigh the costs. There are however many factors that may influence the profitability of specific projects such as revenues for recovered materials efficiency of technology environmental taxes and waste disposal fees labour regulatory compliance expenses and so on. We will categorise such factors into a few critical drivers enablers and barriers for implementation of LFM and discuss them in terms of technology legislation and market interactions.”

Impacts of decoupling on future supply of waste and residues – The case of wood

Witold-Roger Poganietz, Silke Feifel, Liselotte Schebek

“A strategic goal of the European Union is to achieve a sustainable development by decoupling the input requirements and the environmental impact from production. Although this goal aimed to be reached on macroeconomic scale it has to be realized on the scale of technologies. But this will not happen over the whole economy smoothly but rather uneven. Due to this the short run economy-wide effects of resource-enhancing innovations are not straight forward. The “excess supply” of resources could be demanded by other potentially less resource-efficient industries since the changed relative prices of the abundant resources could promote such additional demand. Next to the short-run effects a decoupling will lead to a decline of waste supply in the future. In case of renewables in the short and longer-run the supply of residues could decline. Possibly both effects could constrain the perspectives of a waste-residual based strategy as an additional strategy for achieving sustainable development.

The objective of the presentation is elaborate these divergent effects of decoupling on today’s use of resources and future supply of residues and waste using wood as a case study. Due to its versatile use wood is of exceptional interest. Comparable to some mineral resources for recycling of wood products is connected with downgrading of the recycled good e.g. recycling of paper. Contrasting to mineral ressources wood as a biomass is also part of a biomass-based energy strategy of the European Union it is also demanded by the chemical industry as an element of their “biomass” strategy. This is especially true for wood residuals. The versatile use of wood will raise the complexity of possible outcomes. The discussion will make use of a dynamic material flow material stock model of Germany which grounds on CarboMoG.”

Manufacturing Energy Consumption for Solid State Lighting Systems

H. Scott Matthews, Deanna Matthews, Paulina Jaramillo, Christopher Weber

"Lighting consumes about 9% of the U.S. residential electricity consumption and has been the focus of energy efficiency and conservation programs for decades. With the advent of compact fluorescent light (CFL) bulbs in the past decade consumers have seen cost-effective reductions in their lighting energy consumption versus traditional incandescent bulbs. However CFL bulbs still face resistance due to warm-up time to full brightness overall light color and questions regarding exposure to mercury contained in the lamps. While technological advances are improving the operating characteristics of CFL bulbs the potential mercury hazard continues to confuse and dissuade consumers.

Emerging lighting technologies face similar significant market tests in terms of operating characteristics embedded materials and net energy efficiency in order to achieve widespread consumer acceptance. Solid state lighting (SSL) luminaires are a lighting technology nearing mainstream consumer use encountering these market tests. SSL luminaires comprise a set of power light emitting diodes (LEDs) similar in composition to indicator lights on electronic products but with high brightness and white light color. Operating characteristics of SSL luminaires are easily quantified using standard testing protocols and embedded materials are considered to be non-hazardous. However while SSL luminaires offer great energy savings during use the net energy efficiency is under question as the upstream manufacturing processes for the individual LEDs are energy intensive. This paper examines the life cycle energy consumption of LED manufacturing and potentially the comparison of SSL luminaire use versus incandescent and CFL lighting technologies. Preliminary estimates indicate that a 1mm square LED die requires on the order of 10 kWh of total energy-equivalent to manufacture. Considering an average-sized luminaire with 20 LED in the array this is 200 kWh of upstream energy consumption which easily results in a net energy savings over the life of the luminaire compared to traditional incandescent lighting."

Preliminary Global Cycle of Neodymium

Tianming Chen, Thomas Graedel

“Rare Earths metals are a collection of seventeen chemical elements in the periodic table. They are considered as strategic materials because they are expanding their utilization in high-tech products what’s more there are few effective substitutes for them. Neodymium is one of Rare Earths elements the demand of which keeps growing fastest among all the Rare Earths elements for a decade. Special magnetic and optical properties make Neodymium more and more extensively utilized in electronics lasers and other high-tech products. In order to keep the its demand-supply relation going in a sustainable way I am tracking preliminary global cycle of Neodymium to understand the its cycles to evaluate the potential for minimizing Neodymium dissipation and to investigate the policy-relevance aspects of Neodymium use.”

Material Recyclability Evaluation of Urban Structures using Urban-ore TMR

Eiji Yamasue, Ryota Minamino, Hiroki Tanikawa, Ichiro Daigo, Hideyuki Okumura, Keiichi N Ishihara

“We always discuss on the elemental/material recycling from “urban mine” like not only e-waste but also urban structures as a new resource. However we have to consider the potential problem that the recycling sometimes needs more energy and materials inputs than smelting from natural ore. Thus it is important to evaluate the recyclability of elements/materials in the new resource. We newly developed a framework of Urban-ore TMR (total materials requirement to recycle elements from urban ores UO-TMR)[1] which can be compared with Natural-ore TMR (total materials requirement to smelt the elements from natural ore NO-TMR) reported by Halada et al.[2].

In this study the elemental/material recyclability for urban structure (wooden light-gauge steel and reinforced concrete etc.) has been evaluated using urban-ore TMR. The materials composition in them are determined using literatures (macroscopically) and actual elemental measurement (microscopically) and chronological change in the composition is also considered. Target elements/materials are steel aluminum concrete wood tile and gypsum etc. For the evaluation several scenarios are considered changing the recycling rate. Based on the estimated results the elemental recyclability of the urban structure will be discussed.”

[1] E. Yamasue et al.: Materials Transactions (under reviewing)

[2] Kohmei Halada: Materia Japan Vol.46 No.8 (2007) pp.543-548

Tracking embodied environmental factors in the global trade system: the case of CO2 emissions and material flows

Stefan Giljum, Christian Lutz

"The past years saw an increasing debate on the distribution of the environmental pressures between production and consumption. Whereas production indicators are available from national statistics and in the case of greenhouse gas emissions reported under the Kyoto protocol comprehensive indicators on the environmental responsibility of consumption are still under development. Several so-called multi-regional input-output models have been presented in the literature in the past few years aiming at calculating this type of environmental consumption indicators in a global perspective. The Global Resource Accounting Model (GRAM) is one of these multi-regional environmental input-output models and disaggregates 50 countries plus two world regions and their bilateral trade relations. In earlier work the GRAM model has been applied to investigate the raw materials embodied in international trade. In this paper we present results from a research project funded by the Austrian Climate and Energy Fund in which the GRAM model is extended by a global data set on CO2 emissions provided by the International Energy Agency. We calculate physical trade balances of embodied CO2 emissions of different countries and world regions and thus identify the main net-exporters and net-importers of embodied CO2 emissions in the world economy. As the GRAM model also includes a global data set on material extraction we can for the first time perform a parallel analysis of both embodied material flows and embodied CO2 emissions in the global trade system. Focusing in particular on the European economies we identify the main providers of raw materials for Europe and investigate whether the main resource suppliers are also those countries with the highest export of embodied CO2 emissions. The findings have important implications for the design of policies which aim to increase resource productivity and decrease pressures of consumption on the global climate."

Closing a loop: substance flow analysis of nitrogen and phosphorus in the Finnish coastal aquaculture

Eero Asmala, Laura Saikku

“Ongoing eutrophication is a great threat to the Baltic Sea ecosystem causing e.g. biodiversity loss decreased visibility and anoxic bottoms. Eutrophication is by definition the increase of the primary production in the ecosystem caused by excess nutrients essentially nitrogen and phosphorus. Aquaculture causes relatively small-scale nutrient emissions considering the whole Baltic Sea but the local environmental impact may be considerable in the coastal areas. We used substance flow analysis to identify and quantify the most significant flows and stocks of nitrogen and phosphorus related to Finnish rainbow trout aquaculture which accounts for over 90% of domestic aquaculture production. The production and consumption system of Finnish aquaculture is fairly open. In 2004–2007 the average input of nutrients to the system in form of fish feed was 829 tonnes nitrogen a-1 and 115 tonnes phosphorus a-1. Around one fifth of these nutrients ended up in human consumption. Of the primary input 70% of nutrients ended up in the Baltic Sea directly from aquaculture and through waste management. Fish feed used in Finnish rainbow trout production originates entirely from outside of the Baltic Sea drainage resulting as a large net flow of nutrients to the Baltic Sea basin. The nutrient cycle could be closed partially by using local fish in rainbow trout feed instead of imported fish. This would also act as a restoration method as nutrients from the Baltic Sea would be removed in form of fish. In our scenario the net nitrogen load of rainbow trout aquaculture would be reduced to one fourth and phosphorus load to a fraction.”

Food feed fuel fibre or nature? Towards sustainable land use – a life cycle multi-criteria approach

M. Brandão, R. Clift, Milà i Canals, L. Basson

"As part of strategy to reduce greenhouse gases (GHGs) emissions government policy worldwide is promoting the production and use of potentially renewable energy from biotic sources. This policy also contributes to other political and social objectives such as reduced reliance on fuel imports and increased income to farmers and rural communities. Debate over the benefits of biofuels is intense and many issues deserve attention including the limited potential of energy supply from biofuels and bioenergy competition for land with food crops and other land uses and rising food prices. A further significant issue is the high variability and sensitivity of study results regarding potential reductions in emissions of greenhouse gases and changes in carbon immobilised in the soil and in above-ground biomass.

This research has investigated the potential role of UK land use (LU) in contributing to reducing global net carbon emissions and simultaneously providing other ecosystem services. The objective is to identify more sustainable land use options in the UK by systematic Life Cycle Assessment (LCA) to identify emissions of GHGs associated with different types of land use along the complete chains of land-use products with focus on food and bioenergy systems. This required the improvement of existing LCA methodologies on carbon accounting. Other LCA developments include the modelling of impacts of land use on ecosystem services and biodiversity.

The LCA results are combined with economic analysis of different crops and cultivation regimes using a form of Value Chain Analysis (VCA). The results are combined to give a model of environmental impacts and economic benefits which provides the basis for multi-objective optimisation (MOO) to compare different scenarios and profiles of land use. The results can be used as input to Multi-Criteria Decision Analysis (MCDA)."

Advisement and results related to the range of coverage and the substitution of selected metals

Dominic Wittmer

“Within past decades the material input into the anthroposphere grew steadily. For most materials notably metals this effects an increased production which cannot be covered at large by recycled material. Therefore maintaining technical metal cycles is currently highly dependent on the primary production. However the unrestricted longterm availability of metals was increasingly doubted and reconsidered in recent years due to rising demands. As a result of this the range of coverage i.e. the quotient of metal reserves and annual production was adjusted downwards and new questions arose regarding future scarcity of metals. Consequently several studies were performed on future use and availability of metals including “criticality reports” that linked these two levels successfully. However new mining activities that could lower such impending scarcity are often linked with increasing economic and ecologic efforts per ton of metal. Research in this field is still fragmentary and not sufficiently structured. The study addresses this linkage between rising metal demands by hypothesising that such above-mentioned efforts are high for metals with low coverage.

Firstly an overview on the relative environmental impacts of the primary production of metals is presented. The study aims at comparing those with economic efforts. Secondly apparent drawbacks for the coverage are addressed: To provide a basis for sustainable resource management the definitions and the process of determination of the coverage are reviewed for selected metals. The study aims at estimating and classifying the uncertainties of the coverage. Finally the study investigates the trend of coverage for selected metals by comprising trends for their use intensities. Beside reuse and recycling substitution shows a potential to decrease the environmental impacts due to balances on their specific environmental impact. The results shall clarify the need for qualified data on primary production in order to evaluate metal cycles to the full extent.”

Non-destructive recycling: a latent opportunity for meeting the 2050 carbon emissions targets in industry

Julian M. Allwood, Jonathan M. Cullen, Rachel L. Milford

"The need for a reduction in global carbon emissions of 50-80% by 2050 is widely accepted and the process of translating such cuts into policy has begun. The production of just five key materials—steel concrete plastic paper and aluminium—contributes 20% of global CO2 emissions. Given that demand for each of these materials is predicted to more than double by 2050 it is important to critically review current emission reduction strategies to see whether they are sufficient to meet the proposed targets.

There are three key emissions reduction strategies under discussion: improved manufacturing process efficiency increased recycling energy supply decarbonisation. By analysing the global flow of these materials and their associated emissions it is shown that the carbon targets cannot be achieved using existing strategies alone even if the yet-untested technologies proposed were rapidly and universally implemented. Nevertheless this analysis demonstrates that the targets could be achieved despite doubled demand if a proportion of all discarded material were re-used directly with non-destructive recycling.

Non-destructive recycling (NDR) describes the re-use of material in which the energy intensive structure is not destroyed but instead only modified in shape or form. It results in significantly lower carbon emissions because the energy intensive processes required to deconstruct the structure (e.g. melting scrap metals re-pulping paper fibres crushing concrete) and to form new products (e.g. extruding plastics forming metals papermaking/drying) are no longer required. The physical reality of such re-use is discussed with examples. However it is unlikely to be pursued by industrial based research programmes or in current policy because it falls outside the financial interests of the sector. Therefore support from governments and other funding agencies in the form of research initiatives and policy change will be required."

The role of the automobiles for future aluminium recycling

Daniel B. Mueller, Sebastiano Scacchetti

“Compared to other metals aluminium has a relatively short history of use by humans. The stock of aluminium in use is therefore growing fast. As a consequence aluminium is mainly produced from primary resources (bauxite ore) while scrap availability is still relatively small limiting the potential for recycling. Recent studies showed that one of the largest and fastest growing reservoirs of aluminium in use resides in automobiles. Of particular importance are engine blocks made of cast aluminium because they constitute the largest aluminium component in new cars replacing cast iron engine blocks and because cast aluminium engine blocks can be made from aluminium scrap of any alloying composition providing a lot of flexibility for recycling.

In order to understand future aluminium demand for the automotive industry as well as potential scrap availability from end-of-life vehicles it is important to understand the dynamics of the automobile stock and its penetration of aluminium. In this presentation we show the results of a dynamic model for aluminium in the Norwegian automobile stock. The simulation results show that aluminium scrap from automobiles is increasing rapidly over the next few decades as more aluminium cast engines reach end of life. Since engine blocks can currently only be recycled as engine blocks this will significantly limit the role of engine blocks as a sink of other aluminium scrap. As the cast aluminium engine block reservoir saturates this imposes significant limitations to the strategy of downcycling frequently employed today. These limitations would become even more urgent if the combustion engine will be replaced by alternative engines that do not require classical engine blocks. New recycling strategies need to be developed to maintain the value and composition of aluminium which includes better sorting strategies of post-consumer scrap.”

Determining the best options for improving global energy efficiency

Julian M. Allwood, Jonathan M. Cullen

“Improving the efficiency of energy use will play a crucial role in the global effort to reduce carbon emissions. However the current basis for selecting between efficiency options appears to lack any clear or consistent physical basis. Previous attempts to explore energy efficiency options provide useful technical examples but rarely prioritise the options described. At best efficiency options are ranked according to their marginal costs of reducing emissions however these studies survey only known technologies identified in current research and development. However in assessing the long-term benefits of energy efficiency technologies it is important to remove the influence of today’s market drivers from the assessment. Therefore this analysis compares efficiency options based on their physical potential for improvement at the global level.

The first part of the analysis tracks the global flow of energy from primary energy sources (such as fossil fuels and renewables) through numerous conversion steps to final services (such as thermal comfort illumination and transport). Particular emphasis is given to the technical elements of this flowpath: energy conversion devices (for example engines motors furnaces and lightbulbs) and passive systems to which energy is delivered (for example vehicles buildings and factories). The second part of the analysis assesses the efficiency with which energy is converted in the global energy system by considering the multiple conversion steps along each energy flowpath. Exergy efficiency (or availability) is used as a measure because it allows devices to be compared to their theoretical ideal and takes into account the “quality” of energy or its ability to perform useful work. The global loss of energy in conversion devices is then broken down into useful categories. The result is a consistent platform based on technical engineering limits which can be used to direct future research and policy initiatives in the area of energy efficiency.”

Challenges in closing the cycle for scarce metals in consumer products – an industry perspective

Christina E.M. Meskers, Christian Hagelüken

“Consumer products in particular electronic devices contain a large number of elements as a highly complex mixture of metals plastics ceramics and glass. As such they represent a considerable material resource in society. The recovery of materials from End-of-Life products in a sustainable manner contributes to materials supply security a decreased environmental impact of metals production and a positive societal impact.

Typical for consumer goods is also their relatively short life time high number of devices high global mobility and multiple changes of ownership which results in an open life cycle for these products and the materials in them. At End-of-Life not all products are recycled due to inefficient collection or disappearance in illegal export flows. During recycling losses occur as well. Metals are not recovered because they do not enter the appropriate recovery process because of lack of (efficient) technology or economic drivers for example. This affects steel copper or aluminium recovery but even more the recovery of scarce metals like gold silver palladium or indium.

A transition towards a closed product and material life cycle requires a holistic approach and a suitable array of tools. The former includes looking at the entire life cycle each stage and the interactions within on a global regional local and product/process level. In addition it has to include technical economic legislative and societal aspects.

Suitable tools take into account the detail and complexity necessary for analyzing and quantifying what happens. This can range from more macroscopic (regional) material flow analysis or carbon footprint calculations to microscopic (detailed) calculations of recoveries and environmental impacts or advanced recycling and process models on a process or plant level. Combined in a complimentary manner they can provide necessary information for quantitative evaluation of the current situation as well as for the transition towards closed life cycles.”

Material Constraints of new Energy Pathways

Rene Kleijn, Ester van der Voet

“The supply distribution and use of energy is connected to large flows of materials both in the form of the energy carriers themselves and in the form of materials that are needed for mining processing and transport infrastructure. We have used a combination of life cycle assessment and a dynamic material flow analysis to compare new energy pathways to existing ones on the basis of material inputs en CO2 emissions. We considered pathways related to both electricity generation and mobility. The results show that although some technologies have the potential to significantly reduce CO2 emissions the generally require larger and less basic material inputs. Furthermore it is shown that if these new technologies were to be scaled up to the level of the current world demand for electricity and mobility the amount of material needed can exceed the current total world supply of these materials. The work suggests that an energy transition to non-fossil and/or CO2 neutral energy pathways will lead to a substantial increase and diversification of material demand. This in turn will lead to higher levels of mining and exploration with all economic social and environmental effects that are connected to this. In some cases the material constraints might even be show-stoppers. Cases that will be discussed are the hydrogen economy battery electric cars and carbon capture and sequestration.”

Closing the loop: implications of multi-generation extension to secondary batch planning decisions in aluminum production

Gabrielle Gaustad, Elsa Olivetti, Randolph Kirchain

"Compositional variation within scrap streams defines one of the long-term challenges for increased recycling. This is due in part to the presence of high levels of unwanted or "tramp" elements for example iron and silicon in the case of aluminum particularly in post-consumer scraps. Recent literature on this issue cites several causes for this accumulation of elemental impurities including inherent contamination during processing as well as ineffective segmentation at end-of-life. Previous work by the authors has shown that certain modeling techniques specifically chance-constrained optimization provide a tool to increase the potential for usage of recycled materials as well as manage compositional uncertainty for single generation batch planning. However devising strategies to mitigate the problem of accumulation requires an extension of these models to comprehend a multi-generation closed loop recycling system. Previous research examining the accumulation of tramp elements in recycled streams has generally neglected economic implications and the active role of stakeholders within the recycling system. In order to consider the important trade-offs between economic and environmental impacts it is necessary to consider them in combination. The expansion of batch planning models to multiple generations aims to address some of these shortcomings. Results from this multi-generation model will be compared to results in the literature that make use of a variety of methods including: 1) historical extrapolation of material flow analysis and 2) simulation based models. Initial results suggest that it is possible to identify and inform proactive production strategies that reduce accumulation and therefore increase scrap use compared to these cases."

The Heat Exchanger Network Optimization of the Glyphosate Production System

Wangyuan, Yuan Zeng-wei, BI Jun

"The wastewater from pesticides or glyphosate production system has seriously polluted the environment. As one of the largest producers of glyphosate in the world most of China's glyphosate production is of large energy consumption and serious wastewater pollution. This study targeted at a large Pesticide Group in China and applied the industrial metabolism analysis to its glyphosate production system. Through the quantitative analysis of the water metabolism in the glyphosate production system the main water-using units were checked and screened. On this basis this study applied the pinch design method to the main water-using units to optimize its water network in order to minimize its water consumption and waste water. The result showed that the glyphosate water system was found to be of a few shortcomings including the redundancy of the steam units the single heat exchanger network with a large steam usage and a serious waste of condensate and a lack of the water-reusing. Among which the methanol and triethylamine recovery units were both the main steam consumption units. Therefore the one-way energy integration to the single process was applied to these two units to maximize the recovery of its internal heat and to reduce its external steam consumption and waste condensate. In other words first realized the heat exchange between the hot and the cold material flows in a single process or device then the rest material flows were heated or cooled by the public utilities."

Sustainable resource management in food production – the ecological backpack of food products

Holger Rohn, Michael Lettenmeier

“Within the field of nutrition numerous important social ecological and economic aspects are involved: The food industry belongs to the most significant economic sectors worldwide and the increasing population of 9-10 billion in 2050 will cause a growing demand on food. Changing lifestyles especially the global rising consumption of meat and dairy products enhance environmental damage like erosion soil degradation biodiversity reduction climate change etc. Concerning resource consumption the share of the food sector amounts to approx. 20% (German situation). Moreover our health and wellbeing are the direct result of healthy or unhealthy nourishment and influence follow-up indicators like work productivity.

In terms of sustainability it is crucial to optimize both the products and their ingredients and the production processes along the whole value chain in relation to ecological social and economical aspects. This must cover the whole life cycle of the products from the extraction of raw materials to the processing industry distribution/trade phase of consumption to recycling and disposal.

To use more sustainable ways of fulfilling food needs it´s essential to create systematic knowledge of the demand of natural resources for providing different agricultural products (herbal- and livestock-production food and energy-products). A broad overview of average material intensities for different foods is still lacking. To specify the material flows caused by agriculture and food products the MIPS methodology (Material Intensity Per unit Service) can provide relevant data and information.

The authors would like to present research results from different research projects in the sector of food and nutrition which provide a first overview of material-intensities for selected products form herbal- and livestock-production as well as estimates for subsequent processing. This will include an outlook on next possible steps and important research questions for the material-intensity evaluation and a more sustainable resource management of food production and consumption.”

A Tale of Two Countries: Patterns of Iron Use in China and India and Their Global Impact

Tao Wang, Daniel B. Müller

“Patterns of iron use in China and India were investigated by tracking the historic flows of production trade and use of iron products and assessing the material stocks embodied in buildings infrastructure and capital goods-in-use. For China the study was conducted with two complementary approaches: a top-down approach that characterizes the national iron cycle in 1950–2005 and a bottom-up approach that examines the stocks of several hundred iron-carrying product categories and their iron concentrations. For India the analysis was mainly made from a top-down angle. The results show that in 2005 China’s iron stocks have climbed to approximately 2.0 metric tons per capita (t/cap) with a current increase rate of 8% per annum. Nearly half of the iron is contained in buildings followed by 30% in industrial equipment and 14% in infrastructure. With a pace of urbanization and the development of manufacturing industry less rapid than China India’s iron stocks have reached 0.5 t/cap of which the majority can be found in construction. But the rate of stock increase is accelerating in recent years. These patterns of iron stocks reflect the two countries’ rising need for goods and services and the diversified features of iron utilization in providing these products. If China and India sustain the current growth rates of iron stocks a saturation level of 8–13 t/cap observed in several developed countries will be reached in the period 2025–2035 in China and 2065–2075 in India. China may require an additional 15–27 Pg (109 metric tons) of iron in the coming decades and the requirement of India is expected to be 17–31 Pg. A significant fraction of today’s globally known iron ore reserves (containing about 79 Pg of iron) is likely to be depleted and truly extraordinary energy and environmental consequences will be caused.”

Comparing the Life Cycles of Bioenergy Feedstocks to Choose the "Best" Biofuel

Shelie Miller, Jim Chamberlain, Saumya Sarkar

"Governments around the world are mandating the use of biofuels as fossil fuel substitutes. Although there is some debate regarding the extent to which biofuels should be promoted it is clear that biofuels will continue to become an increasing proportion of our global energy portfolio. If biofuel adoption is inevitable it is necessary to take a close look at the types of bioenergy crops we are growing and determine their relative environmental profiles and optimal use. Prior life cycle analyses have indicated that the major environmental impacts associated with biofuels are land use and water quality impacts. In order to use land resources effectively bioenergy crops are compared on the basis of nutrient and land use requirements in order to determine their relative impacts. Twelve current and potential bioenergy crops are compared on the basis of their energy yield land use climate change and eutrophication potential. None of the chosen feedstocks is preferable in all four categories however some interesting trends emerge. Oilseed crops such as soybean and rapeseed tend to have the most unfavorable profiles whereas sugar crops (sugarcane sugar beet) perform well in almost all of the chosen categories. Algae also indicate significant potential to have relatively few environmental impacts. Factors such as indirect land use change and technological barriers to implementation will also be discussed."

Increasing use of secondary and renewable materials in production planning

Elsa Olivetti, Gabrielle Gaustad, Frank Field, Randolph Kirchain

"Increasing the efficient use of both secondary (recycled) and renewable (bio-derived) resources provides one strategy in achieving more sustainable consumption. Secondary recovery enables reduced energy use forestalls depletion of non-renewable resources and avoids the deleterious effects of extraction and winning (albeit by substituting some effects of its own). The benefits for renewables including carbon sequestration reduced energy use and non-renewable depletion remain controversial for many current technologies but the trend in technology development is promising.

Use of either secondary or renewable materials suffers from at least one shared barrier related to economic implementation – increased quality variation in incoming raw materials. In many instances variability in quality is larger for raw materials derived from waste or bio-derived sources than that from more conventional resources (i.e. primary or synthetic sources). Controlling variation is crucial for producing materials that reliably meet quality specifications. The most prevalent batch planning tools a key means for production planning in process industries overestimate this disincentive and thereby underutilize highly variable raw materials. This research examines the benefits in terms of increased recycled and renewable materials use of one approach to batch planning that explicitly considers feedstock variability a chance-constrained (CC) model formulation. This work examines the pervasive nature of quality variability management through examples in both recycled and renewable materials contexts including cases from industries such as metals recycling rubber processing and biomaterials production. Methods to manage feedstock variation could benefit a broad range of seemingly disparate industries by enabling incorporation of increased amounts of secondary and renewable raw materials. We explore the generality of the benefits of a CC-based batch planning model over more conventional batch planning strategies the drivers of that benefit and the conditions that maximize benefit."

Urbanization in China and its implication for iron and steel industry

Mingming Hu, Stefan Pauliuk, Tao Wang, Daniel B. Mueller, Gjalt Huppes, Ester van der Voet

"Urbanization is a key driver for material demand in China which has significant implications for global raw material markets especially metals. We focus on iron and steel in this paper. China has become the largest iron and steel consumer as well as the largest producer in 2007 China accounted for 36% of world crude steel production which can be attributed to a large extent to the growth of Chinese cities and transport infrastructure. Therefore understanding the development dynamics of the building and infrastructure systems in China is essential to forecast China's future iron and steel demand and its impact on the global iron and steel industry. Residential construction and demolition has a major share in China's primary iron and steel demand and secondary scraps supply. A dynamic MFA model was developed to analyze the dynamics of the rural and the urban housing systems. This model is expanded to specifically cover the iron and steel demand and the scrap availability from housing demolition. The evolution of China's housing stock is simulated from 1900 through 2100. For almost all scenario calculations the simulation results indicate a strong drop in new housing construction demand over the next decades which will cause a significant decline in iron and steel demand from the housing sector. The magnitude of this drop in construction activity and iron and steel demand depends heavily on the assumed lifetimes. Most scenarios show that the demolition level will not change significantly in the next couple of decades releasing relatively small amounts of scrap for recycling. Only with extreme short life times for the houses built during the first building surge starting first half of the Nineties as expected by some specialists will the drop in housing production be less severe and will scrap come on the market earlier. The service lifetime of China's houses is the most relevant factor for the long-term behavior of iron and steel in dwellings which not only depends on the quality of houses and city infrastructure but also on cultural economic institutional and political factors and is therefore worth to be investigated further."

A model for assessing food production systems' sensitivity to phosphate rock shortages at the world scale

Marion Dumas, Roland Scholz

"Phosphorus is an indispensable and non-substitutable resource as agriculture is impossible if soils do not hold adequate amounts of this nutrient. Phosphorus is also considered to be a non-renewable and increasingly scarce resource as phosphate rock reserves – as one measure of availability amongst others – are estimated to last for 50 to 100 years at current rates of consumption. The work we present is a thought-experiment by which we imagine that we run out of phosphate minerals for fertilizer production and we estimate by how much and over what time scale food production would decline in different regions of the world all other factors kept stable. To this end we build a simple stochastic simulation model where annual phosphorus flows are computed on a yearly basis reflecting the important plant-soil nutrient dynamics the distribution of cropland and grassland soil erosion the recycling flows of food products and their imports and exports between regions. The world is divided in regions to reflect the natural constraints stemming from climate soil properties and those stemming from management and past fertilization histories factors which all influence the vulnerability of a given region to the potential shortage.

The model aims at bringing together several decades of research and measurements from soil science plant nutrition and long-term agricultural experiments from around the globe to explore the structure and vulnerability of the global agricultural phosphorus cycle. It also creates the basis to construct future trajectories for management of this resource such as building up reserves in the poorest soils and getting closer to a closed-cycle by effective recycling of waste flows. The first results from three different regions will be presented in addition to the model and database structures on which they are based."

Impacts of PHEV and Renewable Energy Technologies on Marginal Displacement of GHG Emissions

Jarod C. Kelly, Gregory A. Keoleian

"Gasoline and diesel automobiles dominate current personal transportation in the United States. The automotive industry has been developing PHEVs (plug in hybrid electric vehicles) in response to increased concerns related to US reliance on these petroleum products and the adverse effects of the related GHG emissions. The wide spread acceptance of a need to move away from reliance upon these fuels has lead to the emergence of public interest in PHEVs for personal transport. PHEVs reduce reliance on liquid fuels by coupling a traditional internal combustion (IC) engine with electric motors and batteries. Some PHEVs are driven entirely by an electrical motor. This differs from current hybrid vehicles which can use the IC engine to drive the automobile. For short trips (~50 km) PHEVs are expected to be capable of running entirely on battery power thus all electrical power would come from the existing electrical grid. For longer journeys an onboard IC engine would provide the needed energy.

As PHEVs achieve market penetration the current electrical grid will be subject to increased demands to meet the additional capacity of charging the PHEV batteries. Half of the US grid electricity is generated from burning coal a highly carbon intensive fuel source. In order to drastically reduce GHG emissions a transformation of the grid to renewable sources is required. Wind and photovoltaic energy systems are the fastest growing renewables that can generate electricity and displace carbon intense sources

It is important to understand how the grid will respond to the penetration of both PHEVs and renewable energy technologies specifically photovoltaics and wind turbines. It is equally important to quantify the impact that those technologies will have on GHG reduction. This paper looks at the impact of increasing electrical demand by simulating this new PHEV load with historical electrical demand data. This new load will place increased stress on the current electrical system and require more electrical power supplies to be dispatched to meet that load. An analysis is conducted to examine the mix of generating assets (renewable vs nonrenewable)that would be utilized in a test case that explores deployment of PHEV in Texas. The findings show the reductions in GHG emissions given in grams per mile driven for differing rates of PHEV penetration and for the type of renewable technology used photovoltaics or wind turbine. All results show a significant decrease in GHG emissions versus the baseline of traditional automobiles and the current electrical grid."

Potential Dematerialization of the Australian Economy

Graham M. Turner, Heinz Schandl

"Dematerialization has been proposed as a general means for reducing an economy's resource use and output of wastes and emissions. We test the long term dematerialization potential for Australia in terms of materials energy and water use as well as CO2 emissions. We create a dematerialization scenario based on specified efficiency targets for major sectors. Using the Australian Stocks and Flows framework we model all system interactions to understand the contributions of large scale changes in technology infrastructure and lifestyle to decoupling the economy from the environment. Major improvements are introduced in the construction and housing transport and mobility and food and nutrition sectors in the Australian economy and coupled with significant reductions in the resource export sectors these substantially improve the current material energy and emission intensive pattern of Australia's production and consumption system. The modelling shows a considerable reduction in overall natural resource use while energy and water use decrease to a much lesser extent because a reduction in natural resource consumption creates a trade-off in energy use. While related CO2 emission trajectories also show a large reduction they are insufficient to achieve proposed targets for avoiding dangerous climate change. The results also show that trade and economic growth may continue but at a reduced rate compared with a business-as-usual scenario. Additionally there are important impacts on labour employment in many of the sectors associated with high material flows. The eventual level of dematerialization achieved depends on the socio-economic response to these labour force issues highlighting the role of the rebound effect. It is evident from our results that Australia cannot rely on incremental efficiency gains but has to undergo a sustainability transition to achieve a low carbon future to keep in line with the international effort to avoid climate change and resource use conflicts."

Energy and Civilization: A history of energy production and consumption in a global cultural technological and economic context

Carolyn Mattick, Eric Williams, Braden Allenby

“Global energy production has a history of complex and interdependent interactions with the human population. From hunter-gatherer societies to the current industrial/knowledge (or production/consumption) economy innovation led to the discovery and utilization of fuels with increasing energy densities which led to further innovation resulting in a positive feedback loop of increasing productivity. However with greater productivity came greater output growing incomes and expanding consumption accompanied by increasing emissions and waste in developing nations. Further concerns that oil production may reach a peak with no obvious substitute point to great uncertainty regarding the future of global energy availability.

This paper looks at historical trends of energy production and consumption in a global context. The work centers on historic energy production and consumption data for primary sources of energy: from biomass for food and fuel to renewable sources such as water and wind to fossil and nuclear fuels. Population and economic data from the same time frames are then overlaid to highlight parallels and trends. Finally causes and effects in the quantitative data are analyzed through the qualitative lens of cultural and technological theories such as those discussed by Jared Diamond David Landes and Arnulf Grübler.”

Resource Management and Integration of a Sea Water Pumped-Storage System in the island of São Miguel

Filipa Amorim, André Pina, Carlos Silva, Christos S. Ioakimidis, Paulo Ferrão

“The energy system of the islands of Azores is an isolated autonomous energy system with limited prospects of inter-connection due to the large depth of the sea and the diversity of the territorial dimensions. At the same time this energy system is largely dependent on imported fuels for the diesel/heavy oil engines exposing the region to the economic burden of fluctuating global oil prices. However there is significant renewable potential with São Miguel - the largest island in the Azores - presenting a number of different potential sources (e.g. geothermal wind hydro). Future investments plans show a commitment by the local government to increase the RES penetration yet this investment is limited due to the low base demand during the nights which makes necessary the use of a storage system. Such a solution could be the Sea Water Pumped-Storage system which could store excess energy from weekends and night hours so to be used during peak hours. In this way it could be able to have increase installation of different renewable energy sources while it would be economically and technically viable. The scope of this paper is to present how the above multiple and complicated (due changes through time) integration of the different renewable energy sources in the energy system of the island can be properly managed in such a way so that to be profitable as well as sustainable for investors and local people.”

Billions and Billions: Reusing Non-Hazardous Industrial Waste

Marian Chertow, Carlos Camara Ortiz, Tara Parthasarathy

"The largest waste stream identified in US environmental policy is the category called non-hazardous industrial waste with generators in industries such as electric utilities pulp and paper and food processing. Huge quantities of wastewater and solid materials constituted the nearly eight billion tons estimated by US EPA in the mid 1980s at a time when municipal solid waste (MSW) was closer to 200 million tons. It is attention to the billions and billions of tons of the vast resource of non-hazardous industrial waste that following significant reduction through cleaner production can be put to use as a mainstay of industrial symbiosis activities in the US and around the world. This paper reports on data and information from the only US state that comprehensively tracks detailed information about non-hazardous industrial waste. Since 1994 the State of Pennsylvania has tracked 110 material categories and 13 waste destinations including four types of recovery from all generators discarding at least 13 tons per year. From these data lifecycle estimates of environmental measures and other quantification have been completed and are reported here. Total waste declined from 700 million tons in 1994 to 525 million tons when wastewater is included. For solid residues total generation declined from 37 million tons to 20 million tons. Trends in reuse and disposal are shown through GIS mapping so that when and where materials are found can be figured into a broader program of sustainable resource management."

Measuring resource productivities of motor vehicle and liquid crystal display industries in South Korea

Sangwon Suh, Yunhwa Chung, Kelsey Jaeger, Brian Remackel, Sang-Jun An

“Resource productivities of Motor Vehicle (MV) and Liquid Crystal Display (LCD) industries in South Korea are measured for priority resources for the years 1995 2000 and 2003 using hybrid input-output accounts (IOAcc). Priority resources are surveyed for these industries and input-output tables are augmented and hybridized using data gathered for those resources. Resource productivities of these industries are measured by life-cycle resource embodiment per unit production both at each material-level and also at an aggregated level using material-specific weights. Sets of material-specific weighting factors are developed considering scarcity price volatility and supply-security. The results show general trends of improvement in resource productivities of these industries for the selected resources. For instance according to the results South Korean MV industry achieved 23% - 39% reduction in iron and steel use per unit Korean Won (KRW nominal) of product between 1995 and 2003. More reduction has been achieved by ‘Trucks’ and ‘Heavy equipment vehicles’ than ‘Passenger cars’ and ‘Buses’. Uses of copper aluminum and molybdenum per a KRW of production by MV industry during the same period however have been increased in 3% - 13%. LCD industry reduced the use of iron and steel copper and aluminum by 6% - 15%.”

National Environmental Indicators for the Mining Sector of Slovenia

Slavko Šolar, Ana Burger, Deborah J. Shields

“Information sharing and public participation are two important aspects of sustainable resource management. Indicators are a tool that can be used to monitor progress toward sustainability goals and also keep the public debate informed with relevant accurate and integral information. The goal of the Slovenian National Mineral Resource Plan (NMRP) is to ensure sustainable mineral resource management. By regulation the NMRP must have a Comprehensive Environmental Impact Assessment (CEIA) that has been approved by the Ministry of the Environment. Both the NMRP and its subsidiary CEIA have the same environmental goals: minimize negative environmental impacts of present minerals supply / extraction and assure access to resources for future generations. Indicators are a mandatory part of a CEIA' which is consistent with and complements the NMRP's monitoring and reporting requirements on environmental as well as economic and social aspects of mining activities. Furthermore the exercise of creating a set of environmental indicators was a welcomed action to fill the gap on the environmental dimension as that data had not previously been collected. A set of 19 indicators has been created that comprises information on: air water soil (agriculture land) landscape (mining) waste climate change material flow nature conservation cultural heritage local community health and safety access to resources. The indicators were populated with data by extracting mineral information from existing environmental and other existing databases and also by minor supplemental data collection. Sources included the EU minerals indicators set the Slovenian Environmental Agency the Ministry of Economy the Statistical office of Slovenia the Geological Survey of Slovenia and other data sources. The first round of data collection and interpretation has been completed. It has been made available to decision makers and the general public providing them with a more complete picture of the Slovenian mining sector and its contribution to sustainability.”

Life cycle assessment of an integrated biofuels production system in Brazil

Simone Pereira de Souza, Sergio Almeida Pacca, Claudinei Andreoli, Márcio Turra de Ávila

"Sugarcane and palm oil plantations produce the highest biofuel yields per area 6 to 7.5 thousand liters of ethanol per ha and 3.5 to 7 thousand liters of vegetable oil per ha respectively (UNICA 2005 LIMA et al 2000). About 30% of the life cycle energy input in ethanol production in Brazil comes from diesel consumption during the agricultural and transportation phases. It is expected that the future expansion of mechanical harvesting which is supported by the law phasing out pre harvesting burning will increase diesel consumption for ethanol production. Therefore we propose an alternative system of sugarcane production in which part of fossil fuel inputs are displaced by palm oil. The proposed combined cropping scheme aims to reduce fossil fuels consumption and their corresponding greenhouse gas (GHG) emissions thus increasing the sustainability of sugarcane's ethanol production. We assessed the effects of substituting B30 for diesel in tractors and trucks used in ethanol production. Based on 7000 liters of ethanol per ha and 4000 liters of palm oil per ha yields we calculated the net energy ratio and GHG emissions of the biofuel systems. The energy intensities and greenhouse gas emission factors were obtained from EBAMM and GREET models. The net energy ratio for biodiesel and ethanol separately produced was 10 and 6 respectively. The GHG emissions of the coupled system using the B30 use was 26% lower than emissions due to ethanol production using diesel. This reduction corresponds to 18% when the full ethanol life cycle is considered. In order to run such a system we estimated that for every 28 hectares of sugarcane it is necessary to cultivate 1 hectare with palm trees so that the B30 demand for ethanol production is met."

Supply chain carbon footprint model for forest industry in New Zealand

Barbara Nebel, David Drysdale, Julie Sandilands, Ian Nicholas

"Changes in consumer and retailer demands are driving substantial changes in the value chains related to New Zealand's primary industries. There is an increasing expectation that products should have sustainability credentials and that these can be verified. Cabinet agreed in September 2007 to the development of a comprehensive strategy for greenhouse gas footprinting for the land-based primary sectors. A key part of this strategy is the development of sector-specific methodologies for GHG footprinting based on life cycle assessment approaches. The results will be used to allow each sector to learn about their specific GHG emissions in producing a product and will also provide the information and tools to measure manage and mitigate emissions along a supply chain. Given the differences between specific primary sectors the development of sector-specific methodologies in New Zealand will also provide guidance (and a comparison) as to the robustness of generic methodologies for measuring the GHG footprint of a primary product.

For the forestry sector an average results for log production was generated. Case studies for saw milling particle board production bioenergy and pulp production were also undertaken. Based on the case studies generic guidelines for these sectors were developed. This will enable other players to implement the approach more easily. A key aspect in the study was the uptake and storage of carbon during the useful lifetime of the product.

Similar projects are undertaken for the kiwifruit wine lamb and dairy industries. Collaboration between these projects ensures that a significant part of the primary sector in New Zealand will be represented based on the same underlying data and methodologies."

Dynamics of the interrelationship between material cycles: the case of nickel and stainless steel in 2000 and 2005

Barbara K. Reck, T.E. Graedel

"Metals are indispensable materials in industrialized societies. Their use has grown exponentially over the last century and continues to grow due to increasing demand from rapidly developing economies. Metals are used in elemental and in alloy form. Some substitution between metals is possible it is generally driven by availability and price. This study investigates the life cycles of nickel and stainless steel through material flow analysis. Nickel is an example of a widely utilized industrial metal which is selected among other reasons for its toughness high-temperature stability and elevated corrosion resistance. Stainless steel is a corrosion-resistant high-performance alloy made of iron and chromium. It is produced in different chemical compositions most commonly classified into austenitic and ferritic grades. Nickel and stainless steel are highly interdependent: 74% of stainless steel crude production is for austenitic grades that contain nickel. The nickel used for austenitic grades corresponds to two thirds of refined nickel production. For both materials this study provides detailed life cycles for more than 50 countries eight regions and the world for the years 2000 and 2005. The cycle starts from ore extraction in the case of nickel and alloy production in the case of stainless steel and it includes fabrication and manufacturing use and waste management and recycling as main life stages. The analysis shows how the two material cycles are interdependent in terms of demand and supply for primary and secondary materials. It also demonstrates how their relationship has changed over the time period investigated. While in 2000 austenitic stainless steels were exclusively chromium-nickel grades this rate dropped to 85% in 2005 following the rapidly increasing nickel price during this period. Chromium-nickel steels were substituted by chromium-manganese ones a trend initiated by India and China and still ongoing."

How uncertainty issues affect life cycle GHG emissions and energy efficiency of biodiesel

João Malca, Fausto Freire

"Many studies have addressed the environmental life cycle (LC) impacts of biodiesel but they often neglect data uncertainty assessment and the implications of modeling assumptions which affect the results and compromise the reliability of the studies' outcomes. This research addresses uncertainty issues –namely related to parameters and concerning how co-product credits are accounted for (uncertainty due to modeling choices)– in the LC modeling of RME (rapeseed methyl ester biodiesel). An evaluation of the implications in terms of energy savings and avoided greenhouse gas (GHG) emissions of RME as an energy carrier displacing fossil diesel (FD) has been performed based on a systemic description of a typical European RME life cycle. In particular emissions from land use change have been estimated which result in different carbon stock change values. Energy renewability efficiency and GHG emissions of RME have been calculated in terms of probability distributions using system expansion three allocation approaches and ignoring co-product credits. Primary energy savings and avoided GHG emissions when RME displaces FD have been also calculated: 0.7–1.0MJ of primary energy and 37–65gCO2eq per MJ of FD replaced depending on the co-product evaluation method chosen. It was found out that uncertainty due to modeling choices is more relevant than parameter uncertainty when assessing the energy renewability efficiency while parameter uncertainty dominates over scenario uncertainty in the calculation of greenhouse gas emissions. Avoided GHG emissions show considerably higher uncertainty than energy savings mainly due to land use (nitrous oxide emissions from soil) and land use conversion (carbon stock changes). Another important source of uncertainty arises from glycerin's various potential uses which generate very different credits and depend on market conditions. Results demonstrate the relevance of applying uncertainty approaches and emphasize the need to reduce uncertainty in the LC modeling of biofuels so that sound decision making can be reached towards improved sustainable resource management."

Climate Infrastructure Analysis for Sustainable Resource Management: How Fast Should We Build? How Fast Can We Build?

Constantine Samaras, Inês Lima Azevedo

“Climate policy in the U.S. is beginning to gain momentum and it is likely that a framework for GHG emissions trading is forthcoming. A disconnect remains both in the academic literature and public discourse between climate economic analysis and climate infrastructure analysis i.e. differences in prescribed technologies and the reality of funding construction and integration of new technologies. The establishment of a carbon allowance price does not directly and instantly result in emissions reductions via new power plant infrastructure. Flow analysis and methods from industrial ecology can assist stakeholders improve climate policy and resource management under this reality.

Using data from the U.S. EPA and U.S. Energy Information Administration we construct a model to assess the stocks and flows of U.S. power plants from 1950-2006 as well as the build rates capacity and GHG emissions. We then use a bounding analysis to prospectively examine the required rates of U.S. future power plant construction under carbon constraints. In addition to the uncertainty in approximating input flow and useful life variables we include the uncertainty regarding the construction time from permit approval to commencement of operations. This time lag generally measured in years has the ability to considerably affect the number and build rate of low-carbon plants required to meet emissions reduction targets (e.g. 80% below 1990 levels by 2050). Our results show achieving specific considerable emissions reductions from U.S. power plants by 2050 is more difficult than currently envisioned absent a climate emergency that induces widespread deployment.

The methods and results of this analysis are critical to both integrated sustainable resource management and climate policy. By thinking about the timing and magnitude of climate infrastructure construction society can make informed choices on mitigation options and better plan for the final demand for material resources such as steel cement and copper.”

Applying the sustainability potential analysis framework on scarce metals supply systems and identifying implications for sustainable scarce metals supply management

Patrick A. Wäger, Daniel J. Lang

“Until recently only little attention has been paid to potential supply restrictions for geochemically scarce metals. However with the mass diffusion of emerging technologies - which have functionalities that are significantly depending on such metals - this issue is rapidly gaining in importance.

According to the National Research Council (2008) significant restrictions to supply may occur due to the following reasons:

(1) demand may increase significantly and unexpectedly

(2) relatively thin (or small) markets may find it difficult to quickly increase production if demand increases significantly

(3) supply may be prone to restriction if production is concentrated in a small number of mines a small number of companies or a small number of producing countries

(4) minerals whose supply consists significantly of byproduct production may be fragile or risky

(5) markets for which there is not significant recovery of material from old scrap may be more prone to supply risk than otherwise.

In our contribution we will take Sustainability Potential Analysis (SPA) described by (Lang et al. 2007) as a framework to evaluate primary and secondary scarce metals supply systems from a systemic sustainable development perspective. Sustainability Potential Analysis (SPA) applies criteria which refer to evolutionary developmental and cybernetic system theories and are among others: performance and efficiency well-structuredness interdependencies with other systems buffering capacity and resilience.

The analysis will be based on a description of the characteristics and particularities of selected scarce metals supply systems with focus on the interdependencies governing the dynamics of scarce metals supply systems (i.a. the interrelations between primary and secondary supply systems).

In view of establishing governance structures that allow to sustainably manage scare metals supply and demand we will briefly discuss some implications of the analysis for key actors on different societal levels (company branch state international community).”

The metabolic scale of the world economy in the past century – dynamics drivers impacts.

Marina Fischer-Kowalski, Fridolin Krausmann, Julia Steinberger, Nina Eisenmenger

“This contribution will a) present material flow data by material categories for the past 100 years on a global scale on the basis of a newly developed and cross-validated database b) show the results of a decomposition analysis of global material flows to identify the drivers of this dynamics. Several long term country case studies both from industrialized and from developing countries will be used to validate and in some cases to more clearly specify the results of the decomposition analysis. c) We will explore into the potential impacts of each of the component material flow categories in the form of mind maps that can be partially quantified. d) By the parameters attained we will construct future scenarios for global material resource use make an attempt to evaluate them concerning environmental impacts and discuss the relevance of existing and potential policy targets.”

Ecological assessment of agricultural modernization with ecological footprint in Japan, Korea and China

Tomoyo Toyota, Daisaku Goto, Shinji Kaneko

“Capital intensive agriculture contributes to improvements in land productivity, as lesser land input and more production, while production and use of the capital causes environmental pollution and burden. Ecological footprint (EF) is an accounting framework of the land which is required for assimilating environmental burden. For measuring ecological footprint as required indirect lands, one might consider environmental pollutions discharged from production processes of agricultural machinery and chemical fertilizer and pesticide, carbon dioxide emissions in use of agricultural machinery, water catchments for irrigation water and etc. The EF enables to translate the impacts of various different environmental burdens into the area of land, as a size of environmental externalities. In the process of agricultural modernization, the trade-off between increases in land productivity and ecological footprint can be observed in such a way that harvested land to produce one unit of agricultural product (land input) is declining, whereas the EF is increasing. The study focuses on the optimal ratio between land input and ecological footprint.

First, ecological footprint of non-modernized and modernized grain production in Japan (1930-1954, 1956-1975), Korea (1961-1971, 1972-2002), and China (1961-1978, 1979-2003) are empirically estimated. Second, production functions with two inputs, namely direct land input and indirect land input are specified. Under the several assumptions including that prices of direct and indirect land inputs are same, farmers behave with profit maximization principle and perfect competition of the market, optimal combinations of direct and indirect land inputs are empirically identified for each period. Third, the gaps of annual combinations of these land inputs from the optimal combination are measured.

The study found that relative significance of direct land inputs in the optimal combinations is increased with agricultural modernization. The gaps of annual actual combinations of these land inputs from the optimal are increasing over time for those three countries.”

Understanding Linkages Among Resources

E. van der Voet, T.E. Graedel

"Various categories of resources are crucial for the survival of humanity, such as energy, materials, water and land. Each of these is the subject of a wide research field, including statistics and database creation, modelling, technology development and assessment, scenario development and forecasts, indicator development, etc. Although these research communities operate independently, the insight grows that the use of these different resources is related, and that these linkages need to be taken into account to assess developments and identify progress on the road to sustainable development. An already well known example is the relation between land and energy, especially related to land-requiring bio-fuels. A transformation towards a bio-based economy may thus lead to unwanted side-effects in the area of food provision. A similar linkage can be expected with the use of water: presently, already 70% of water use is for agriculture; when crop production must be multiplied because of energy crops, the water requirement rises as well. Another important linkage is discovered between energy and minerals: the energy demand due to decreasing ore grades may require energy levels unforeseen in the established energy forecasts. And there are many more of such examples. To go forward on the route of sustainable development, it is essential that such linkages are identified and quantified, and that the approach to sustainability becomes truly interdisciplinary. We will present a number of specific examples of resource linkages and discuss how those linkages may constrain options in ways heretofore unidentified."

5th International Conference on Industrial Ecology

2009 ISIE Conference

Visions on new IE-based paradigms toward Sustainability

How Complex are Subway Networks?

Sybil Derrible, Christopher Kennedy

“The study of complex networks is a growing field in Industrial Ecology. Public transit systems consist of stops/stations linked by transit vehicles they are obvious physical networks. Considering public transportation is gaining importance around the globe the objective of this research is to analyze transit networks seeing how complex they are and how they grow.

In this research we look at 33 subway networks in the World. First we use graph theory to transform transit networks into workable graphs where all nodes and links are itemized. We then try to identify a pattern of development. As far as complex networks are concerned emphasis is put on transfer-stations as they are the hubs of public transit. The third step is to compare them to scale-free networks that are traditionally categorized as being “natural” networks. The principal measure is calculated via a histogram showing the number of stations for each node degree (number of lines shared per station). A scale-free network systematically follows a power law distribution.

From this point forward we can effectively assess how complex subway networks are. We find that subway networks are scale-free networks. However where a degree exponent between 2 and 3 is typical for such networks subway systems lie between 2.5 and 4. What is more this number does not seem to change as network grows. In fact larger systems tend to dwell around a degree exponent of 3. Consequently it is possible to build a model on how transit networks should grow. The results may help transit planners to design better suited and more attractive transit networks.”

From Life Cycle Analysis (LCA) to Life Style Analysis (LSA)

Timothy Gutowski

“In this talk we use the Input/Output LCA technique to estimate the environmental impacts for 19 different life styles (ranging from the homeless to the very rich) in the United States. This approach requires detailed personal information (mostly obtained from personal interviews) and has all the advantages and disadvantages of the input/output technique. For example it can address the impacts associated with one’s economic life but on a highly aggregated basis. In spite of these and other issues (which will be addressed in the talk) the approach has several significant advantages: 1) It reorients the discussion to focus on how people live rather than about the details of products. We believe this to be a far more productive viewpoint for addressing sustainability. 2) The method takes into account the so-called rebound effect. 3) With the appropriate national data one can verify the accuracy of this modeling technique by returning national average impacts from national average expenditures. 4) The method offers a way to evaluate potential improvements associated with life style changes and 5) The method clearly reveals certain system effects. For example from this study we were able to determine a national impact floor. That is there is a level below which no one drops. For the case of CO2 even the most modest life styles in the United States (homeless person member of the Amish community Buddhist monk) never dropped below 8.5 metric tons (Mt) per year. While this is less that half the U.S. average (20 Mt) it is still about double the world average. The method also revealed significant constraints on voluntary actions to reduce ones impacts as well as possible paths forward.”

Principles of Ecology:
Analogies for Resilient Regional Eco-Industrial Development

Paul D. Jensen, Malcolm R. Bailey, Lauren Basson, Emma E. Hellawell, Matthew Leach

"The triple-bottom-line benefits delivered through the successful implementation of industrial symbiosis (IS) by the United Kingdom's National Industrial Symbiosis Programme (NISP) are manifold. It is recognised that many of the synergies (IS company agreements) have arisen to-date on an opportunistic one-to-one basis. The one-to-one synergies delivered by NISP have significantly aided the UK's drive for greater sustainability whilst also making a considerable contribution toward the country's Kyoto Protocol obligations. However it is argued in this paper that possessing the ability to implement IS in a systematic manner on a regional basis viz. regional eco-industrial development would generate cumulative triple-bottom-line benefits above and beyond those already being delivered.

The proposed framework for regional eco-industrial development is based on the practice of modelling industrial processes and developments on systems observed within nature which led to the emergence of the field of industrial ecology. Although a considerable amount of research has already been conducted on the metaphoric comparison of anthropogenic industrial systems and biospheric ecosystems this paper argues that the ecological sciences posses further as yet unexplored insights into the genesis evolution and maintenance of complex ecosystems suitable for providing the foundations of a model for resilient eco-industrial development.

By exploring the concept of an IS conducive environment the paper presented will detail how ecological theories and concepts such as energy-stability-area theory niche theory keystone species and island biogeography theory can all be used to inform regional spatial strategies and planning. In addition the paper will present the practical application of the theoretical research via GIS based strategic IS planning maps for the UK. This work suggests that planning spatial developments based on the concept of an IS conducive environment will allow for the systematic evolution of industrial ecosystem resilience and thus industrial ecology driven sustainable development."

A framework for sustainable development processes

Philip Sinclair, Damiete Ogunkunle, Roland Clift

“It is a generally accepted principle that sustainable development requires participatory processes involving the interactions between human economy society and the environment. These processes encompass communication learning and decisions. Part of the challenge of sustainable development is to find frameworks within which these processes can be undertaken effectively.

Building on existing frameworks for decisions that are provided by Multi-Criterion Decision Analysis (MCDA) Multi-Objective Decision Making (MODM) and other processes such as Life Cycle Impact Assessment (LCIA) and Cost-Benefit Analysis (CBA) this presentation will propose a framework which includes all these processes as specific cases and therefore provides a basis for developing further possibly more comprehensive processes. The framework recognises that all participatory processes must be iterative and also reflexive in the sense that information must be able to pass in both directions between participants and domains of knowledge. The construction and use of this framework will be illustrated using case studies including some carried out in the sustainability assessment of bioenergy in the UK. Other potential applications of the framework will be discussed.”

Succession Ecology as an Analogue for Sustainable Community Development

Michelle Adams

“It has been suggested that succession ecology follows an orderly predictable progression of ecological change towards a stable ecosystem in equilibrium with the surrounding environment. Secondary succession is normally initiated with either a catastrophic disturbance to the current system such as a fire or hurricane or evolves more slowly due to alteration in resources such as those resulting from climate change (e.g. changes in precipitation pattern). These predictable patterns have provided some of the foundation for restoration ecology the process of “kick-starting” the succession process through human intervention. In effect restoration ecology is an attempt to follow the pattern of succession ecology in a more timely nature. This work hypothesizes that the redevelopment patterns found within succession ecology may be expanded beyond the restoration ecology and provide a methodological approach that could facilitate sustainable development within (human) communities as well.

Like the precursors to the succession trigger the underpinnings of communities typically give way in two fashions: (a) the catastrophic collapse where for example the sudden loss of a major economic driver (such as a mill closure) could be likened to an ecological event such as a fire or (b) the gradual alteration in resource patterns where the gradual decline in the world-wide economic value of pulpwood for example could be likened to a decline in water supply due to changes in precipitation. Within a natural system the barriers and drivers to the successful evolution of that system are related to the biophysical needs of the participating species as they interact and compete for resources and how resources are introduced and cycled within the system. It is intended to show that by evaluating these interactions and cycles which are already known to ultimately result in a stable ecological system an analogue may be developed to provide insight on how to support and alter the economic social and environmental interactions and cycles needed to promote sustainable development within communities.”

Agent-based scenario analysis: a new approach to planning industrial ecosystems

Ruud Kempener, Jim Petrie

“The success of an industrial ecology depends on the exchange of energy and resources between different entities within the system be these industrial organisations business units or public infrastructure services. Although each organisation may commit to optimise resource use within the ecosystem of which it forms a part their performance is also affected by exogenous events which can affect their activities and objectives now and in the future. Future uncertainty and its implications for organisational activities makes it difficult to design and plan industrial ecosystems over long periods of time.

This presentation discusses the use of agent-based scenario analysis as a methodology to explore different potential futures and their consequences for the performance and evolution of an industrial ecosystem. The methodology combines scenario analysis with an agent-based model which describes how organisational behaviour affects the dynamics of resource exchange over time. Firstly conventional scenario analysis is used to develop a set of possible futures on the basis of different uncertain external factors (e.g. different assumptions about the future oil price the effects of globalisation population growth etc.). Subsequent to this a set of different agent-scenarios is developed each describing different organisational responses towards future uncertainties captured by the scenarios and how these responses affect strategic investment and exchange decisions of entities within the network. In combination this agent-based scenario analysis provides a number of “worldview scenarios” each consisting of a set of different evolutionary pathways which reflect the consequences of different organisational responses towards future uncertainty. This set of possible evolutionary pathways can subsequently be used to explore how interventions (either from external agents such as government instrumentalities or eco-industrial park management or from organisations within the industrial ecosystem) might affect the sustainable development of the system.

The structure and implementation of this agent-based scenario analysis is demonstrated using a case study of a regional bioenergy network in South Africa.”

Mineral Carbonation as the core of an Industrial Ecology for Energy-Intensive Minerals Conversion

Jim Petrie, Geoff Brent

"As the planet grapples with the real consequences of inaction against climate change the ability of the minerals sector to survive in the longer term is likely to hinge on innovative solutions to the challenge of energy intensity and CO2 management. Carbon capture and storage technologies are perceived as attractive mitigation options for CO2 release. However the focus to date has been almost entirely on geo-sequestration and there is little confidence in such a technology being deployed in time and at sufficient scale to make a major impact on desired CO2 reduction targets. As an alternative mineral carbonation the reaction of carbon dioxide with magnesium silicate minerals such as serpentines represents a thermodynamically favourable safe and readily auditable route to the sequestration of carbon dioxide. But this technology is itself both energy intensive and resource intensive though our modeling studies have shown that at a plant level a net sequestration capability of about 85% is possible for capture-ready CO2 steams under realistic conditions. Opportunities for its successful deployment will require innovative thinking beyond this process plant boundary to give due consideration to all material and energy life-cycle issues and to optimize its integration within the energy-minerals complex.

Industrial Ecology represents a framework within which synergistic opportunities for material and energy exchange are exploited to the mutual benefit of all partners in a collaborative network.

This paper explores the potential of situating a minerals carbonation plant at the heart of an integrated minerals-energy complex to stimulate its own industrial ecology. Consideration is given to energy minimization water conservation by-product utilization and waste management. The added value created by such a complex has the potential to significantly off-set the direct costs and energy penalties of mineral carbonation. What this suggests is that greenfield minerals beneficiation and metals refining plants should consider closer integration with the power production and energy provision plants on which they depend and where mineral carbonation is a critical element of such integration. Whilst this is a conceptual study the insights generated go some way to the promotion of sustainable practices within the minerals sector."

Strategies and tools for refashioning the social metabolism: IE as a key to the transition to sustainability

Edgar Hertwich, Marina Fischer-Kowalski, Reid Lifset

"The world has acknowledged the lack of environmental sustainability of our current development. Both exhaustible and renewable resources are rapidly being depleted biogeochemical cycles are being altered with fundamental implications for ecosystems and the climate and some toxic trace substances have reached disconcertingly high concentrations. Ayres and Kneese recognized already in 1969 that environmental externalities were pervasive significant and a systemic feature of our economic model. Sustainable development requires taking into account the material and energy flows causing these externalities controlling these flows to address the array of problems sketched above. We briefly outline the required redesign of our social metabolism using the need of reducing GHG emissions to 1tCO2e/person-year for illustration. We argue that IE is indispensible for a transition to sustainability: (1) A fundamental understanding of the evolution of social metabolisms provides insights into development patterns socio-ecological connections and required changes. (2) A systematic evaluation of the efficacy of proposed transition strategies and their energy material and ecological implications allows society to avoid costly mistakes such as biofuel mandates. (3) Specific solutions need to be designed implemented and evaluated. An understanding of metabolic organisational behavioural political and economic dimension can assist the development and diffusion of specific solutions. (4) Transition strategies will focus simultaneously on micro meso and macro levels changing the technology and aspiration of households the systems and infrastructure of provision and global production networks and resource governance. Metabolic measures that are consistent across levels allow us to study the interaction of simultaneous changes on several levels complex systems approaches offer insights into the emergence of phenomena on a higher level. Justifying planning and assisting the transition to sustainability pose a tremendous challenge and a momentous opportunity to our field. As society gets serious about making the transition IE practitioners have plenty of work on the micro- and meso levels. As an emergent property however sustainability can only be understood on the macro level challenging us to find ways to reflect the macro-level implications of actions on the lower levels"

Co-Evolutionary method and toolbox for Agent Based Modeling of industrial network evolution

Igor Nikolic, Christopher B. Davis, Emile J.L. Chappin, Gerard P.J. Dijkema

“Industrial and infrastructure systems are an essential part of human society and are critical if it is ever to become sustainable. They can be viewed as complex evolving multidimensional (social technical and biogeochemical) networked systems.

We conjecture that in order to sufficiently understand and manage these socio-technical systems so that they emerge sustainable behavior we need models that match their scale complexity and co-evolutionary nature.

In order to eventually capture the full diversity and adaptivity of the \'world system\' and specifically the industry and infrastructures that sustain it we have therefore developed and evolved a modular approach for developing models of infrastructure evolution which mimic the structural properties of the real world. Our co-evolutionary modeling method we envisioned as a four dimensional coupled fitness landscape. This landscape consists of the the technical design of the model (a modular Java based simulation engine) a staged and tested social process that enables model specification and a knowledge formalization process for creating a formal ontology and a process for facts collection.

The ultimate goal of this co-evolutionary method and the models created by it is to underpin decision-making in or on infrastructure systems. In the paper we will introduce the basic requirements necessary for creation of the evolving modeling and illustrate the adaptive approach for Agent Based Model development by showing a series of ever more complex models. Spanning Flow Based evolution combination of infrastructures a range of regional industrial clusters and the global metal network this series of models span increasingly complex cases and knowledge domains.”

Green Islands Project: An integrated socio-techno-economic framework towards the implementation of a sustainable energy system in the island of São Miguel Azores

Carlos Santos Silva, Christos Ioakimidis, Paulo Ferrão

"The island of São Miguel in Azores Portugal consists in an isolated autonomous energy system largely dependent on imported fossil fuels even though the island presents a significant potential of renewable sources such as geothermal wind and hydro. The Azores government is striving to transform the energy system of São Miguel by leveraging locally available renewable resources increasing end-use energy efficiency and designing advanced energy grids. Together with the MIT Portugal Program it launched the Green Islands Project to design and implement a sustainable energy system for the island of São Miguel based on the Industrial Ecology metaphor namely on the urban and social metabolism as a new framework to design a sustainable region.

The scope of this paper is to present the framework that is being developed to design and implement a sustainable energy system. Such a framework involves modeling multiple future scenarios based on technological and economical trends and then analyze these scenarios under the social political economic and environmental needs of the island. It also requires the design of new energy related products and services that will allow achieving the chosen scenarios. Further the framework enables the dialog between the different stakeholders by bringing to the same level of understanding the technical economical and social constraints and requirements of a sustainable energy system.

The paper describes how different industrial ecology tools such as life cycle analysis cost benefit analysis or energy systems planning are used at the different stages of the Green Islands project defining in this way a general methodology that can be apply not only in the design of a sustainable energy system of an island but also at energy systems of local urban or regional spatial scales."

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Chapter 3

POSTER SESSION 1

Designing Sustainable Cities - The Urban and the Social Metabolisms

How does network size affects the energy use of subway systems?

Sybil Derrible, Christopher Kennedy

“Considering the current environmental problems the world is facing it is no under-statement to say that public transit is a key component to reduce greenhouse gases emissions. As urbanization on the planet is increasing past 50% public transportation systems are likely to grow. While transit is more efficient than other modes of transport such as the private automobile not much work has be done on the impact of network growth on energy use. How does the energy consumption of transit networks change as these networks grow? Since we are more concerned with the relative energy consumption the main indicator here is energy use per ride.

For this research we look at 19 subway networks around the world. In terms of data the interest lies in energy use network size and ridership. Energy use is collected in mega-joules (MJ). Network size is considered as total track length (km) and number of transit units (wagon). Finally ridership is accounted for in number of rides per year. Previous work has shown a decreasing marginal effect of adding new stations (1). This means that increasing the number of stations does not increase ridership linearly. Energy use however tends to be linearly related to track length although it decreases with the number of transit units this is somewhat expected. What we finally find is that energy use per ride remains fairly constant in all networks studied from the small Lyon Metro to the large London Underground namely it is independent of network size.”

(1) Derrible S. Kennedy C. Network Analysis of Subway Systems in the World Using Updated Graph Theory. Presented at 88th Annual Meeting of the Transportation Research Board Washington D.C. 2009.”

Could we learn it from honey-bees (Apis mellifera)?

Tamara Galonja-Coghill, Ana Prcic, Djordje Mrkic

“Human development characterized by industrialization and urbanization has distanced human civilisation from its natural environment and threatens to endanger his existence. Therefore great attention has started to be given to the concept of sustainable industry agriculture tourism and urbanism.

As the ecological niche of today’s man described by both human habitat and human habitus encompasses entire Planet there are more and more species marked as pests being exposed to merciless extinction which is particularly apparent in agriculture.

Being social creature man develops through its community. In bridge with human communities there exist other who express their modus vivendi and modus operandi in a manner that does not endanger its environment and yet have lived and evolved besides and with man.

This paper gives the example of honey bee (Apis mellifera) society elegantly designed according to the requirements of sustainable development and makes a comparison with human society based on few elementary postulates of sustainable development:

• elastic and adaptable social arrangement as a prerequisite of harmonic co-habitation within constantly changing natural environment

• ecological building including ecological materials and flexible planning and design enabling both species to base their activities in more than one eco-system

• mutually beneficial relationship with other species

Futuristic designs alone may not be the ultimate solution to urban development at least as long as there are useful examples in natural world from which we can learn.

And then Homo SAPIens and Homo APISiensis could meet in a point of life harmonically fit into environment.”

Monitoring the House sparrow Passer domesticus population at different scales of urbanization Coimbatore India

Dhanya R, Ranjini J, P.A. Azeez

"House sparrows are symbionts of humans and reflect the state of the urban ecosystem. As the extent and level of urbanization increase the existence of this bird is in predicament. The present research addressed the status of House sparrow along an urban to rural gradient and the distribution of species at different scales of urbanization. The habitat variables which will determine Sparrow population of different grades of urbanization are also studied. Attempt is made to resolve cause of decline of the species.

The study was conducted along an urban to rural gradient at Coimbatore India. Coimbatore is an important industrial city of Southern India and holds the eleventh position in India in terms of population. The area includes reserve forest villages and urban areas. Bird surveys were carried out in the representative points selected at equal distance along the transect which runs form core to the periphery of the urban area. Satellite imageries were used to determine the scales of urbanization and categorized as urban suburban and village. From each category grades (Point count n= 30 50m radius) were taken to study the distribution of the species. For assessing the habitat variables satellite imageries and Global Mapper were used.

The sparrow density declined as a function of urbanization. Among the three categories of urbanization levels distribution of the species was high in commercial zone. The Habitat variables Open area influenced the population positively where as built area was negatively influenced.

Decline of this synanthropic species reflects an unhealthy urban ecosystem. The house sparrow distribution among different grades will help as to conserve them by monitoring the habitat variable which they prefer. Hence the current study deduced the repercussions of urbanization on avifauna."

Legal and Policy Aspects of Developing Ecocities

Asanga Gunawansa

"One of the recent initiatives towards responding to the problem of climate change has been the development of ecocities. In the modern context the result of such a development would be the birth of a city that is friendly to the surrounding environment in terms of pollution land use and mitigation of global warming. The use of Public-Private-Partnership (PPP) model which is used for development of physical infrastructure facilities with innovative project financing and risk allocation schemes between the various project participants is being widely considered as the suitable vehicle for developing ecocities. The Author argues that PPP may not be ideal for the development of ecocities. This is because the concept of developing ecocities requires not only the successful completion of a project but also the long term maintenance of the sustainability of the city and its public acceptance. Thus in addition to concerns such as the financial viability of the project cultural considerations environmental sustainability community needs capacity for future maintenance of the city and the regulations for community behavior are important considerations.

The aim of this paper is to consider the suitability of the existing policy and legislative frameworks in some Asian countries for the development of ecocities with the use of PPP. In addition the effects of the relevant multilateral agreements including the Kyoto Protocol and various regional initiatives such as the Asia-Pacific Partnership on Clean Development and Climate Change on the development of ecocities will be considered. Furthermore the effects of various new project development guidelines of multilateral agencies (eg. The Equator Principles of the International Finance Corporation) on the use of PPP for development of ecocities would be considered. The findings based on these considerations would be applied to identify the necessary modifications to the current PPP model."

Social Metabolism for Livable City: The Seremban Municipality Case

Shaharudin Idrus, Abdul Samad Hadi, Abdul Hadi Harman Shah, Ahmad Fariz Mohamed

"Livable city is illustrated by many authors in various ways for the past five decades. The terms of 'livable city' involves many interdependent factors contributing to the quality of life in the urban area. The complete physical and social infrastructures are an essential base to enhancing the quality of life of the urbanites. The livable city imperative is important today because the urbanization process in Malaysia is moving towards harmonizing with the principles of sustainable development. The concept of social metabolism is mobilized to understand the linkages of the landscape urban dynamic and the impact in the urban area. The concept of livable city is used as the representation of sustainable city. The Seremban municipality area – a growing and prosperous spaces situated in Negeri Sembilan about 80 kilometers south of Kuala Lumpur Malaysia is the base of the study. Multi-disciplinary and collaborative research contributions are necessary for making cities in Malaysia more livable in transition towards sustainability due to the rapid progress in making Malaysia a developed nation by the year 2020. This paper examines a conceptual social metabolism framework and then goes to consider the various factors that are involved in making the city livable for various ethnic groups in Malaysia. This paper also demontrates some preliminary results of the livable city project using water consumption data to highlight the vulnerable areas which are lacking the physical and social infrastructure and areas that are fully developed – livable area in the industrial area of Seremban Municipality for the past 15 years to reflect on the livability of the city."

Achieving Circular Economy through Urban Symbiosis in Dalian (China)

Shizuka Hashimoto, Tsuyoshi Fujita, Xudong Chen, Yong Geng

"The city of Dalian China chosen as a demonstration city of the Circular Economy (CE) concept aims to improve resource use efficiency as well as to minimize the amount of waste produced and converting wastes into useful resources. Among them improvements in levels of reuse recycling and recovery of solid wastes are one of the key issues in Dalian. In this study in order to identify Dalian's potentials to achieve the CE concept alternative waste management and urban symbiosis scenarios were designed for Dalian China paying special attention to its MSW management practices. Frour alternative scenarios were set for this purpose considering future waste management practices and the cooperation with local cement industry as a consumer of MSW. Life cycle analysis was employed to estimate the total CO2 emission and final landfill volumes for each scenario. The functional units set for the scenarios were defined as the amount of MSW generated in Dalian in 2006 the volume of the cement produced by a local cement company and the amount of electric power generated for sale all of which were kept at a constant value across the scenarios. The results of our analysis implied that the construction and operation of a waste incineration plant would promise significant reduction more concretely 70% or 18800 thousand tons of final landfill disposal whilst it would inevitably increase the total CO2 emissions 493 thousand tons at a maximum due to incineration of wastes with fossil origin. Though the cement industry could use various wastes as raw materials in its production process the amount of resources estimated to be recovered in Dalian's MSW management is too large for a single company to fully utilize. As such wider cooperation is necessary to improve Dalian's resource efficiency in the form of urban symbiosis."

WECOBIS - An Harmonized Builiding Product Information System on Application Health and Environment

Martina Klingele, Werner Geiger, Wolfgang Linden, Sepp Starzner, Rainer Weidemann, Petra Wurmer-Weiß

"German round table on sustainable buildings headed by the Federal Ministry of Transportation Building and Urban affairs is supervising a programme to develop a harmonized system of planning and assessment tools for sustainable buildings. Within this framework a set of tools starting from the level of hazardous substances to building product groups building elements and buildings has been tailored to interact using live cycle oriented information and generating valuable qualitative and quantitative support to planners decision making. One of these tools is WECOBIS supporting a sound assessment and selection of building products as a key task of increasing challenge for architects and planners for sustainable design erection and maintenance of buildings. Providing manufacturer neutral information on building products by WECOBIS by concept is dedicated to the relevant life cycle phases including information on hazardous substances from the hazardous materials information system WINGIS and building product EPD indicators from the German EPD-Programme. WECOBIS information on the long range is updated by a body of experts acting online in a tailored editor's environment from their individual location being supervised by a chief editor in a dedicated workflow. The project is of Arbeitsgemeinschaft Bayerische Architektenkammer where scientific consultancy and technical realisation are carried out by Karlsruhe Institute of Technology (KIT) with Hochschule Augsburg Hochschule Lübeck and further experts on the building product information side. http://www.nachhaltigesbauen.de/baustoff-und-gebaeudedaten/wecobis.html. WECOBIS-information can be directly addressed by building sector LCA tools like LEGEP or BauLoop which have been tailored for this in a joint project."

Darjeeling: Making sanatorium town a sustainable city

Bina Sengar

“Darjeeling is a town established by the Britishers as a sanatorium Town in mid of nineteenth century. Soon after its establishment this town located on the lush green background of Himalayas became a lavish destination of people from world around. The population of the city town grew to leaps and bounds to challenge its geographical potentials to incapacitate the growing population and its need. The local government and native and inhabitants of the place then brought forward several solutions to make the city be sustainable.

The paper explores the socio-political and cultural dynamism involved in the making of the sustainable growth of the city since nineteenth century.”

Transforming cities: Introducing adaptability in existing residential buildings through reuse and disassembly strategies for retrofitting

Anne Paduart, Wim Debacker, Caroline Henrotay, Willy Patrick De Wilde, Hendrik Hendrickx

“Since the existing building stock will remain with us for decades their importance as economic social and cultural capital should not be wasted. In the framework of the current ecological and social issues these buildings therefore need to be re-evaluated and re-designed based on their environmental impacts. In European countries existing buildings account for over 40% of final energy consumption of which residential use represents 63% of total energy consumption in the buildings sector. Consequently there is an urgent need to increase the building thermal and energy performance of the existing residential buildings. On the other hand building transformations are more and more required to answer variable factors of everyday life. However the lack of flexibility in the conventional building design does not enable these crucial transformations often causing demolition of building parts or even demolition of entire building structures in present renovation of buildings.

The aim of this paper is to specify a systemic design approach to adapt residential buildings extending their initial material and energy consumption while providing additional value to the buildings in environmental terms. Features are being incorporated into the retrofitting of residential buildings which enable future transformability and which introduce reuse of building products providing answers for the increasing construction and demolition (C&D) waste in the current built environment. Through a case study for retrofitting of a high-rise residential building a systemic approach introducing disassembly and reuse strategies is being explored. New opportunities are being created by stripping the building to its bearing structure and adding a new adaptable infill composed of reconfigurable and reusable building components. This will allow similar buildings to easily (re)transform their spatial configuration to answer changing living conditions in the future and to keep the building physics performances up to date without taking part in the increasing C&D waste streams and the current environmental degradation. “

Modeling Transitions Towards Sustainability in the Bernam-Linggi Region Malaysia

Abdul Hadi Harman Shah, Abdul Samad Hadi, Shaharudin Idrus, Ahmad Fariz Mohamed

"This paper presents findings from a research that looks at how changing local industries impact upon the socio-environment of the Bernam-Linggi region in Malaysia. The Bernam-Linggi region is a fast industrializing region that spans four states in Malaysia. The region has been receiving sporadic injections of capital especially in terms of large industries that compete for space and manpower in the area. Yet the region has also been undergoing fluctuations in its industrial sector due to several economic slowdowns that have resulted in erratic investments and disinvestments. This situation extended for more than two decaded have had a large impact on the sustainability of local communities. It has forced local communities to adapt as to sustain their livelihood and environment. The research attempts to model the changing sustainability conditions of the area due to changes in the major local industries and the different phases of adaptations by the local communities. Borrowing ideas from complexity analysis and urban metabolism the research also attempts to trace the resulting livability of the region and provide some considerations in the planning of its urban and rural areas."

Ecoinnovation in the Skin of Cities to Face Global Warming

Jordi Oliver-Solà, Ramon Farreny, Raul Garcia-Lozano, Alejandro Josa, Xavier Gabarrell, Joan Rieradevall

“Old cities are growing and new ones are emerging worldwide. Despite representing only 2.7% of world\’s surface area (UN 2007) world\’s cities are responsible for 75% of the world\’s energy consumption and 80% of greenhouse gas (GHG) emissions. Therefore cities and specially public space are a cornerstone in the implementation of strategies for energy conservation. A case study of the relevance of public space in GHG mitigation is presented for neighborhood of 558 dwellings in 2.5 hectares in middle-size town in Europe.

In about 1 hectare of pedestrian use there are three types of concrete sidewalks (with different structural characteristics) consisting on: a) slabs (4cm) mortar (2cm) concrete (15cm) and subgrade (9756 m2) b) continuous concrete layer (15cm) and subgrade (140.9 m2) c) blocks (6cm) sand bed (3cm) and subgrade (47.2 m2). The results for a Life Cycle Assessment show that that the CO2-eq. emission for the slabs system is 28.3% higher than for the continuous concrete system and 73.5% higher than for the blocks system.

Concerning the uses there aren’t any motorized uses over the sidewalks. However there are underground service networks for water gas and telephone. This combination (low structural requirements plus need to trench for maintenance) determines that the blocks system is the most optimal from a functional and environmental perspective.

The environmental savings obtained from optimizing the neighborhoods’ sidewalks by progressively installing the block system and according to the existing sidewalk distribution would represent a cut off of 537 tons of CO2-eq. This value is the same that could be achieved in 2.46 years if all the neighborhoods’ roofs were covered with photovoltaic panels (2220 m2).

As a result the environmental strategies in the public space are crucial in the redesign of cities that are willing to minimize their contribution to global warming.”

Student Mobility and it's effect on the Development of a Sustainable Urban Environment in Metropolitan Valparaíso Chile.

Luis Agustín Alvarez Aránguiz, Lisandro Silva Arriola, Marcela Soto Caro

"The issue of sustainable growth in the movement of people information and goods (Ascher 2004) experienced by countries and cities all over the world is significantly worrying due to the social territorial and environmental cost. In that sense sustainable development strives for an optimal balance between economic social and ecological objectives. The main concern should be long term risks of current resources consumption reflecting the real goals of "intergenerational equity" (Litman 2005). Sustainable mobility is conceived like one of the present needs for not jeopardizing the future of the existing natural resources territorial urban cohesion and a sustainable economic growth. This research stresses the effects of student mobility trends concerning the dynamic changes inside the urban metropolitan context of Valparaiso Chile.

These dynamic urban changes are mainly characterized by functional imbalances inside the metropolitan urban structure namely: (i) the increase of global accessibility concerning investment programs in road infrastructure for the main urban corridors and (ii) the progressive incorporation of more heterogeneous groups of students covering the entire socioeconomic spectrum. Both the traditional model of the University oriented to the professional excellence and a social network of aid for the low income students have shifted as is seem reflected in the increasing dissociation between living-/ and workspace. This problem was solving 50 years ago by the Residential Campus area. A new model emerges by increasingly externalizing student residence towards the metropolitan urban context. Preliminary research outcomes reveal complex social and urban-environmental consequences in the urban development."

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Eco-Design: Products and Services of the Future

Environmental impacts of nanotechnology: A life cycle analysis of QDPV modules

Thomas L. Theis, Hatice Sengul

"Some emerging technologies are expected to be pivotal for solving many of the environmental problems faced by society especially those related to energy. Many of these technologies can incur large environmental impacts during raw materials acquisition and manufacturing while having environmental benefits during their use.

This paper explores those features of nanotechnology and its products that are especially energy and material intensive. A specific example of an emerging product quantum dot photovoltaic systems is presented that illustrates the need for more efficient and less wasteful manufacturing methodologies. The example reports results of a cradle-to-gate life cycle analysis of a new type of nanophotovoltaic module quantum dot photovoltaic (QDPV) module and comparative assessment of its impacts with that of other types of PV modules and other types of energy sources both renewable and nonrenewable. QDPV modules may have the potential to overcome two current barriers of solar technology: low efficiencies and high manufacturing costs. If high efficiencies are realized QDPV modules might pave the way to large scale implementation of solar energy. On the other hand candidate materials such as quantum dots for solar cell applications are mostly compound semiconductors such as cadmium selenide and lead sulfide which are toxic and for which renewable options are limited. In addition the toxic effects of these materials may be exacerbated by their nanoscale features."

Evaluation of the Introduction of Active Disassembling Fasteners using Hydrogen Storing Materials in Electronic Appliances: An LCA by the Waste IO Method.

Eiji Yamasue, Kazuyo Matsubae, Yasushi Kondo, Shinichiro Nakamura, Keiichi N Ishihara

"Design for disassembly (DfD) emerges as an effective strategy to overcome material recyclability [1]. In appliances fasteners are used to keep its parts and components intact. The extent to which fasteners can liberate parts and components is an important factor of the efficiency of disassembling process and hence of DfD. We have developed a new type of fastener that is characterized by the feature of "active disassembling": it disassembles by itself under certain disassembling conditions [2]. The fastener consists of iron-based alloy that includes 6-10 at % Mmof a mixture of rare earth elements such as cerium and lanthanum. The latter acts as a hydrogen storing material and hence can break when exposed to hydrogen under appropriate temperature and pressure. Since the conventional fastener can easily be replaced with this fastener it is expected that the use of the fastener in appliances increases the efficiency of disassembling and raises the quality of recovered materials/parts.

This paper is concerned with an LCA of the introduction in electronic appliances of this type of active disassembling fasteners by use of the waste input output (WIO) method [3]. While input-output analysis (IOA) is nowadays widely used in LCA we choose to use the WIO because of its property to consider the EoL process explicitly which is not the case with the conventional IOA."

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[2] K. N. Ishihara and E. Yamasue: Journal of Energy and Resources 24-3 2003

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Post-disaster shelter design: the process from aid to sustainable development

Caroline Henrotay, Wim Debacker, Anne Paduart, Hendrik Hendrickx, Marijke Mollaert, Willy Patrick De Wilde

“Disasters – natural as well as man-made – and the resulting need for shelter may occur all over the world. As a result relief agencies have to manage a diversity of preconditions with regard to the local context and the nature of the disaster. In addition even within one specific post-disaster situation the different phases of relief (emergency – transit – reconstruction) are characterized by very different shelter needs. Therefore along each post-disaster recovery process a variety of specific shelter solutions are required that suits the logistical socio-cultural and economic needs the local climate the family size the livelihoods etc.

Due to a disintegrated post-disaster shelter approach and the static end-state design of the presented shelter solutions current post-disaster shelter relief remains far from sustainable. On the one hand the presented solutions hardly meet the needs of the affected population which moreover evolve over time. On the other hand beside inadequacy the lack of adaptability causes a waste of financial and natural resources but also environmental degradation.

In order to increase the effectiveness and adequacy of post-disaster shelter response a novel and integrated design approach has been developed at the Vrije Universiteit Brussels that aims to support the various shelter and settlement options and to sustain the process from aid to sustainable development.”

Environmental considerations on land use impact for design and development of biopolymers

Daniel Garraín, Rosario Vidal, Vicente Franco, Carlos Muñoz, David Cebrian-Tarrason

“In recent years biodegradable polymers have been the focus of many research studies. Many research centres in the world are researching natural and synthetic biodegradable polymers. Linked to the sustainable development and to the environment protection biopolymers from renewable resources could be an alternative at counterparts from fossil resources.

When designing a product made of biodegradable materials all of the impacts associated with the product along its life cycle should be taken into account. The replacement of conventional plastics by biopolymers entails modifications of environmental impacts which are not always evident or easy to quantify.

The most widely used tool for evaluating environmental impact is the Life-Cycle Assessment Methodology (LCA). The impact categories most often developed in LCA of biomaterials are global warming acidification eutrophication or fossil resource depletion while other relevant categories that would lead to a more detailed and therefore more realistic assessment such as the land use impact category are left aside. Because the organic fraction of biodegradable products often comes from agricultural products or waste this category arises as an essential environmental issue due to the impacts of crops.

There are several methodologies available to assess the impact of land use within LCA. Recent studies have focused on a series of methods to present indicators that measure the decrease of biodiversity and impairment of life support functions due to land occupation and transformation. However no reliable methodologies have yet been developed to assess this category in global terms.

This study aims to provide a methodological basis for a comprehensive analysis of land use impact within LCA through the inclusion of Analytic Hierarchy Process (AHP) which supports the multicriteria decision-making process to yield rational consistent assessments that reflect land use impacts comprehensively: effects upon biodiversity life-support functions and even landscape or aesthetic impact.”

Dematerialized Solar-Powered Eco-Streetlight

Raul Garcia-Lozano, Xavier Gabarrell, Joan Rieradevall

“Urban systems play a fundamental role in the sustainable progress of the planet. Eco-design is a key tool in making a change towards a sustainable city. One of the most important environmental subsystems is the urban setting in this setting urban lighting has been used since antiquity to satisfy city dwellers’ needs for illumination safety signposting etc. The design of public street lighting installations in urban settings is a decisive factor in the quality of life of our society.

Street lighting consumed 10 percent of all the electricity used in Europe in 2006 or 2000 billion KWh and resulted in carbon emissions of 2900 million ton. In spite of that streetlights are designed without taking into consideration environmental aspects associated with the consumption of energy waste material maintenance etc.

These environmental impacts can be mitigated by applying eco-design in the development of the streetlights themselves which can thereafter be applied on a global scale.

The streetlight ecodesigned that is totally independent of any external power supply function as mini photovoltaic plant and is considered to be perfectly integrated in the urban areas. The eco-streetlight consists of a conical body and a support manufactured as a mesh which opens up at the top in the form of a panel and holds a photovoltaic module. The high efficiency lamps are fixed at the top of the support and are regulated in accordance with the presence of users and sunlight. The photovoltaic battery is place in a storage space next to the premould basis structure.

Comparative results between the eco-streetlight and other streetlights on the market show that it is possible to reduce global environmental impact by more than 37%. In addition there are other benefits such as dematerialisation of urban setting reduction of light pollution and approaching environmental aspects to street lighting.”

Ecological Architecture as Driver of Holistic Sustainable Building Practices

Maria Zapata

“In the context of depletion of ecosystems and negative effects of buildings on the environment several initiatives have emerged. They aimed to reduce the impact of buildings on the natural environment. 2030 challenge rating systems green standards and other building codes seek to raise awareness of sustainability in construction. The potential of buildings to contribute to the well-being of occupants cannot be limited to satisfaction of human needs. Building practices need to experience a paradigm shift. The old mechanical view of built environment as a giant mechanism composed of machinelike pieces is being replaced by new concepts. The ecological discourse is changing the way architecture is conceived. Synergy and dynamics between man made and natural systems provide great opportunities for innovation when confronting environmental challenges. New developments and technologies could play a major role in the paradigm shift. A holistic design approach is required to cope with the challenges. This paper discuss a case study identifying strategies and technologies that enhanced the performance of green buildings. The contents of this discussion are guided by several different ecological philosophies that have shaped the architectural practice of recent years.”

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Environmentally Extended Input Output

EXIOBASE: Principles and design of a database for multi-region input-output tables and environmental extensions

Reinout Heijungs, Arjan de Koning, Gjalt Huppes

"Within the EU-FP6-funding scheme the EXIOPOL project addresses besides the development of the assessment of externalities the development of a database for environmentally extended input-output analysis. Several of such databases exist already but the ambition of the EXIOPOL project is higher in several respects.

1) It will comprise tables for all 27 EU-countries and all main trade partners (US China etc.).

2) It will do so in a harmonized supply-use structure distinguishing 129 products and 129 industries.

3) It will use advanced approaches to establish the trade links between all countries in a consistent way.

4) It will contain environmental extensions for quite some environmentally relevant issues (pollutants and resources) for all these sectors and all these countries.

5) It will have implemented algorithms to convert the supply-use tables to input-output tables.

All these elements have been brought into a coherent database structure. The presentation will discuss the main principles and design and will discuss practical issues (such as implementation and performance) as well.

A methodological framework to assess environmental impacts caused by material flows of an economy: the ENVIMAT approach

Jyri Seppälä, Sirkka Koskela, Ilmo Mäenpää,Tuomas Mattila

"Natural resource consumption has increased in the Finnish economy during the last few decades. The growth of total material requirement (TMR) is due to increasing consumption and production volumes of Finnish export industries. In 2006 the Finnish R&D project called ENVIMAT started in order to clarify the most environmentally harmful material flows of Finnish economy. The basic assessment was made according to 151 industries (economic sectors) using environmentally extended input-output modeling in which domestic material flows and environmental interventions (emissions land use and resource extractions) were assessed using the best Finnish data sources representing the years of 2002 and 2005. The data of imports were assessed by using life cycle databases and domestic emission factors due to lack of data. The overview of TMR flows of Finnish economy offered the starting point for the analysis: 50 % of TMR used in our economy originated from domestic nature 47 % from imported products provided to intermediate use and only 3% was imported as final products. From the viewpoint of the outputs of our economy exports have a 54 % share of TMR. The Finnish consumption causes almost equal environmental impacts as exports with slight variation in different impact categories. In the project the results of 10 impact categories such as climate change and acidification on the basis of life cycle impact assessment methodology were produced. Also the contribution of greatest imported natural resources such as wood and metal ores to TMR were assessed and their environmental impacts were assessed on the basis of their life cycle inventory data. Furthermore the environmental impacts of exported products were assessed according to the results of final products of different industries obtained from the EEIO model."

Methodology for the Construction of an International Supply-Use Table

M.C. Bouwmeester, J. Oosterhaven

"The EU-funded EXIOPOL project has as its main objective to create an international environmentally extended input-output database. Instead of focusing on symmetric input-output tables the core of the database will be formed by trade-linked rectangular supply and use tables. Supply-Use Tables (SUTs) have not yet been used as framework in international databases even though they are superior for statistical reasons. Trade-linking the tables is essential for estimating the actual environmental impacts of international production and consumption. Analyses based on these tables will attribute both direct and indirect environmental impacts to an internationally traded product or service irrespective of the stage of its production chain in which they are created.

To provide an economically sound database this paper describes a non-survey method to construct alternatively an international supply table or an international use table. Due to the valuation layers of taxes subsidies and trade and transport margins that are added to products when they are traded internationally import-use tables and export-supply tables cannot be trade-linked simultaneously. Both alternative trade-linking processes consist of two main steps. The first step is the split-up of the import-use table (export-supply table) into bilateral use (supply) tables using trade ratios derived from an import (export) trade database. The second step is to reconcile the international commodity trade flows obtained from trade-linking with information in the national SUTs by applying a generalized RAS method.

This methodology is tested on a limited set of countries resulting in the first trade-linked international supply tables and international use tables. The two alternative international tables obtained by trade-linking the import-use tables and the export-supply tables are analyzed to interpret any differences."

The Carbon Footprint of Nations - A global trade-linked analysis

Edgar Hertwich, Glen Peters

“Processes causing greenhouse gas emissions benefit humans by providing consumer goods and services. This benefit and hence the responsibility for emissions varies by purpose or consumption category and is unevenly distributed across and within countries. We use the carbon footprint to quantify the greenhouse gas emissions associated with final consumption of goods and services for 72 nations and 15 aggregate world regions. We address CO2 from fossil fuels and industrial processes but not land-use change and CH4 N2O and F-gas. We analyze the contribution of 8 categories: construction shelter food clothing mobility manufactured goods services and trade. We use a global multiregional input-output model based on the GTAP database for 2001 to link emissions in the value chain of products to the final consumption of the products. National average per capita footprints vary from 1 tCO2e/y in African countries to ca. 30t/y in Luxembourg and the US. The expenditure elasticity is 0.66 less than that for CO2 only (0.82). Emissions of CH4 and N2O are mostly caused by food production and do not vary as much by income. On the global level 72% GHG emissions are related to household consumption 10% to government consumption and 18% to investments. Food accounts for 20% of GHG emissions the operation and maintenance of residences 19% and mobility 17%. There is a substantial change in consumption patterns across wealth levels and a high correlation of total expenditure with carbon footprint of specific activities especially transport and manufactured goods. The structural change in consumption on the aggregate level does not contribute to explaining the reduced emissions intensity with wealth leaving product quality and technology differences as potential explanations.”

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Industrial Ecology in Developing Countries

Reverse Logistics Activities for Renewable Resource Industry: a case study from Tianjin in China

Xu He

“Reverse logistics was brought up in 1990s and its academic research is continually developing by the influence of sustainable development stratagem and developing circular economy. Reverse logistics mainly focuses on how to take back the returns and recycle them efficiently and economically. Its goal is to extract more value from the returns or deal with them correctly. Renewable resource industry of China has developed for about 50 years. It has built complete networks and markets and also the recycling technology. From this point of view if the renewable resource industry introduces the concept of modern logistics they will be the best carrier for the activities of reverse logistics. The paper aims to find out the way for the renewable resource enterprises taking part in the reverse logistics and how they can cooperate with the Manufacturing Industrial Park and then form the Regional Eco-Industrial Park.

This study chooses two typical districts in Tianjin. One is Tianjin Ziya Environmental Protection Industrial Park also called Tianjin Ziya Industrial Park. It is a large industrial park that specifies in disassembly processing and utilization of waste imported electromechanical products in North China. Established in accordance with the general requirements of the Ministry of Environmental Protection and Tianjin Government the Park is one of the projects in the overall developmental plan of Tianjin Government and one of the provincial development areas in Tianjin with national approval. And the Manufacturing Industrial Park we choose is Tianjin Economic Technological Development Area one of the first national-level development area has ranked in the forefront of all national-level economic zones for ten years in row of main economic indicators and boasted mature development of electronic communication industry represented by Motorola and Samsung the automobile and machinery manufacture industry represented by Toyota and SEW.

This paper discussed the foundation and the steps for the renewable resource industry to built reverse logistics system based on case studies from the mentioned-above two areas. And the problems in the construction of reverse logistics system are also discussed.”

Ecosystem Approach for Sustainable Industrial Hazardous Waste Management in Malaysia

Ahmad Fariz Mohamed, Shaharudin Idrus, Abdul Samad Hadi, Abdul Hadi Harman Shah

"Manufacturing industries industries play a vital role for the Malaysian economic growth for the past four decades. In the process of industrialisation industrial activities generated large amount of hazardous wastes having a detrimental impacts on the environment and the human health. Hazardous waste generation by Malaysian industries shows varied trend within the period of 1994 to 2005. 417413 metric tons of waste generated in 1994 and increased to 632521 metric tons in 1996 later reduced to 548916 metric tons in 2005. The existing practice by the industry in Malaysia is focusing on end-of-pipe approach. Most of industrial hazardous wastes generated were send to treatment plant and landfilled in a secure landfill. This practice is not sustainable as it requires more resources especially in the need for more land for land-filling. It is time to change the practice of managing the industrial hazardous wastes from end-of-pipe towards a more sustainable manner. Ecosystem approach has been identified as a better approach than the end-of-pipe. The ecosystem approach has been promoted as one of the approaches which is able to achieve sustainable industrial development in the future. With the assumption that Malaysia's industrial system as a sensitive ecosystem the hazardous waste generated by industries was identified as an important resources. In the industrial ecosystem the wastes is cycled between industries as resources using the concept of "your waste is my resource". This paper analyses the trend of industrial hazardous waste generation and scenario of existing management system. Results of the analysis were used to develop an ecosystem model for sustainable industrial waste management in Malaysia. The ecosystem model shows how key stakeholders important mechanisms and processes put in place to make the industrial ecosystem functional and able to provide service towards achieving sustainable industrial hazardous waste management in Malaysia."

Economic metabolism And Management in circular economy: analysis framework

Junfeng Wang, Huiming Li, Xiaodan Gui, Wenjing Liu

“Economic system is not isolated but linked up with the natural ecosystem through the material and energy flow. Economic systems and natural ecosystems shall be well matched with economic development in different levels including local regional and community level through material and energy flow. However how to understand material and energy flow in the economic process economists have not given enough attention on it. Until the 1960s Ayres and Kneese first studied the basic material flow model of the economic system (Ayres 1969). Moreover Industrial metabolism and industrial ecology is an important evolution from the material flow analysis of the economic system. Compared to previous research industrial metabolism assimilated systematic ideological focused on the material and energy flow between economic system and the environment especially the industrial metabolism\’s strength and its affects on the surrounding environment the research of metabolism scale is the core content of the concern (Ayres 1994).

In china circular economy is an important way to promote the harmony between economic growths with environmental protection. From the perspective of the material flow of economic system circular economic study focused on two levels in depth. To the macro level the focuse is to explore the regional economic development model with the limitations of economic scale. While in the micro level it is an important to explore how market mechanisms influence material flow under such restrictions. However most of policymakers only make closed-loop material cycle as its typical features and substitute circular economy with it which in results delays or hinders further development of circular economy. In this paper with the economy analogy to metabolism of biology authors are in an attempt to understand circular economy from the perspective from the metabolism. Moreover authors present the concept of economic metabolism and bring forward the analysis framework including throughput of economic metabolism pathway of economic metabolism and management of economic metabolism.”

Evaluation of 3R Waste Eco-Efficiency in the Petroleum and Petrochemical Group Map Ta Phut Industrial Estate Thailand

Kitikorn Charmondusit, Umaporn Khwankue

Eco-efficiency concept has emerged as a valuable tool towards the target of sustainable development. The general definition of eco-efficiency is referred to the relation of 2 elements which are environmental impact and value of production. Map Ta Phut Industrial Estate (MTPIE) is located in Rayong province east of Thailand. It was developed in 1989 by the state enterprise Industrial Estate Authority of Thailand (IEAT) Ministry of Industry. Presently there are 53 factories located within the MTPIE which can divided into 5 industrial groups which are petroleum and petrochemical (PP) group industrial gas group utility group iron and steel industry group and chemical industry group. PP group was found to be the main important group in MTPIE which are 31 factories or 58.49 percent of the total factories located in this group. This paper presents the eco-efficiency indicator called environmental improvement productivity (EIP) for assessing the environmental improvement from 3R waste of the PP group in the MTPIE. The EIP is defined as the ratio of total 3R waste as a value of production to the total amount of CO2 reduction by the 3R activities as an environmental impact value or environmental improvement of 3R waste which was evaluated by the CO2 emission calculated from the basis of 3R waste incineration. The total amount of waste and 3R waste generated from the PP group in fiscal year 2007 which was separated into 4 quarters were collected and used to create the waste flow diagram of the PP group. The results show that more than 60% of the total waste generated from the PP group in the MTPIE was classified to be as a 3R waste. The evaluation of eco-efficiency shows the decrease of EIP values from quarter 1 to quarter 4 which refers to the increase of environmental improvement. The research can demonstrate the environmental benefits from the 3R waste which will feed into strategic development and would enable to encourage the 3R activities for industrial sector in Thailand.”

Eco-Efficiency Assessment as a Support Tool for Cleaner Technology: Case Study of the Canned Pineapple Industry in Thailand

Kamonporn Dechpong, Kitikorn Charmondusit

"Cleaner technology (CT) is the continuous effort to prevent pollution to reduce the use of resources and to minimize wastes in the production process. Some new CT options generated from the CT assessment process provide only one dimension either an economic dimension or environmental dimension.

Each option must be evaluated for quality with the appropriate tool before being selected for implementation.

The concept of eco-efficiency has been widely accepted as a tool to judge the combined environmental and economic performance of production process. The environmental cost-effectiveness (ECE) one type of eco-efficiency is defined as the ratio of net environmental benefit to net financial cost. In this research ECE is proposed to support CT and to assess the quality of a CT option in terms of environmental cost- efficiency.

The canned pineapple industry was chosen as a case study whereby ECE was used to determine the most appropriate option to balance the environmental expenditure and economic gain. The reduction of total emissions (CO2 SO2 and NO2) resulted from the proposed options was quantified as the net environmental benefit. The total investment cost was quantified the net financial cost. The relative eco-efficiency levels of each CT option were analyzed by snapshot graph. The results showed that improving the combustion efficiency of a boiler (option 6) provided the highest degree of eco-efficiency and was also located in the fully eco-efficiency level on the snapshot graph. Therefore option 6 presented the best balance an economic and environmental aspect. Option 6 was the most appropriate option and should be implemented in the production process.

Thus eco-efficiency with ECE can be used as a tool to support CT and to assess the quality of a CT option in a comprehensive manner by considering both environmental and economic benefits at the same time."

A Case Study of the Evolution of a Phosphorus and Coal Chemical Industrial Ecosystem on the Regional Scale

Hui Gao, Dingjiang Chen, Shanying Hu

"With open and self-organizing characteristics an industrial ecosystem is often viewed as a living complex organism. In general its evolution is acknowledged while the remarkable changes of material and energy flows of the system are observed. This paper studies the evolution process of a regional industrial ecosystems located in southwest China via data from a 2003~2008 tracking survey. The changes of the material network and energy input to the system are visualized with Sankey diagrams. Four portraits of the system are presented: (1)underdevelopment stage before 2003 (2)the stage promoted by an EIP plan during 2004~2006 (3)the stage responding to market stimulates self-organization of the stakeholders of the system especially the SMEs around 2007 (4)the stage expected in the coming 5 years. The major factors affecting the evolution of the system are summarized and discussed at the end of the paper."

Comparison of industrial symbiosis delivery models in developed and developing nations

D. Rachel Lombardi, James Woodcock, Adrian Murphy, Paul Knuckle, Peter Laybourn

"In the three years the NISP model of facilitating industrial symbiosis through a free and open network has been operational nationally in the UK it has delivered 4.6 million metric tonnes of CO2 4.1 million metric tonnes of Land Fill avoided £140 million increased revenue for its member companies and £116 million avoided costs. In 2007 International Synergies Limited (the company behind NISP) rolled out its successful model to regions in China and Mexico funded by the UK Defra Sustainable Development Dialogs. In both countries substantial potential for IS has been identified as measured by metric tonnes capacity identified and number of member companies engaged. However very different outcomes have been achieved in terms of synergies completed and the economic and environmental impacts listed above.

A comparison of the 3 programmes 1 in a 'developed' country (UK) and 2 'developing' (China and Mexico) yields three distinct classes of lessons:

a) Reinforcement of known necessary conditions for a successful IS programme: the importance of facilitation the need for the programme to be free for businesses the critical role of stakeholders such as business organisations policy makers and regulators.

b) New lessons learned with regard to delivery include: the importance of an independent business focused delivery partner as opposed to a governmental regulatory body and the requirement for a dedicated full time resource capable of focusing on relationships and driving the synergies forward time to develop relationships before launching the programme and the impact of these factors on recruitment of members.

c) Key differences have also arisen as strongly dependent on the local culture: the relationship between business and the regulator informing the role of the regulator in delivery the developing regulatory regime and the evolution of waste policy and the business norms informing the scheduling and timing of any events."

Linking eco-industrial development to climate change adaptation in the Pt. LIsas Industrial Estate Trinidad

Ashton Weslynne Ashton, Suzana Russell

"Trinidad is the most heavily industrialized island in the Caribbean. Its economy is based on the exploration and processing of oil and natural gas and the utilization of these fuels in downstream industries such as methanol production and steel manufacture. Pt. Lisas Industrial Estate established in 1966 is home to approximately 100 companies in these and other sectors which together consume almost half of all the energy produced on the island. Several of the Pt. Lisas facilities are in the process of upgrading or expanding operations and a few new actors are establishing operations either within or near to the park. The issue of climate change has recently emerged as a pressing one for the regional industries as many are high-volume generators of greenhouse gases and the impacts of rising sea-levels are already being felt in the park and the country as a whole. This presentation highlights the results of an investigation to document and map the flow of energy and materials among firms within the park and identify existing and potential industrial symbiosis practices especially byproduct exchanges collaborative resource management and infrastructure sharing. The study also demonstrates through scenario modeling how adaptation strategies employing these practices might reduce the impacts of climate change on the park. We evaluate the barriers to realization of these practices and how they can be overcome. In particular we examine the relevance of the developing country and small island developing states (SIDS) contexts for application of industrial ecology tools and consideration is given to the regulatory environment and institutional mechanisms that foster inter-firm collaboration."

SWOT Analysis for Discussion of Success Factors and Obstacles on EIP Projects in Several Asian Countries

Juan LIU, Toru Matsumoto, Yonghai Xue

“Development of EIP in Asia is nearly ten years. Though in every country they have their own background and framework separately the development of EIP in these countries all brings benefit not only for enterprises but also for community on both economical and environmental aspects. But circular economy development is not on a smooth way. Some problems are common in all the countries and success factors are also useful for their improvement.

This paper aims to evaluate the development and effectiveness of (Eco-industrial Park) EIP as an implementation of the concepts of circular economy and industrial ecology in several Asian countries: Korea China and Thailand. Basing on data and information from document review and on-site investigation situations of EIP projects in these countries are introduced especially policy and support from government which affects development of EIP projects. And through SWOT analysis on EIP projects in these countries discussion on success factors and obstacles are conducted. Lastly this paper gives useful advice about policies and execution for the EIP projects.

From SWOT analysis the factors for success on development of EIP could be itemized as:

a) Perfect policy system

b) Stably financial support

c) Communication

d) The third part

e) Understanding and participation of stakeholders

the factors for obstacles on development of EIP could be itemized as:

a) Policy system

b) Technology

c) Economical benefit of industrial network and recycle

d) Up-down stream”

Industrial symbiosis in Nanjangud: resource flows and cooperation in Indian eco-industrial networks

Ariana Bain, Megha Shenoy

“Karnataka a state in South India combines rapid industrial development with strong environmental regulations and enforcement. In Karnataka Nanjangud is the focus of this study because the town contains two estates managed by the Karnataka Industrial Areas Development Board (KIADB) a number of additional independent facilities that span a size range from cottage industries to multinational firms a diverse product mix and a regulatory climate that enables verifiable research. This paper explores applying material flow analysis to an economically diverse industrial area through structured interviews resource flow analysis and resource utilization mapping. Industrial relations in Nanjangud demonstrate a high level of resource reuse and recycling inter-firm cooperation around both raw material inputs and byproduct trades and agricultural residues replacing coal diesel and furnace oil as industrial fuels. Scrap dealers play a central but still unclear role in supporting resource efficiency. The paper examines the role of cooperation communication and material cycling in developing adaptive and robust responses to market volatility in emerging markets and to evolving environmental regulations. Finally it addresses the potential for future research and analysis of industrial ecosystems in India.”

Putting Theory into Practice in China: Creating a sustainable energy infrastructure in Tianjin Economic Technologic Development Area (TEDA)

BinBin Jiang, Shi Han

"Tianjin Economic Technological Development Area (TEDA) is one of China's earliest hot spots for foreign and private investment. Today TEDA is putting its efforts towards creating an infrastructure that will allow the area to also become one of the country's first eco-industrial parks. This paper will evaluate the production and consumption of energy and emergy in TEDA in order to determine baseline performance compare current levels of operation with international and domestic benchmarks for energy intensity and resource consumption and analyze scenarios (e.g. utilizing inter-firm cooperation and renewable energy) that will meet and exceed these benchmarks. This paper also identifies the barriers to establishing possible measures to optimizing the energy structure of TEDA. Given economic and resource constraints of the region we identify possible solutions for minimizing greenhouse gas emissions and energy consumption."

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Industrial Ecology tools for Sustainability

Environmental Performance of the Portuguese Dairy Sector using a life cycle aproach

Érica Geraldes Castanheira, Ana Cláudia Dias, Luís Arroja, Rui Amaro

"The present study contributes to evaluate the environmental impacts associated with the dairy sector in Mainland Portugal. For that purpose Life Cycle Assessment (LCA) was used as an environmental management tool. The environmental impacts associated with UHT milk curd cheese and yoghurt were estimated over their life cycle which includes dairy farm industry transport chemical production and energy production systems.

The result of the quantification of the environmental impacts of the dairy farms in Mainland Portugal in year 2005 was 51 thousand tons of Sb eq year-1 for the abiotic depletion potential 1973 ktons of CO2 eq year-1 for the global warming potential 239 tons of C2H4 eq year-1 for the potential formation of photochemical oxidants 308 thousand tons of SO2 eq year-1 for the acidification potential and 10 thousand tons of PO43- eq year-1 for the eutrophication potential. The majority of these impacts were caused by the dairy farm and the industrial systems. The dairy farm was the main responsible for global warming (60%) acidification (81%) and eutrophication (86%) whereas the milk industry had the main contribution for the depletion of the abiotic resources (46%) and the formation of photochemical oxidants (52%).

In the UHT milk subsector the majority of the environmental impacts were due to the activities taken place in the farms and in the milk production industry. On the other hand in the curd cheese subsector the cheese production industry is only the main responsible for the acidification and eutrophication categories. Finally for the yoghurt subsector the activities associated to the yogurt production industry contribute less than 10% for all the impact categories.

This study provides useful information that can assist the dairy industry in identifying the main environmental impacts and their sources allowing the industry to improve its environmental performance not only at the mill level but also on the other systems along the production chain."

Material Budget of a Biosphere Reserve - Material Flow Indicators as a tool for identifying potential environmental impacts and for certification of prospective Biosphere Reserve aspirants

Frank Hartmann, Yves Deluz

"Today's rapid growth of resource consumption implies unwanted by-products caused by resource extraction (e.g. land consumption unused excavated materials) or cost-intensive and particularly environment polluting oftentimes hidden material flows and emissions. At the same time permanent increasing anthropogenic material stocks (e.g. constructions boarding and paving) are built up e.g. in large urban systems. Planning which means monitoring controlling and optimizing of such systems and the corresponding material stocks poses an interesting challenge. Finally all materials (with partially strong varying lifespan) either become –concerning the ideal case- secondary resources or -assumed that such materials can not be recycled- have to be pre-treated and afterwards are deposited. At present most of those materials are irrecoverably lost. All those challenges require a modern interdisciplinary resource management. For comparing controlling and optimizing the material budget especially of states Material Flow Indicators (MFI) can be applied whose method is based on two publications of the European Union. One intention using this method is to identify potential environmental impacts prior their appearance and therefore can be prevented. In this paper a project is presented where this MFI method is applied to a Biosphere Reserve. First results especially concerning the Input indicators DEU (Domestic Extraction Used) and DMI (Direct Material Input) will be presented. Data collection methods are presented here. This collection is much more complex than in an ordinary state where normally a state-controlled data collection is automatically implemented. In this project therefore surveys on site and mathematical extrapolations have to be done.

Based on this study an international comparison of such Biosphere Reserves concerning their resource management is aspired. Furthermore the application of such indicators for certification of areas that are potential Biosphere Reserve aspirants is checked. Finally the possibility of using such MFI as an indicator for sustainability within such Reserves will be reviewed."

Local development and definition of the common good: how the method of metabolism may help to define the pertinent scale?

Nicolas Buclet, Sabrina Brullot

“European and National Institutions ask local decision-makers to define local strategies for sustainable development. It is often tricky to implement policies the scope has been defined at a global level. In the name of which common goods define such a strategy? This contribution questions the notion of common good between global priorities local tensions and even individual temptations. We would like to demonstrate that the response to those questions cannot avoid a discussion on the legitimacy of the characteristics of the common good. Is this a simple mean to favour individual initiatives within a liberal scheme or the result of the elaboration of collective objectives requiring explicitly coordinated solutions? We would like to show that following the second option gives more sense to the analysis of a territorial system’s metabolism. Yet some conditions are required. One must go beyond the quantification of physical flows going in and out from the system. It is necessary that the stakeholders of the system to be analysed question the consequences of import and export of those flows in other parts of the world. We consider that combination as one of the most promising way in order to define a local common good not being in contradiction with the global common interest.”

Assessing the environmental impact of natural cork stoppers by using Life Cycle Assessment

Rui Pedro Silva, Belmira Neto

"Portugal is the largest worldwide producer of cork products such as natural cork stoppers used as a closure for bottled still wines. Cork stoppers are the dominant product of the cork industry. The current national production of natural cork stoppers amounts to 3500 million closures per year. This represents a share of about 70% of the worldwide cork stoppers' production. This figure presents an exportation value of about 850 million Euros.

The Life Cycle Assessment (LCA) methodology is applied to cork stoppers in order to assess their environmental impact. The system included forest management cork preparation manufacturing packaging transportation and end-of-life management. An indicator for the overall environmental impact is assessed by using three different weighting methodologies: considering all environmental problems equally important using an expert panel method suggested by the available literature and using the distance to target methodology. The environmental impact is evaluated by using data available from a natural cork stoppers manufacturer company located in Portugal. Not only does this study allow for the identification of the environmental problems associated with the life cycle of cork stoppers but it also analyses scenarios including either alternatives processes or waste management options. Three different scenarios analysed include: an alternative to the current management procedure for the forest's solid waste considering recycling as the only possible option for the end-of-life management and finally by eliminating a specific production process used by the company under analysis.

Results show that cork stoppers contribute to seven environmental problems. The most important ones are the production of solid waste the formation of tropospheric ozone and acidification. Other problems as the depletion of natural resources global warming eutrophication and human toxicity have a comparatively lower importance. Results show that the scenarios included may lead to a reduction of the overall environmental impact up to 18%."

Life Cycle Inventory Analyses for CO2 Emission and Cost of District Heating and Cooling Systems Using Wastewater Heat

Takashi Ikegami, Toshiya Aramaki, Keisuke Hanaki

"In order to accurately evaluate effectiveness of introducing District Heating and Cooling (DHC) systems using wastewater heat Trunk Sewer Model and DHC Plant Model were developed. The evaluation of the effect of wastewater temperature change which became possible with using these models was conducted and the required wastewater flow for DHC systems using wastewater heat was calculated. Life cycle inventory analyses for CO2 emission and cost were applied as the evaluation methods. These allowed more accurate evaluation of the CO2 emission reduction and the analysis of economic efficiency by utilization of wastewater heat. Applying these models and life cycle analyses to hypothetical areas which have various heat load characteristics it was found that a large amount of CO2 reduction at a low CO2 reduction cost are achieved when DHC systems are introduced in some office buildings hotels and hospitals. The results of applying these models and evaluation methods to northern part of Shibaura Treatment Area show that the potential of CO2 emission reduction is about 2.1-2.5 ton CO2 per 10000m3 of wastewater volume in this area. Furthermore the results of the model simulation in Tokyo 23 wards show that the potential of CO2 reduction by utilization of wastewater heat is about 140 thousand tons of CO2 by introducing 320 DHC systems and its average cost is about 16800 JPY per ton of CO2."

Disaggregated decoupling indicators of the European manufacturing industry exemplariliy for Germany

Sibylle Wursthorn, Witold-Roger Poganietz, Liselotte Schebek

“In the current international political debate how to achieve sustainable development OECD for example but also the UNESCAP have identified decoupling of environmental use from economic activities as one of the most important objectives for the first decade of the 21st century. Generally decoupling means breaking the link between “environmental bad” and “economic goods”. Appropriate indicators are a necessity to assess the ways to achieve decoupling.

In the context of decoupling an indicator should consider a meaningful link between economic activity and environmental impacts of economic activities. Although the aim of decoupling has to be reached on a macroeconomic scale to map the driving forces (and the trailing one) of decoupling a more sophisticated information base is necessary i.e. the indicator should capture on the one hand the activities of industries. On the other hand the chosen indicator should allow to plot the whole economy comprehensivly. Additionally the underlying data should be publicly available and regularly updated.

This presentation aims to show and discuss a decoupling indicator exemplarily for Germany on the level of industrial classes. The presented indicator – environmental impact in E99-points per turnover in Euro of an industrial class – make use of the emission data base European Pollutant Emission Register (EPER) in combination with the life cycle impact assessment method Eco-Indicator 99. The used method allows not only to give an overall picture of an industrial class but also to differ along different impact categories. Due to data constraints in a first approximation the results for just two years are shown. Since in the future the data sources will be updated annually the indicator could be used for an analogous time period.”

Optimization of Sawmill By-Product Flows in Southeastern British Columbia

Yu Li, Jérôme Alteyrac, Paul McFarlane

“Material flow analysis (MFA) applies the concepts of industrial ecology to study how materials flow into through and out of a system. This study used MFA to investigate the flow of sawmill by-products to other downstream mills such as pulp mills finger-joint plants wood composite plants and biomass energy facilities. With a provincial roundwood harvest in the range of 80-90 million m3.year-1 the optimization of sawmill by-products utilization in British Columbia (BC) is important from the viewpoints of material use efficiency economic outcome social benefit and environmental impacts.

In BC sawmills represent the primary fractionation phase of wood processing. he lumber produced typically comprises 40-50% of the roundwood input by volume and the yield of wood by-products including bark sawdust chips shavings and off-cuts is usually in the range of 50-60% by volume. Taking full advantage of wood by-product utilization and increasing the social and economic values are becoming more and more important for BC’s forest product industry particularly when the whole industry is experiencing one of the worst cyclical downturns in its history.

This study developed an optimization model using linear programming to evaluate “optimum scenarios” for an integrated forest product company consisting of two softwood sawmills a finger joint plant and a softwood kraft pulp mill in southeastern BC. The model focused on optimizing wood by-product flows in response to geographic locations marketing requirements manufacturing performances wood by-product prices and transportation costs to search for the best combinations of wood by-product end uses in order to achieve the most economic benefits for the company. Sensitivity analysis was used to quantify the extent to which each constraint in the model affected the results. Comparisons between the “optimum scenario” and the “conventional scenario” were also assessed in order to determine the net economic benefit of the “optimum Scenario”.”

Pavement Asset Management and Optimization Model: Informing Policy and Enhancing Sustainability

Han Zhang, Gregory A. Keoleian, Michael D. Lepech

"Pavement preservation (maintenance and rehabilitation) requires large resource investments and generates significant environmental impacts. A project-level pavement asset management system (PAMS) including life cycle assessment life cycle cost analysis and life cycle optimization models is developed to determine the optimal pavement preservation strategy. Multi-constraint and multi-objective optimization is conducted to study the impact of agency budget constraints on user costs and total life cycle cost identify the trade-offs between energy consumption and costs and understand the relationships among material consumption traffic congestion and pavement roughness effects. A case study of a hot mixed asphalt (HMA) overlay system shows that a reduction in total agency preservation budget from$2 million to $0.5 million increases the total life cycle cost from $54 million to $61 million over a 20 year service life. A Pareto optimal solution that minimizes energy and cost objectives is also developed to enhance the preservation strategies. The influence of fuel taxes and government subsidies on a PAMS is explored and specific policy recommendations are provided. For example proposals by presidential candidates Clinton and McCain to temporarily suspend the gas tax in the summer of 2008 would have had a detrimental life cycle societal cost impact.

To improve sustainability in pavement design a promising alternative material engineered cementitious composites (ECC) is studied. Dynamic programming optimization technique is applied to minimize total life cycle energy consumption greenhouse gas (GHG) emissions and costs within an analysis period. The results show that the optimal preservation strategies will reduce by 5%-30% the total life cycle energy consumption 4%-40% the GHG emissions and 0.4%-12% the costs for the concrete overlay system the ECC overlay system and the HMA overlay system compared to current Michigan Department of Transportation preservation strategies respectively. "

Characterizing and Managing Uncertainty in Life Cycle Inventories

Eric Williams, Christopher Weber, Troy Hawkins

“Life Cycle Assessment (LCA) is increasingly being used to inform decisions related to environmental technologies and polices such as carbon footprinting and labeling national emission inventories and appliance standards. However LCA studies of the same product or service often have very different results affecting the perception of LCA as a reliable decision tool. This does not imply that LCA is intrinsically unreliable we argue instead that future development of LCA requires that much more attention be paid to assessing and managing uncertainties. In this article we work towards developing a hybrid approach combining process and economic input-output approaches to uncertainty analysis of life cycle inventories (LCI). Different categories of uncertainty are sometimes not tractable to analysis within a given model framework but can be estimated from another perspective. For instance cutoff or truncation error induced by some processes not being included in a bottom-up process model can be estimated via a top-down approach such as the economic input-output model. A categorization of uncertainty types is presented (data cutoff aggregation temporal geographical) with a quantitative discussion of methods for evaluation particularly for assessing temporal uncertainty. We propose a long-term vision for LCI in which hybrid methods are employed to quantitatively estimate different uncertainty types which are then reduced through an iterative refinement of the hybrid LCI method.”

The Yin and Yang of the global economy? Biophysical constraints and enabling factors to the socio-economic development of Japan and Australia

Heinz Schandl, Hiroki Tanikawa, Clemens Grunbuhel, Kozo Mayumi

“Accounting for materials and energy and related resource use policies has become a major field of investigation in industrial ecology research. However the integration of physical economy analysis into integrated analysis frameworks capturing all domains of sustainability has not yet been well-represented. In our presentation we provide an integrated analytical framework for assessing biophysical social and economic indicators across scales to identify factors that have enabled or constrained socio-economic development in Japan and Australia since the 1970s. The framework is based on the concept of bio-economics introduced by the economist Georgescu-Roegen. We employ material and energy flow analysis and land use analysis for the biophysical dimension of economic development and time use analysis for the social domain. These indicators are complemented with standard economic indicators.

Casual observation suggests the economies of Japan and Australia represent a very different pattern of natural resource use and resource productivity. This results in very different policy discourse around these issues. While Japan has introduced a high level policy goal of becoming a sound material cycle society Australia is faced with the potential challenge of matching a resource dependent economy with the introduction of sustainability policies. It is apparent however that in the global economy the two patterns represented by Japan and Australia are linked and increasingly dependent on each other.

With our analytical approach we inform an integrated sustainability assessment for Japan and Australia. We present national data for both economies as well as data for two major cities Tokyo and Melbourne. We present the different drivers of economic growth as well as the factors that have constrained growth such as for example a diminishing labour supply in the Japanese economy. We distinguish between aggregate effects at the level of the national economy and the contribution of urban centres. We also discuss future scenarios for environmentally sustainable economic growth in both countries.”

LCA of the South African Sugar Industry

Livison Mashoko, Charles Mbohwa, Valerie Thomas

“The South African sugar industry can be used as a starting point in implementing sustainable projects in South Africa. It can contribute through high energy efficiency cogeneration of heat and power and through the production of ethanol. This paper examines the environmental impacts of sugar production from a life cycle assessment perspective. Life cycle assessment was chosen as the appropriate tool for the evaluation of the environmental impacts of the sugar industry in South Africa since it has been found to be a good basis for informed decisions with regard to the environmental impacts of human activities. The data for the inventory stage of the research was supplied by and obtained from the South African sugar industry and the analysis mostly uses South African data in the inventory stage. The work informs decision making in the sugar industry and parallels can be applied to sugar industries in other countries.”

Life Cycle Optimization for Residential Air Conditioning Replacement

Robert De Kleine, Gregory Keoleian

“The electrical consumption from central air conditioners currently accounts for about 14% of residential electrical use in the United States. Utilizing more efficient air conditioning units is one strategy to curb energy consumption. However the potential energy savings and greenhouse gas emission reductions from operating a more efficient unit must be measured against the burden associated with the fabrication of a new unit and disposal of the old unit. It is often difficult for consumers to know how long to use products and when to replace them in order to minimize environmental impact and operating costs. A life cycle optimization (LCO) model was developed to evaluate the ideal replacement schedule for a typical central air conditioner from 1985-2025. Life cycle profiles for each air conditioner model year were key parameters input into the LCO model. An algorithm was used to determine in which years the unit should be replaced. Replacement schedules were explored for the various climate zones in the continental United States. Using this method replacement schedules were developed with the objective of minimizing (1) energy usage (2) greenhouse gas emissions and (3) cost to the consumer. The model was also used to examine how rates of efficiency improvement and changing energy costs impact this schedule. Furthermore the research will explore how demand-side management can be used to correct misalignment between the cost schedules and the energy and emissions schedules through the use of utility incentives for early replacement of inefficient units. The results are expected to help manufacturers consumers and policymakers understand the environmental and economic benefits of the replacement of old air conditioners with new units.”

Design Tool for Environmentally Conscious Metal Cleaning Process

Riichiro Kimura,Yasunori Kikuchi, Masahiko Hirao

“In this study we develop a practical design tool for environmentally conscious process. When we design or improve a process generation of alternative candidate processes based on the necessary evaluations is inevitable. Although there are well-established tools for process evaluation such as life cycle assessment (LCA) risk assessment (RA) and economic assessment any practical tool to generate alternative candidate processes satisfying on-site requirements has not been proposed yet. The tool for alternative generation should provide concrete and feasible plans for engineers by extracting process parameters e.g. device operation and environmental parameters to be changed.

We employ metal cleaning process as a case study. In metal cleaning process various chemicals are utilized as cleansing agents and a significant amount of such chemicals is released to the environment. In order to generate process alternatives to reduce chemical risks evaluated by LCA and RA understanding of the relationship between causes of chemical risks and process alternatives through process parameters is needed. We analyze the relation between the causes of chemical risks and the process parameters by collecting the knowledge of experts who have experiences of cleaning process design. In Japan a large part of metal-parts manufacturers is small and medium sized enterprises (SMEs). Though each cleaning process has its individual conditions the experts can identify the key process parameters causing emission of chemicals by investigating the process and by using their implicit knowledge. Therefore we extract and classify the experts’ implicit knowledge by analyzing the generated alternatives and then construct a knowledge database. We implement a support tool for alternative generation based on the knowledge database. Integrated use of this tool and the evaluation tools e.g. LCA and RA enables engineers in SMEs to carry out process design.”

Analysis on international policy trend of MFA (Material Flow Accounting/Analysis)-based on indicators for resource productivity and the possibility of international cooperation for developing countries

Chika Aoki-Suzuki, Yasuhiko Hotta, Magnus Bengtsson

"Achieving sustainable resource use through improving resource efficiency is becoming an important international environmental policy agenda. This attention reflects the increasing resource demand and environmental impacts from resource extraction use and disposal. In this context and in line with the OECD council recommendations several OECD countries have developed policy indicators/targets based on economy-wide MFA (Material Flow Accounting/Analysis) in order to track changes in resource efficiency and to monitor negative environmental impacts.

In the autumn of 2007 a study of the international policy trends in using MFA-based indicators was conducted. The study found that the OECD countries have developed MFA and indicators through different approaches depending on their political and economic circumstances. In general resource-scarce countries whose main industry is export-oriented manufacturing like Japan and Germany are more active on MFA and target setting. For non-OECD countries the study assessed the potential capacity for utilising MFA in national environmental policy development. The study found that most non-OECD countries currently are lacking in capacity and concluded that further development of MFA data collection and calculation methodologies capacity building efforts and joint international research projects which could facilitate the implementation of MFA in developing countries are needed. The study also emphasized that developing countries need both micro-level technological improvement in resource efficiency and macro-policy tools such as MFA and resource productivity indicators which can be used for monitoring and policy development towards improved resource efficiency.

Increased international harmonization of MFA methodologies and resource productivity based policy targets among developed countries should be further developed. It is argued that these developments would be useful for resource productivity improvement in both OECD and non-OECD countries."

Dynamic substance flow analysis of brominated flame retardants in Japan: A basis for risk assessment with life-cycle of chemicals

Satoshi Managaki, Yasukazu Yokoyama, Shigeki Masunaga, Hiroki Hondo

"In regular risk assessments only rather limited knowledge is available concerning all life-cycle processes of organic chemicals. To obtain basic information for long term measures toward strategic chemical management at their life-cycle we conducted time series substance flow analysis of brominated flame retardants (i.e. HBCD) which is currently undergoing a risk assessment around the world. For 2000 HBCD consumption in Japan for all application areas was around 2000 tonnes. The stock of HBCD in the use phase was simulated as 16000 tonnes and the total stock in landfills related to this application area is 2200 tonnes. The time series substance flow analysis was conducted from 1986 to 2001 and extrapolated to 2030. HBCD represents a steadily increasing consumption rate. The future consumption reached 3300 tonnes/year in Japan. Emissions of HBCD have been increasing to date in future. The largest component of the emissions is simulated to be into the atmosphere. These emissions are estimated to be as high as 1500 kg/year in 2030 which correspond to 0.045% of annual consumption. As the stock in the use phase and landfill have been growing over the whole period the source profile of environmental emission would shift from upstream to downstream of product chain. These results suggest that these stocks in anthroposphere will be potentially long-term sources of pollutants leaching or volatizing to the environment in the future. Although there are still remaining data gaps in Japan substance flow analysis could be useful tool to recognize the potential chemical exposure at an early stage. Also as a second step we will examine time- and location- analysis of several risks associated with life-cycle assessment."

Well to wheel analysis of hydrogen as an energy carrier

Rosa Gudmundsdottir, Brynhildur Davíðsdóttir

“The objective of this poster is to analyze the hydrogen pathway and the utilization of hydrogen as fuel for the transport sector in Iceland and to analyze a scenario where hydrogen provides a total share of the transport energy consumed by vehicles in Iceland in the near future. A complete hydrogen pathway analysis is referred to as \’well-to-wheel\’ (WTW) analysis in the transport sector. A WTW analysis of hydrogen pathways covers all stages of the supply chain from energy feedstock recovery to energy delivered at the vehicle wheels.

In this study first a WTW approach was applied to evaluate the energetic and environmental impact of introducing hydrogen in the transport sector both in terms of primary energy demand and GHG emissions under relevant conditions for the Icelandic energy system assumed in 2030. In order to combine uncertainties in the pathway and arrive at a plausible range of variation for the total pathway a Monte Carlo approach was used.

Then by using the hydrogen pathway analysis and vehicle forecast based on the future scenario that all vehicles in Iceland are driven by hydrogen the primary energy required to produce the required hydrogen for the transport sector to replace fossil fuels and the associated GHG emission was evaluated.”

IMEA: IMports Environmental Accounting: towards an integrated framework

Damien Friot, Isabelle Blanc, Julia Steinberger, Arnold Tukker, Ilmo Mäenpää, An Verclasteren

“The ability of dealing with exchanges and regional specificities of existing Environmental Accounting Methodologies (EAM) e.g. LCA MFA environmental footprints or environmentally extended Input-Output is currently explored by national agencies as well as the business community. Existing EAMs are challenged on multiple grounds: treatment of imports trans-boundary pollution or practical relevance for specific goods and services.

The EU SKEP ERA-NET is funding the IMEA (IMport Environmental Accounting) project to provide a state-of-the-art review of environmental accounting methodologies and a reflection on their adaptation to trans-national issues. IMEA aims at proposing guidelines for developing a context-relevant integrated methodology for assessing trans-boundary issues i.e. exchanges of goods services and environmental burdens. IMEA project raises the following issues. (1) Is a generic methodology adequate to assess the large range of environmental issues related to trans-boundary exchanges ? Can it be flexible enough to account for environmental specificities the diversity of regions and of products? (2) What is currently achievable with existing EAM and datasets alone or in combination? (3) What are the methodological and data improvements required to get a consistent basket of methodologies: for a descriptive analysis of the current situation forecasting and modeling?

The analytical framework considers the following dimensions: (a) environmental reporting (b) coverage (c) quality and reliability (d) trans-boundary ability (e) integration potential (f) extensibility and (g) support to policy making. These dimensions are explored along various stages i.e. data sources system and boundaries calculation (weighting conversion factors normalization) and final environmental indicators.

We will present general results of the project and focus on some of the key outputs for the industrial ecology community. Further information is available on www.imea-eu.org.”

A quantitative assessment of the impact of policies on the Ecological and Carbon Footprint of Northern Ireland using the REAP Model

Robin Curry

"Northern Visions built on previous Material Flow Analysis and Ecological Footprint research to provide the first evidence based footpath setting out the actions that need to be taken to achieve the step changes in the Ecological and Carbon Footprint of Northern Ireland required to meet the challenge of a low carbon economy. The Ecological Footprint has been adopted as a headline indicator for the sustainable development strategy. Decisions are now being made on future economic and social development which will lock Northern Ireland into a resource and energy/carbon intensive model of development for years to come. In order to quantitatively assess the contribution of regional strategies to reducing the Ecological and Carbon Footprints a range of policies and strategies were evaluated using the Resources and Energy Analysis Programme (REAP) an Environmentally Extended Input Output Model. Current Government policy was benchmarked and the difference between the aims and actual reductions that would be achieved quantified. The analysis demonstrated that current policy commitments will not lead to the necessary reductions in either the Ecological Footprint or CO2 emissions."

Credentials for the ‘green and clean’ image of New Zealand

Barbara Nebel

“New Zealand has for a long time built on its ‘green and clean’ image. However in recent years the need for verification of the green credentials has become apparent. The New Zealand Government has therefore in 2007 launched the ‘ecoverification strategy’ and announced a number of other sustainability initiatives.

This paper provides an overview of New Zealand’s journey towards the implementation of a number of Life Cycle Management tools as part of the ecoverification strategy and other government initiatives. One of the key initiatives is led by the Ministry for Agriculture and Forestry who have initiated Carbon Footprinting projects for 11 primary sectors including forestry dairy wine kiwifruit lamb and others.

Another important milestone is the set up of a steering group for Life Cycle Assessment which includes member of government industry researchers and consultants. The key aims of the group will be to provide leadership in LCA to facilitate communication between the stakeholders to disseminate information and to develop a scheme for quality assurance of LCA studies.

There are also currently discussions underway to develop New Zealand specific Life Cycle Inventory data. An invitation for the Australian Life Cycle Initiative has already been received in New Zealand.

Comprehensive courses on Life Cycle Assessment and Life Cycle Management are currently not offered in New Zealand. However the Ministry for Agriculture and Forestry have now announced that it will sponsor a professorship in this area. This will broaden the skill base in New Zealand significantly and will enable a faster implementation of Life Cycle Management tools.

Although New Zealand might be a late adopter of life cycle approaches in comparison to some European countries it can be described as a ‘fast follower and implementer’. This might provide valuable insight of other countries that yet have to get on the ‘sustainability journey’.”

LCA of highways: a hybrid approach to the construction and use phase

Maria Fernanda Padilla, Joseph Marriott, Melissa Bilec, Amy E. Landis

“With more knowledge about energy consumption resources and alternatives we can decrease or at least make use of the energy the best way possible. When we are looking at the lifetime of the highway we not only look at the building phase but also the use phase and the end of life stage. In the use phase the energy consumption is also an important aspect to address. If we are able to increase the fuel efficiency of the cars using the highway we would be decreasing the overall energy consumption over the lifetime of the highway. This research study will present preliminary results of the LCA that involves the construction and use phase of a highway in the United States. The results will include air emissions energy use and global warming potential. The results will present a comparison between different types of pavement materials and techniques. For this particular study different traffic patterns will be discussed as well as different fleet distribution. “

5th International Conference on Industrial Ecology

2009 ISIE Conference

Industrial Symbiosis

Principles on the Design of EIP for Chemical Industry and sustainable development Evaluation

Yu Chen, Su-ling Liu, Yun Zhang, Shu-shen Zhang, Shu-shen Zhang, Hong-bo Zheng, Lei Cheng

"The following principles on designing new chemical eco-industrial parks (CEIP) were adopted for planning the Dalian Songmu island Chemical Industrial Park: taking environmental capacity into account improving eco-efficiency keeping ecologic niche relying on and cultivating high-tech and perfecting ecologic landscape. Because of the complexity of the chemistry for the ease of the planning the chemical industries were grouped into several sub-CEIPs (inorganic chemical fine chemical and petrochemical industries). The construction of the eco-industrial chain of the CEIP was based on the design of the sub-CEIPs. Enhanced eco-industrial chains and public facilities were also considered in the planning. The first-phase project of Dalian Songmu island Chemical Industrial Park has completed. The designed Songmu island Chemical Industrial Park has four main eco-industrial chains and was constructed from the aspect of stage implementation intermediate product balance and integrated infrastructure matching. Furthermore a set of systematic indices for sustainable development evaluation on CEIP was constructed. The general assessment method was investigated with respect to the indices and their weights and the assessment methods. The Comprehensive Evaluation Method was used in the sustainable development assessment of the well-developed Lubei CEIP using 27 indices and giving a comprehensive score of 88.8 that shows a high sustainable development level which will be further used for the assessment of the Dalian Songmu island Chemical Industrial Park."

Historical development of the Kymi Eco-Industrial Park – the evolution of an industrial symbiosis in Finland

Laura Sokka, Matti Melanen, Suvi Pakarinen, Ari Nissinen

“Industrial ecology (IE) studies the interactions between the human economy and the environment. It aims at minimising inefficiencies and the amount of waste created in the economy (Chertow 2000). Central to IE is the analogy to nature. Industrial systems and their development are compared to the evolution and functioning of natural ecosystems (e.g. Jelinski et al. 1992 Hardy & Graedel 2002).

The purpose of the present study is to describe the development of an eco-industrial park centered around a pulp and paper plant (the Kymi plant of the Finnish UPM Kymmene Corporation see e.g. Sokka et al. 2008). The pulp and paper plant was founded in 1872 by the river Kymi in South-Eastern Finland. In this paper the park\’s development and main material and energy flows are presented in six different years (1890 1914 1935 1971 1990 and 2005) ranging from 1890 to 2005. Data on emissions to air and water is also displayed. The development of the system is analysed with concepts derived from social network analysis (e.g. Ashton 2008).

The study indicates that the environmental impacts of the system have become more far-reaching during the 100-year period studied. In the late 1800s and early 1900s raw materials were imported from closer areas and there were fewer different products although most of the production was exported already then. Wood production areas were closer and also used energy resources mostly were local consisting of primarily hydro-power during the first decades of operation. Emissions to air and water peaked in the 1970s and decreased after that due to developing environmental legislation and other policy measures. The results show that the number of actors and the linkages between them has been continuously growing in each successive period. At the same time the production of the system has been continuously growing.”

Unifying and extending eco-industrial symbiosis typologies in order to develop new computer-aided tools for industrial ecology practices

Patricia Le Moenner, Cyril Adoue

“As part of the French “Grenelle de l’Environnement” initiative « circular economy » an application of industrial ecology is emphasized as an ecological development favoring competitiveness and employment. Alongside this the French National Agency for Research has sponsored a three-year program Comethe from the beginning of 2008. Comethe aims to develop new tools methods and knowledge to support the development of industrial ecology in the country and to complete the existing support offer such as the Presteo tool.

As part of this initiative the company Systèmes Durables has worked on the development of methods supporting evaluation of eco-industrial synergy regulations. This led Systèmes Durables to revisit the taxonomies of eco-industrial symbiosis and synergies. This communication aims to present research relating to these state of the art taxonomies and new proposals and questions. Indeed some specific ideas have been created for eco-industrial synergy and symbiosis. A new point of view has been considered drawing from Venn diagrams and developing into a static and a dynamic driven point of view.

Starting from the works of authors such as Chertow Van Berkel and co or Adoue the barriers of topics considered has been extended towards a more comprehensive sustainability vision for example places or human resources. All this work allowed us to define a new typology of eco-industrial synergies and symbiosis especially suiting our needs to design a method for evaluating the situation of a project towards regulations. This new typology aims to extend the scope and awareness of sustainable attitudes. It will be tested through the new tools developed and its suitability for pilot territories in the context of the Comethe project. It is hoped that it could also be a means for people involved in an industrial ecology project to discuss unusual topics such as land consumption.”

Methods and tools for reglementary evaluation of industrial ecology projects

Patricia Le Moenner, Cyril Adoue

“As part of the French “Grenelle de l’Environnement” initiative « circular economy » an application of industrial ecology is emphasized as an ecological development favoring competitiveness and employment. Alongside this the French National Agency for Research has sponsored a three-year program Comethe from the beginning of 2008. Comethe aims to develop new tools methods and knowledge to support the development of industrial ecology in the country and to complete the existing support offer such as the Presteo tool.

As part of this initiative the company Systèmes Durables has worked on the development of methods supporting evaluation of eco-industrial synergy regulations. Being a French program the primary focus of Comethe is on French and European regulations. Nevertheless a number of our principles should be adaptable to other contexts. First of all a simple observation is that the importance of regulation in today’s industrial life has increased in such a way that a company or public collectivity has to consider regulations in most projects. The regulation dimension of an industrial ecology project becomes often critical because it aims to reuse waste or favors dilution of responsibilities among several entities in shared operations. Therefore it is essential to provide help to the people involved regarding the risks for themselves and society (laws aim to protect against dangers). Due to this regulation awareness it is easier to make educated choice about projects and how to pursue them.

Systèmes Durables has worked on methods to make the regulation situation evaluation smooth. Besides state of the art these methods are based on research into project typologies on related regulation families and on existing computer-aided tools of interest. The aim of this communication is to share the actual findings of this research examples and perspectives in the context of the Comethe program and hopefully more widely.”

Synergy Research Program: The tool Presteo©

Cyril Adoue, Julien Saint Amand Florian

"The identification of eco-industrial synergies demands to pay attention to the materials and energy flowing through local and regional economies. This supposes to be able to collect and analyze information on the flows consumed and rejected by firms household and other urban components. For those reasons technical support and input-output matching appears to be a useful tool in eco-industrial development. That is the purpose of Presteo©.

This software helps to collect and exploit data from the industrial metabolism. A web platform allows to collect Input-Output table from firms and other urban components of a territory. These information are stored in databases and matched then the users of Presteo© can conduct studies to find potential synergies of substitution and/or synergies of mutualization.

Beyond a simple data-processing tool Presteo© includes several methodological tools: a data collection method a formalization method of flux and components and a processing method to filter the results obtained. This tool has been initially developed in French and recently translated in English. It is the result of 5 year research begun at the "Université de Technologie de Troyes" and then continued by the companies "Systèmes Durables".

Presteo© has already been used with success in Switzerland by the state of Geneva and in France by the association Ecopal in Dunkerque and The Club of Industrial ecology of Troyes. Currently Presteo© is used by the firms association Ecopal in Dunkerque and by the Communauté d'agglomération de Marne-et-Gondoire (France) to assist them in improving or reshaping two working areas.

These experiences have produced important feedbacks. New researches on this tool involving "Systèmes Durables" and the "Université de Toulouse II – Le Mirail" are ongoing. By integrating human factors concerns they seek to reinforce the ability of the software to process data and identify eco-industrial synergies. This will lead third version of Presteo©."

Industrial Symbiosis in Biofuel Production Industries: A Categorization of Synergies

Michael Martin, Mats Eklund Professor

“In the production of biofuels for transportation i.e. biodiesel bioethanol and biogas a vast range of unique resource flows surpluses and by-products exist in each respective process. The current research project aims to find synergies demands and surplus material and energy flows which will thereafter be applied to the biofuel industry and external industries in a collaborative effort to increase energy efficiencies and environmental performance through the use of synergies and industrial symbiosis. This is being conducted in order to determine conditions for implementation why some processes and synergies exist how the processes can be made better and to identify new material flows between industries.

During an investigation of synergies apparent in the regional biofuel industries many synergies were discussed during a brainstorming session with industrial actors and researchers. These synergies were recorded and classified in terms of their interaction with other biofuel and external industries. Using the theories of industrial symbiosis a classification method was developed based upon these interactions as well as the origin and destination of their resources. Previous terms from the theories of synergies research were used as background material. Thereafter symbols and classifications were based on the interactions of the synergy i.e. between biofuel industries and external synergies. Furthermore the origins/destinations were also classified as either a product/process or as a utility but with expanded and refined boundaries.

Example: 2UP (A synergy of Class 2 i.e. biofuel to external industry synergy which originates as a utility and is destined as a product/process for the external industry.)

Thus far the project has produced a classification scheme for biofuel synergy projects and research. Using the classification method synergies produced at future brainstorming sessions and discussions with industry will alleviate the reproduction recording and organization of synergies for upcoming interaction with biofuel industries worldwide.”

Accounting for the Greenhouse Gas benefits of Industrial Symbiosis under PAS 2050

David Cobbledick, Lauren Basson, Roland Clift, Anil Kainth

"Linear product systems comprising the traditional economic practices of production exchange and consumption are unsustainable for two principle reasons: firstly they involve depletion of stock resources secondly they create a range of pollutants that threaten human health and the environment. This fundamental flaw is exemplified by the coupled problems of mankind's current dependence on finite carbon based materials and the observed and predicted warming of the climate system attributable to greenhouse gases (GHG) produced in their combustion. Moving to a low carbon economy with benefits in terms of energy security and climate change mitigation is recognised as the one of the greatest challenges of the 21st century. Modification of industrial processes and practices is at the heart of this transition putting great demands on both technological and market innovation. Companies are under increasing pressure to account and report on GHG emissions and management strategies in procurement and supply as well as in-house operations. Thus regulatory and commercial pressures are shifting from the traditional focus on production processes at the facility level to life cycle emissions at the level of products services and the associated supply chains. The propagation and effectiveness of this approach will depend on readily accountable reliable and comparable information being available to decision makers across the value chain and innovative strategies to counter system linearity. This paper considers the relative merits and compatibility of two leading initiatives in each of these areas respectively the UK publicly available standard on life cycle Greenhouse Gas Emissions of products and services (PAS 2050:2008) and regional industrial symbiosis (IS) networks as brokered by the UK National Industrial Symbiosis Programme (NISP). This paper explores the implications of PAS 2050 for both practice and accounting in Industrial Symbiosis and provides proposals for refinements in IS network management and the treatment of open loop recycling under the specification."

EnvISion Eco-Industrial Development: South Humber Bank

Malcolm R. Bailey, Paul D. Jensen, Lauren Basson, Emma E. Hellawell, Matthew Leach

"Decoupling economic growth from environmental degradation is a key element of sustainable industrial development. However convincing many industry leaders and local government planners that the development of environmentally conscious practices and infrastructure can not only provide benefits to the environment but also generate competitive advantage is not an easy task.

Via EnvISion a business led Environmental Industrial Symbiosis development for the United Kingdom's South Humber Bank business leaders and local government have been persuaded to collaborate on the creation of an exemplar model for eco-industrial development. After several years of implementing one-to-one industrial symbiosis schemes in the Humber region local South Humber company Link2Energy aided by University of Surrey research has initiated what is projected to be a world scale eco-industrial development.

This paper presents the EnvISion model for eco-industrial development which is based on four key concepts: viz. decentralised energy production resource innovation public/private sector partnership and the theory of an industrial symbiosis conducive environment.

The paper will reveal how exploiting the South Humber Bank's conducive industrial symbiosis environment will allow for economic growth whilst also generating tangible social and environmental benefits. Capitalising on many natural and existing industrial assets including a deepwater estuary outstanding agricultural land Europe's largest combined heat and power station and significant chemical and petro-chemical processing and research capacity the South Humber Bank in conjunction with its forward-thinking business community is uniquely placed to be the testing ground for innovative industrial ecology research and practice. Furthermore it is contended that the EnvISion framework for eco-industrial development has the potential for replication in conducive environments throughout the UK and beyond."

Systems make it possible people make it happen!

Sabrina Brullot

“Systems make it possible people make it happen!” as J. Christensen said in the international workshop “Frontiers of research in Industrial Ecology” (november 27th- december 1st 2006) at Lausanne University Switzerland. Former manager of Novo Nordisk one of the main companies involved in Kalundborg symbiosis he is now working for the Kalundborg Industrial Symbiosis Institute.

A large number of synergies technically and economically feasible were identified in many projects of industrial symbiosis implementation all over the world for example: North Carolina - United States Gulf of Mexico Rotterdam harbour - Netherland Landskrona Program - Sweden. However only a little part of them has been studied and only few became operational. Synergies are more often potential than real. How can we explain this phenomenon? We share the point of view of J. Christensen and other like M. Mirata Cohen-Rosenthal D. Gibbs or L. Baas: human and organisational factors are highly leveraged determinant. Even if the use of a by-product by a company is technically feasible and profit making it will never become operational if people are not ready to cooperate. We think that a specific organizational and social context (trust exchange of information) should exist or should be created to implement industrial symbiosis successfully.

In this paper we present some methodological recommendations to start up an efficient network of actors in order to success industrial symbiosis implementation. We will show that this is a dynamic process. Specific aspects that govern the success of a program (choice of territory kind of actors involved private/public partnerships etc.) are dynamic too and are defined by and during the process of network implementation. Thanks to the theory of proximity we will show that during the progressive implementation of the industrial symbiosis network actors will share successively geographical proximity and then organised proximity.”

An eco industrial park as a regional business strategy to promote economic development

Inês Costa, Paulo Ferrão

“In an increasingly competitive global economy regional differentiation is a key development asset and environmental performance is a main aspect to be offered as a factor of competitiveness. In this context we offer a case study where a socially and economically depressed region (Chamusca in Portugal) found in industrial symbiosis such differentiation by promoting opportunities of new business ventures related to environmental services at larger scale.

Industrial symbiosis (IS) consists in a collective multi industrial approach to promote competitive advantages by making use of residuals as raw materials/energy and is considered the guiding force behind eco industrial parks (EIP). However engineering top-down approaches and neglecting market influences are referenced as limiting EIPs’ success.

This paper reports the EIP development strategy adopted in the Portuguese region of Chamusca. Battling an eroding social-economical base local government found in political consensus knowledge of local conditions community interaction and waste management experience its opportunity. Participated planning of EIP development lead in three years to thirty industries implemented some being national impact waste management infrastructures.

The paper characterises the main Symbiosis being nourished and the role of Chamusca as a national example on how to face sustainable development challenges and a driver for economically viable industrial solutions.”

Industrial symbiosis's facilitation tools: a Portuguese update

Inês Costa, Rita Pinto, Paulo Ferrão

"Planning Industrial Symbiosis (IS) constitutes a major factor for closing the material cycles in the economy and a relevant research topic among the Industrial Ecology (IE) scientific community. Intense planning efforts to develop Eco Industrial Parks (EIP) in the nineties soon gave way to dismay with the failure to constitute resilient IS networks. These results strengthen the self organizing symbiosis hypothesis in which IS emerges due to private actors' decisions using resource exchange to achieve extra benefits without previous planning. However this model makes IS connections (kernels) difficult to identify and to promote.

This paper presents initial findings concerning the development of an IS facilitation tool which aids to detect kernels and planning potential networks. A database of IS initiatives reported in the scientific literature and in currently operating EIP throughout the world is reviewed and the tool developed is applied in the identification of kernels in a Portuguese region as well as a planning assistant.

The tool was implemented and resulted in the identification of chemicals processing and non metallic mineral products manufacturing as the most intervenient economic activities in IS. Two cases of IS kernels in Portuguese regions were identified one involving two companies and another involving nine and are reported in the paper as an application of the methodology developed."

Better Practices for the Construction of Eco-Industrial Parks

Tracy Casavant, George Friedrich, Emilie Ouellet

"Eco-industrial parks (EIPs) are now envisioned to be far more than a collection of businesses implementing by-product synergies or offering environmental technologies. EIPs are being planned and designed with sustainability in mind up front which influences site planning and even the type of infrastructure installed. EIP infrastructure such as roads water sewer and energy is designed to reduce greenhouse gas emissions and improve environmental performance as well as to facilitate businesses' industrial symbiosis. Innovative utility models are often deployed to operate these innovative infrastructure systems. But what happens during the construction of EIP infrastructure (site servicing)? There has been a gap in applying a life cycle analysis to EIPs and bringing the eco-aspect to the construction phase.

This session will discuss approaches and lessons learned from two EIP case studies in Canada where green construction practices were implemented in addition to green design to optimise energy conservation and materials management in the infrastructure construction phase

Building sustainability into the construction process requires action in a number of stages. In the case studies discussed project-specific Construction Sustainability Plans (CSPs) were developed to guide construction practices and define expectations. CSPs were also used in the tender process to select a site contractor. Various datasets have been collected during construction activities both qualitative and quantitative allowing some evaluation of those specific projects.

Efforts to implement construction sustainability and monitor results on both projects are part of larger benchmarking endeavours to measure the benefits of an EIP approach. General performance measurement in EIPs and related benchmarking activities are a recent development in industrial ecology that requires broad collaboration and information sharing. Construction practices benchmarking has been identified as a research gap that should be addressed shortly."

Implementing Large-Scale Industrial Ecology through Geographic Information Systems

Tracy Casavant, Jenny Rustemeyer, Emilie Ouellet

"Eco-industrial networking (EIN) is a tool for implementing the principles of industrial ecology. It can create collaborative networks between businesses governments and communities to more efficiently and effectively use resources however identifying on-the-ground opportunities can be challenging when industrial businesses are spread over a large area. Policy makers and agencies need a tool that will help them focus their money and time on sectors programs and areas that will provide the most benefit for the entire community.

A Geographic Information System (GIS) is able to process vast amounts of information and facilitate strategically applying EIN in established industrial zones. With the use of online mapping resources such as Google Earth solidly in the mainstream the integration of spatial analysis is becoming an expected part of decision-making. GIS can analyze multiple factors and provide powerful visual displays of possible linkages "hot spots" and baseline measurements that would otherwise be prohibitively time-consuming and expensive to undertake.

This session will present the latest progress in the application of GIS and EIN to large-scale retrofits of existing industrial areas in Canada. For example the Pearson Eco-Business Zone is a 12000 hectare industrial area surrounding the Toronto Pearson International Airport. Launched in October 2008 it is the largest eco-business zone in North America and spans four administrative areas providing a unique challenge to data gathering GIS was essential for identifying EIN opportunities among the many thousands of businesses. Similarly GIS was invaluable when benchmarking sustainability in the Ross Eco-Industrial Park. Above and beyond these case studies this session discusses challenges to the broad scale application of GIS to uncover EIN opportunities in industrial areas."

TaigaNova Eco-Industrial Park – What's happening in the Canadian Oil Sands?

Tracy Casavant, Jaspal Marwah, Jeff Herold, Jenny Rustemeyer, Clay Braziller, Emilie Ouellet

"The Regional Municipality of Wood Buffalo (RMWB) is home to the world's largest oil sands industry with near term investment in this region estimated around $56 billion and a population that is doubling within ten years and enormous land pressures. Unexpectedly the RMWB is now home to TaigaNova Eco-Industrial Park the first conventionally financed eco-industrial park (EIP) in Canada. TaigaNova has been planned and designed to be an environmentally efficient and sustainable industrial park unique to the region.

This session will highlight the urban planning and new municipal policies and tools that were needed to make TaigaNova a success and internationally unique. The presentation will summarize the planning and design process followed and progress achieved to date. Lessons learned in developing and applying new policy tools ranging from zoning to the land disposition process to an innovative buyers' education program will be presented. In addition the management of overall factors such as rapid economic growth and activity in the region sparse availability of industrial land and therefore significant business demand very tight timelines interest from the largest oil and gas companies in the world and an existing stigma that this location constitutes the "absolute opposite of sustainability" will be explored. These factors are at play in many developing and resource-based economies worldwide. This is a rare real world EIP example rezoning is complete the subdivision has been registered underground services have been installed and several lots are already sold and those buyers have commenced their industrial facility designs with their construction scheduled to start in Summer 2009."

People Contribute to Success of Eco-Industrial Projects

Tracy Casavant, Emilie Ouellet, Jaspal Marwah

"Eco-industrial (industrial symbiosis) projects have tended to focus heavily on environmental and economic considerations and outcomes. However the social context in which businesses operate shapes the implementation process and can determine success. Furthermore industrial symbiosis projects often do not have explicit social targets nor are social outcomes well-monitored. Striving for positive social outcomes from industrial symbiosis projects is essential if industrial ecology is to realize its potential as a tool for achieving sustainability.

Part one of this session will compare how the social context was considered to varying degrees of success in the Ross Eco-Industrial Park Greater Sudbury Eco-Industrial Strategy and the Pearson Eco-Business Zone (part of Partners in Project Green). The session will compare the different approaches and specific challenges in each case study especially with respect to the need for sustained local leadership marketing and communications activities and the allocation of human and financial resources. This session will demonstrate how lessons from these case studies can be applied elsewhere.

The second part of this session will discuss how social outcomes have been explicitly set as part of two recent industrial symbiosis projects. The first project the Pearson Eco-Business Zone aims to use an industrial ecology approach to grow "green jobs". The Strathcona Business Improvement Association which is adjacent to the poorest neighbourhood in Canada would like to implement eco-industrial networking to help address concerns and opportunities that arise from working in a socially-challenged district in which industrial facilities homelessness and a thriving artistic community come together. The second part of the discussion will conclude with a wrap-up of lessons learned and discuss the social research that is required to enable the practical application of industrial ecology to include a social dimension."

Environmental impacts of inter-firm collaboration based on a life cycle approach

Dowon Kim, Jane C Powell

"Although eco-industrial development (EID) is attracting increasing attention worldwide as one of the emerging alternative approaches to sustainable industrial development the environmental benefits from EID have not been proved sufficiently. The economic benefits of EID tend to be emphasised as EID activities are mainly driven by economic needs while the environmental benefits tend to have been handled fragmentarily to justify them. However the evaluation of the environmental impacts can lead EID activities to increase sustainability through comparison of diverse EID options. It can also prevent uninformed decisions caused by the inclination toward economic benefits and justify why society should encourage environmentally beneficial EID options even though most EID activities aim to improve business profit.

This study has been undertaken to explore quantifying the environmental impacts of inter-firm collaborations based on a life cycle approach. A life cycle approach enables all the environmental benefits and costs from cradle to grave to be integrated quantitatively and consequently diverse options can be compared for decision making. This study suggests a quantifying approach that is different from conventional life cycle assessment (LCA) to evaluate the environmental impacts of inter-firm collaboration in the process industry.

This study examines both facility sharing and by-product exchange as typical types of inter-firm collaboration. Although facility sharing is considered to be economically beneficial to business due to the clustering effect it has not been clear whether the clustering effect can reduce energy and material use. It is also questionable whether by-product exchange can always generate more environmental benefits than facility sharing. This study compares the environmental impacts of facility sharing with those of by-product exchange by examining three collaboration cases collected in an eco-industrial park in Korea. In addition key implications from the analysis to improve the environmental benefits of inter-firm collaboration are discussed."

Extending industrial ecology principles to nonmaterial flows: the “Widen Symbiosis”

Francesco Fusco Girard

“Extending industrial ecology principles to nonmaterial flows: the “Widen Symbioses”

One of the most important issues in Industrial Ecology is the shifting of industrial process from type I- linear (open loop) systems in which resource and capital investments move through the system to become waste to type III a closed loop system where wastes and by products become inputs for new processes. The aim of this paper is to extend this loop vision of economics which is mainly based on energy and material flows also to nonmaterial flows

As matter of fact companies can be considered as living beings and can be studied according to a systemic approach focusing not only on material flow but also on immaterial flows.

Therefore the first step in setting up a systemic approach is identifying the nodes which are internal to the company and the other external nodes with which the company deals. They are Company internal relationships Relationship among companies and customers (B2C) Relationship among different firms (B2B such as Industrial Symbioses) Relationship among companies and Institutions.

Below we will analyse the above relationships pointing out with many practical examples how in order to really promote sustainable development in industrial production it is necessary to make them a “Widen Symbioses” WS that is to promote cyclic relationship with loops and feedbacks among employers and with other companies Institutions and Customers. So some issues such as Industrial symbiosis wikinomics Customer Relationship Management could be seen as expression of a new “cyclic” WS relationship among different companies with customers and so on...

In the conclusions we will analyse the fundamental role of values and cultural factors to promote Widen Symbioses relationships that is to realise material cyclic economy beginning from immaterial closing loops.”

5th International Conference on Industrial Ecology

2009 ISIE Conference

Managing End-of-Life Products

ReLCD - Recycling and ReUse of LCD Panels

Bernd Kopacek

“Nowadays more and more consumers substitute their conventional TV-sets and computer monitors by LCD panels. In the near future huge amounts of LCDs will start coming back to recycling. As LCDs with hazardous mercury backlight lamps are used an appropriate recycling technology has to be implemented.”

Potential of increased sorting efficiency for combustibles in Sweden- Environmental and economic implications

Niclas Svensson, Joakim Krook, Mats Eklund

“In Sweden a large share of municipal solid waste goes to incineration with electricity production and heat recovery. However many scientific studies suggest that some of the materials which are combusted could be recycled or reused instead. Most of these studies have focused on the waste from bins and bags collected from the households while little attention has been on the significant amount of bulky wastes which are collected at recycling centres in the Swedish municipalities.

An analysis of the combustibles fraction from recycling centres in a Swedish municipality has been performed. Fractions which should or could be recycled reused or needs special treatment such as hazardous waste was collected from 15.4 tonnes of combustible waste collected at 3 different recycling centres. These results are then extrapolated together with known material fractions in municipal solid waste from bins and bags to study the environmental and economic potential of a better sorting of combustibles in Sweden. An analysis of the positive and negative effects of increased sorting for the incineration process is performed. These effects include lower ash quantities less stress on the filter systems a more homogenous fuel but also a decreased amount of combustibles. These effects together with a higher material recovery rate are used in the environmental and economic analyses which are based on a life cycle perspective.”

Industrial project sustainability with simplified pre-study analysis. Case study: waste concrete recycling in the Stockholm region

Graham Aid, Nils Brandt, Monika Olsson

”Many waste management tools (ORWARE Easewaste WRATE etc) have been built to analyze alternative industrial situations (such as material end-of-life options) to extreme levels of depth. However (from a single industry players point of view) when analyzing a large portfolio of potential projects or (from a projects viewpoint) when comparing the major states necessary for a project’s success in various locations such in depth analysis can be overbearing too time consuming and too complex for the pre-study analysis required. This report utilizes the DPSIR (driver pressure state impact response) framework to lay out a simplified analysis path for identifying a project’s major sustainability indicators from the perspective of a market driven industry. Communication and major driver identification is of primary importance. The possibility of major drivers to cause intercoupled states (such as legislation taxes fuel or other associated markets etc) to change in the future and their projected paths is also of prominent interest. Laying out a clear picture of these major drivers states and their related impacts can be of great benefit to making business decisions that include capital layouts requiring longer \’return on investment\’ periods. A case study is presented to illustrate the simplified “pre-study” process for the thermal upgrading of concrete waste streams in the Stockholm region. This study is considered of interest to the field as it embodies an area that is expected to change dramatically in the future due to new EU directives fuel costs environmental concerns and other changes. The results of the study help show the major aspects that need to be in play to support a successful and sustainable project from an initial glance. If the project is shown to be ripe according the pre-study analysis further in-depth modeling and detailed analysis could be called for.”

Dynamic Flow Analysis of PVC in China

Dingjiang Chen, Ning Yang, Shanying Hu

“Chlorine plays very important roles in chemical industries. The industrial metabolism of chlorine brings some negative effects to the environment on different life cycle stages. This paper firstly presents a snapshot of the big picture of the chlorine industrial metabolism in China in 2005. Then PVC which is still expected a fast growing demand at least in a decade is identified as the one sharing the largest portion of organic chlorine products in China. Currently landfill is the primary way of final disposition of PVC products at end-of-life. Foreseen heavy environmental burden would be inevitable if no proactive measures were taken to handle increasing PVC wastes. Accumulation of PVC released to the environment in China is estimated by aggregating historical data. Scenario analysis is carried out based on a model considering the life-span of various major PVC downstream products and the gradual changes of PVC consumption structure. Effects of applying different final disposal technologies of PVC wastes are also discussed.”

The role of collective take-back schemes in WEEE management: the Portuguese case study

Eduardo Santos, Mónica Luízio, Paulo Ribeiro, Paulo Ferrão, Fernando Lamy da Fontoura

"Once discarded electrical and electronic equipments become waste and in some cases hazardous waste given its properties and the presence of hazardous substances. For that extend the European Union introduced a policy instrument based in the extended producer responsibility (EPR) with the objective of improving the performance of electrical and electronic products throughout their life cycle.

Likewise many countries in Portugal the EPR implementation originated a clear preference towards collective take-back schemes both by producers and the government where producers were able to transfer the management responsibility of their WEEE to the collective schemes.

This paper analyses the process that lead to the constitution of the main Portuguese collective system for WEEE management in 2005. It discusses the role of government private agents and academic institutions that were involved the interaction between them and the technical political legal and environmental aspects of the creation of the collective take-back scheme.

The main results obtained by WEEE management system are also presented. They show a clear improvement on the collection and recovery of WEEE and the development and consolidation of the infrastructure that provides for the WEEE collection transport and recovery.

Furthermore the preference towards collective schemes vs. individual systems is discussed taking into consideration the Portuguese case namely in the context of the results obtained and the collective scheme ability to prevent waste production and promote ecodesign and innovation. In this context possible solutions to enhance those aspects in future in the scope of collective schemes are discussed."

A Comparison of End-of-Life Strategies for Used Personal Computer Recycling in a Developed and Developing Country

Aya Yoshida, Tomohiro Tasaki, Kenichi Nakajima, Atsushi Terazono

"Used personal computers (PCs) can be reused or they can be dismantled and some parts reused and materials recycled. Due to differences in treatment technology capacity and socio-economic conditions the end-of-life treatment of used PCs differs considerably depending on location.

The ratio of reuse in the informal sector in a developing country is also clearly higher than that of the manufacturer's plant in a developed country. Labor costs are lower in developing countries and manual dismantling and detailed component separation lead to a higher recover rate of secondary materials. Meanwhile the informal recycling methods leads to severe pollution in e-waste sites: several reports have been published on Guiyu village in China where the levels of toxic chemicals such as PBDEs PCBs dioxins heavy metals in air particles and soils are higher than the background levels by upto 100 folds.

Therefore it is not easy to discuss which option (reuse or recycle and domestic or international) is better from economical and environmental perspectives.

The aim of this study was to compare treatment methods material recovery and environmental damage for used PCs in a manufacturer's recycling plant in Japan a local government disposal facility and the informal sector (i.e. outside the governmental management system) in a developing country to better understand and determine preferable final destinations of used PCs.

In this study the potential material recovery rate and environmental damage at each destination were calculated. The three different scenarios considering the best available technologies and the worse treatment methods in a developing country were compared to discuss which type of improvement measures are effective to the materials recovery and environmental impact."

The potential of e-waste as secondary resources – What kind of e-waste should we focus on?

Masahiro Oguchi, Akiko Kida, Hirofumi Sakanakura, Shinsuke Murakami

“In this study the authors discussed what kind of e-waste should be focused on as secondary resources of metals. When we discuss the potential of e-waste as secondary resources the important aspects are content of metals in one waste product and total amount of metals in total generation of waste products (Murakami 2007). For instance we can focus on the products with higher metal content and larger waste amount as secondary resources of metals. Comparing with the case of primary resources metal content and total amount of metals in waste products correspond to ore grade and size of deposit respectively. In addition collectability of waste products is also important. Possible aspects for collectability are product size and number of waste products generated. For instance smaller products with larger waste number are more difficult to collect because such products dissipate more easily due to their smallness and broader users. Collectability of waste products could correspond to possibility of ore condensation in the case of primary resources respectively.

According to these concepts the authors discussed what kind of waste products should be more focused on as secondary resources on specific product-type level. The authors acquired or estimated the data in Japan from statistical data the survey of literatures analytical approaches and so on. For instance the collectability of several target products of Japanese recycling laws was middle and that of cell phone was the lowest in terms of product size and number of waste products. Moreover the collectability of business use products could be quite high (they could be much less dissipative) comparing with consumer products because the size of such products was relatively large and the number of waste products was small. However the basic information for such evaluation is still inadequate for business use products.”

Quantification and characterization of discarded batteries in Yaoundé (Cameroon) from the perspective of health safety and environmental protection

Samuel Tetsopgang, Gilbert Kuepouo

"Exhausted portable batteries collected from the uncontrolled dumping in Yaounde (Cameroon) are mostly composed of non-rechargeable batteries of type D type AA type AAA with minor contribution of type C type 123 type 9-volt and rechargeable batteries of type AAA. These batteries wastes belong to the carbon zinc alkaline manganese NiMH and Lithium chemical systems with 98.12% 1.00% 0.53% and 0.35% respectively based on the total of 2287 battery waste units collected.

However no battery shows any label about the sound disposal of these batteries at their end-of-life. Several countries forming 83 trademarks are labeled as countries of origin of these battery wastes with China making 66.33% alone. The sole domestic trademark makes 25.74% of these battery wastes and the remaining 7.93% for other countries. Fifty-two percentage of these battery waste units are labeled as containing 0.01–0.025% of mercury and 3% marked as mercury-free 45% have no labeling indicating the added mercury. For cadmium 3% are marked cadmium-free and 97% do not show any labeling on the added cadmium. These batteries wastes will mostly end up in fire by the uncontrolled burning process despite the cautionary notes warning against such practices.

This study highlights the problem of a local mismanagement of portable battery wastes in Yaounde Cameroon. Then these batteries will release hazardous substances such as mercury and cadmium into the local environment. These substances have hazardous properties on the health and environment with regional and even though global impacts beyond the local scale of releasing. Then to reverse the situation in a developing country such as Cameroon with most batteries from foreign countries a better labeling of batteries is needed coupled with the implementation of an import fee system that will support a separate collection of waste batteries and shipped them back to the principal producer countries or companies for reprocessing or safe disposal. The domestic recycling seems to be difficult in this context since the quantity of battery wastes available may not sustain this process."

Application of LCA as a Communication-Support Tool for Stakeholders involved in Plastics Recycling System

Jun Nakatani, Kana Suzuki, Masahiko Hirao

“Various stakeholders i.e. producers consumers municipalities and recyclers are involved in a plastics recycling system. Some of the problems which disturb an effective recycling system affect stakeholders other than those who have the potential to solve the problem and communication among stakeholders is required for the system improvement of plastics recycling. In this study a framework for application of LCA as a communication-support tool for stakeholders involved in a recycling system was proposed and the framework was applied to the quality problems of post-consumer plastics among consumers municipalities and recyclers. Interviews to municipalities and recyclers revealed the actual problems in the recycling system of post-consumer plastics particularly from the quality aspect and the problems were described on a table according to stakeholders who were affected by the problems and who had the potential to solve them. Remediation scenarios were established following requests from the affected stakeholders. For example a scenario where polyolefin polystyrene and other polymers were separately collected by a municipality was established on the basis of a request from a mechanical recycler who suffered from the difficulties in separation of different kinds of polymers. LCA based on process modeling of mechanical and chemical recycling of plastics was applied to evaluation of environmental impacts and resource consumptions in each scenario. Evaluation results of the remediation scenarios were presented both to the affected stakeholders and to the stakeholders with the problem-solving potential and contributed to the communication among the stakeholders.”

New strategies for improved End-of-Life of vehicles

Carlos Muñoz, Rosario Vidal, Daniel Justel, Daniel Garraín, Vicente Franco

“European policies on the environmental impact of transport have raised the matter of reducing the weight of vehicles and the amount of waste produced at their End-of-Life (EOL).

The EOL of vehicles is regulated by Directive 2000/53/EC which sets the environmental goals regarding which vehicle weight percentages are to be recycled reused or recuperated. As of 2008 this weight percentage reaches 85% as required by the aforementioned Directive.

A survey of the typical End-of-Life of European vehicles today yielded the following results: the percentage of recycled materials reaches 785% in weight whereof 73% are metallic –both ferrous and non-ferrous- a 5% in weight is reused and about 25% is recuperated for energy. The remaining percentage –approximately 15% of the vehicle’s weight- is not recovered in any way. This consists of a heterogeneous assortment of materials (fabric foam rubber plastic etc.) which is sent to landfill.

The current vehicle EOL scenario -wherein most of ferrous and non-ferrous metallic materials are recycled while the light fraction and the rest of inert materials are landfilled- needs to be revised in order to meet the goals set by Directive 2000/53/EC for the year 2015. New strategies will have to be developed to allow for an adequate treatment –recycling reuse or recuperation- of those parts that are landfilled today. The incorporation of Design for Disassembly (DFD) and Design for the Environment (DFE) considerations into the development of vehicles it thought to help lower the environmental burdens associated with their End-of-Life. The Life Cycle Assessment methodology is used as a supporting tool to evaluate some of these strategies especially in those cases where the environmental benefits are not obvious (e.g. the substitution of metallic alloys by carbon fibre reinforced plastics which are lighter but also less easily recycled).”

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Sustainable Consumption

If biofuels are the answer what was the question?

Eric Johnson

“Most guidance for carbon footprinting and most published carbon footprints or LCAs presume that biomass heating fuels are carbon neutral. However it is recognised increasingly that this is incorrect: biomass fuels are not always carbon neutral. Indeed they can in some cases be far more carbon positive than fossil fuels.

This flaw in carbon footprinting guidance and practice can be remedied. In carbon footprints (not just of biomass or heating fuels but all carbon footprints) rather than applying sequestration credits and combustion debits a ‘carbon-stock change’ line item could be applied instead. Not only would this make carbon footprints more accurate it would make them consistent with UNFCCC reporting requirements and national reporting practice.

There is a strong precedent for this change. This same flaw has already been recognised and partly remedied in standards for and studies of liquid biofuels (e.g. biodiesel and bioethanol) which now account for land-use change i.e. deforestation. But it is partially or completely missing from other studies and from standards for footprinting and LCA of solid fuels.”

Approaches to eco-efficiency in public procurement

Katriina Parikka-Alhola, Ari Nissinen

“Over the last decade public purchasers have increasingly included environmental criteria in their purchases as green public procurement (GPP) has been fostered by many national and international policies. In public procurement the ‘total economical advantageousness’ forms a framework within which other criteria e.g. environmental criteria can also be taken into account in the award decision in addition to the price.

In business life the concept of eco-efficiency is used as an indicator of economical and environmental performance defined as the ratio between the benefit and environmental burden of a product or service. In this study the relations between the total economical advantageousness environmental criteria and their environmental benefits and the eco-efficiency of public purchases are examined. The theoretical analyses are concretized by several case studies. The first one looks at the use of environmental criteria in public procurement in Denmark Finland and Sweden during the years 2003 and 2005 and whether there had occurred any progress between the years concerned. The case study also presents a methodology to determine the \’greenness\’ of public purchases. The second one focuses on a purchase of a goods transportation service and the third case study looks at a public road construction procurement. The main question is when the most economically advantageous tender is also the one that has the lowest environmental impacts and best eco-efficiency? The weights for the different award criteria have a crucial role here and the study analyses the proper weight values for environmental impacts regarding the competitiveness of the most eco-efficient products and services. It also becomes evident that green criteria defined by the purchaser do not always lead to an environmentally best choice. Thus life cycle assessment (LCA) is used as a means to determine the effective environmental purchasing criteria.”

Life Cycle Assessment of Soybean Biodiesel Coupled to a Sugarcane-Ethanol Plant

Simone Pereira de Souza, Claudinei Andreoli

“Brazil and the United States are the world leader ethanol and soybean production. Many countries are desperately seeking alternative renewable fuels and in this regard sugarcane-ethanol and soybean oil-based biodiesel are the leading alternatives. The objective of this work was to estimate the life cycle of biodiesel and GHG savings in the United States and Brazil when biodiesel production is coupled to an ethanol plant. Three data sources were used – two from USA Hill et al. (2006) and Pimentel and Patzek (2005) and one fro soybean production from Embrapa/Brazil. The renewable energy used to convert soybean oil into biodiesel was supplied by the bagasse of the cane. The use of bagasse yields 146% 32% and 111% more energy than conventional biodiesel production respectively. Relative to the fossil fuels they displace GHG emissions are reduced on average by 32%. The energy of the bagasse from an ethanol-plant was environmental and economical efficient for biodiesel production.”

“The embodied carbon emissions of household consumption in Lisbon: comparing single region and multi region environmental IO models”

João Rodrigues, Leonardo Rosado

“Within the context of Urban Metabolism it is necessary to develop models that explain and manage complex systems. Such models are required to optimize different components of Urban Metabolism and to promote sustainability.

Some of these models are derived from the Input Output methodology and are used to measure the environmental impacts throughout the life cycle of products.

In this paper we report the carbon emissions embodied in the household consumption of the city of Lisbon using two different environmental IO models:

(1) a single region model derived from the OECD portuguese table for the year 2002 and the INE Global warming potential by Activity branch data for the year 2002 and (2) a multi region model derived from the GTAP 6 database for the year 2001.

The carbon intensities computed using the two models were then used together with household consumption survey data from Lisbon to compute the carbon emissions embodied in total household consumption.

The comparison of the two methodologies shows the differences between them and clarifies in which context each one is to be preferred in order to optimize the quality of an Urban Metabolism model.”

The development of the Italian database for LCA information (I-LCA) as tool for Sustainability

Lorenzo Maiorino, Laura Cutaia, Stefania Minestrini

"The development of the Italian database for LCA information (I-LCA) as tool for Sustainability ISPRA (ex-APAT) is planning the development and the management of a national on-line and public database for LCA (Life Cycle Assessment) information (I-LCA) in compliance with the paradigms of European Platform for LCA (ELCD). The availability of qualified data is one of most important difficulty in carrying out valid LCA. The data used in LCA (LCI – Life Cycle Inventory) should be consistent and reliable and reflect actual industrial process chains. The objective of the project is to develop a permanent and self-supporting infrastructure for data supply. Thus the availability and quality of life cycle inventory data shall be improved and efficient use of data shall be enhanced in various fields.

Expected impacts connected with the use of LCA methodology are:

1. LCAs have been used increasingly by industry to help reduce the overall environmental burdens across the whole life cycle of goods and services

2. LCA is also used to improve the competitiveness of the company's products and in communication with governmental bodies

3. LCA is used in decision making as a tool to improve product design for example the choice of materials the selection of technologies specific design criteria and when considering recycling. LCA allows benchmarking of product system options and can therefore also be used in decision making of purchasing and technology investments innovation systems etc.

The benefit of LCA is that it provides a single tool that is able to provide insights into upstream and downstream trade-offs associated with environmental pressures human health and the consumption of resources. These macro-scale insights compliment other social economic and environmental assessments.

The priority intent is to furnish the cognitive platform for identifying realistic environmental scenarios and accelerate sustainable development by sharing validated site-specific LCA data."

Application to Beef Production of a Methodology to Integrate Private and Monetised Environmental Costs

Ricardo Teixeira, Clara Fiúza, Tiago Domingos

"In this paper we develop a method for integrating Life Cycle Assessment (LCA) with economic valuation allowing a trade-off analysis between environmental and economic performance. We use an aggregate indicator for the environmental component namely Eco-Indicator99 (EI99) from the LCA software SimaPro. EI99 calculates a weighted sum of values in the categories Human Health Ecosystem Quality and Resource Consumption. We then convert the value for this indicator to monetary units and then add it to market-based private economic costs.

EI99 measures Human Health in DALY – Disability Adjusted Life Years. We use conventional economic valuation of the Value of Statistical Life (VSL) to obtain 74-175 k€/DALY. The quality of this estimate is confirmed by back-converting from DALY to GHG emissions using the conversion factors in SimaPro obtaining a valuation range of 16-37 €/ton CO2 which falls near the range of 5 to 22 € per ton of CO2 provided by NewExt and the EU Emissions Trading Scheme value of 26 €/ton CO2. We then use the weight for Human Health in EI99 to obtain an economic valuation for EI99 points: 2.83€-6.71€/point. This gives us a monetary valuation for the other categories.

Using this method we compare beef production in natural pastures vs. sown pastures. Beef is a valuable product in the Portuguese market. However its production has considerable environmental impacts. Part of the problem is that steers are usually fed in intensive production systems. This work aims to provide an alternative for steer production namely using extensive systems. We compare the total costs and benefits (private and environmental) of two extensive animal production systems: natural poor grasslands and sown biodiverse permanent grasslands. Contrary to general belief we conclude that the latter although more intensive are better and would be even more so if their use of phosphate fertiliser were optimised."

Environmental Comparison of Maize Produced in Portugal and Imported from Argentina: A Ma(i)ze of Options

Ricardo Teixeira, Tatiana Valada, Ana Simões, Oriana Rodrigues, Tiago Domingos

"In this paper we studied the impacts of maize production and transportation. Maize is a very important tradable good since it is highly used for animal and human food and increasingly used as a biofuel. We use Life Cycle Assessment (LCA) to analyze the environmental impact of its production and transportation. With the assessment results we compare different choices in cultivation methods and locations. We used the aggregation methods Ecoindicator 95 and 99 in software SimaPro 6.0.

Our question is: which is the best environmental option for a farmer in Portugal - should he produce grain maize in his farm buy it from another farm in Portugal or buy imported maize? The farm used for a case study was Quinta da França (QF). Maize from QF is compared to maize produced by average means from three Portuguese regions and Argentina.

Results show that transportation is responsible for an important part of the overall impact. It is so important that it may change significantly the results obtained. In fact at the farm gate Quinta da França is not the best option for maize production when compared with other national regions or Argentina. That is not the case however including transportation.

Results change even more if we consider that the QF farmer may optimize its own production namely using no-tillage techniques adequate fertilization and irrigation. In that case QF becomes the location with a lowest environmental impact.

Therefore small distances for transportation combined with optimized production may be the best combination. In terms of policy it is also the better option since production conditions are easier to regulate locally than to impose them as a requirement for imports."

Carbon Abatement of Photovoltaic (PV) Electricity at the Margin

Deepak Sivaraman, Gregory A. Keoleian

"Introduction: Conventionally CO2 abated by generating photovoltaic electricity has been evaluated using average grid fuel mix profiles at various scales. However at low capacity PV installations it is only the peak-load resources that are displaced from the conventional grid as opposed to the entire average of base intermediate and peak load sources. We develop a novel methodology to evaluate the CO2 abated at the margin by PV electricity in a load zone (ERCOT ISO)(1) and compare the results to the abatement evaluated using average national regional and state fuel mix profiles for the same location.

Methods: The annual hourly data for solar radiation (2) and the load (3) were obtained for ERCOT to model the PV electricity output and demand. The list power plants available for dispatching to meet demand and their characteristics (fuel type CO2 emission factor capacity and capacity factor) were obtained (4). We developed a visual basic excel code to determine the dispatching order in the load zone based on the hourly demand. Using CO2 emission factor with the amount of grid electricity displaced (by PV electricity) from each power plant at the margin the marginal CO2 abatement was evaluated.

Results: Due to utilization of a number of natural gas plants at peak loads the CO2 abated by PV electricity (at eight different capacities from 1 to 1000 MW) was consistently lower when compared to the average fuel mix cases. In the case of ERCOT ISO 95% of electricity displaced at the margin was generated from the less carbon intensive natural gas the marginal fuel uses less coal than the national (51%) regional (23%) and state (38.5%) cases. Over the range of PV installations CO2 was reduced between 329 – 327800 tons for the marginal case compared to average mix cases. Hence carbon abatement using renewable technologies can be significantly different using a marginal displacement approach this study presents one such case using PV technology.

References:

1. An Independent System Operator (ISO) co-ordinates controls and monitors the operation of electrical power system in a region by dispatching power plants to meet demand every hour of the day. ERCOT ISO serves 85% of the Texas' electricity demand.

2.National Renewable Energy Laboratory (Renewable Resource Data Center) 2008. Solar Radiation Data

3.Federal Energy Regulatory Commission (FERC) 2008. Annual Electric Balancing Authority Report

4.Emissions and Generation Resource Integrated Database (E-Grid U.S. EPA). 2008"

Green procurement practice in Norwegian municipalities still a long way to go

Ottar Michelsen, Luitzen de Boer

"Green public procurement is recognized as a tool for promoting environmental friendly products and manufacturers. Most studies on implementation and impact of green public procurement look at procurement at national levels. Studies also typically focus on environmental demands in tender announcements and not so much on the actual or perceived impact of environmental demands in the final procurement decision.

Little research is done on GPP on a local level. The study presented here investigates green procurement practice on the municipal level in Norway. Among other things the study considers the importance of environmental demands in the final supplier selection decision as well as the number of environmental demands in tender announcements.

The study is based on semi structured interviews with public purchasers and questionnaires. Questionnaires were sent to all municipalities and counties in Norway. Questionnaires were also sent to potential national suppliers to Norwegian municipalities. This was done to reveal potential disparities between the municipalities' and suppliers' view on the actual and perceived importance of environmental issues in the final procurement decision.

Even though Norwegian law states that environmental concerns must be considered in all public purchases our study shows that approximately 25% of the municipalities disregard this obligation. Also the study shows that even if environmental demands are included (e.g. in tender documents) half of the municipalities respond that they have never turned down the cheapest offer. The suppliers' understanding of the importance of environmental demands is even lower – 3 out of 4 potential suppliers think environmental criteria are of no real importance in the in the final supplier selection.

In the study we find a clear correlation between focus on green procurement and size of the municipality. In accordance with other studies we find that lack of environmental competence seems to be an important obstacle for incorporating green procurement in the municipalities.

Based on a discussion of our findings we formulate implications for both public (procurement and other) officers and further research."

Designing an Integrated Model for Urban Energy Demand

Ana Gonçalves, Tiago Domingos

“The energy crisis is the cause of multiple political reunions and actions. Energy consumption within cities is even more problematic because it represents 75% of the total value although only about 50% of the global population lives in urban areas.

Our work is focused on the energy demand side more precisely on the creation of models to understand the evolution of energy demand at the city scale and how can that evolution be influenced by political measures. For that we will use some existing models with the purpose of creating a unified theory. These models fall into three main categories:

-One of the first works in economic geography was developed by Von Thuenen who studied the land use relation with the economic activities mainly for agriculture purposes. But there are a number of researchers that have taken their own approach to explain the ways cities grow. One of the most famous works is the one developed by Krugman that tries to understand not only how does the urban area grow but also how it is organized.

-Ecological economy has studied in one of his areas the relation between energy consumption and economical development of an economical entity (city region country). In the 80’s Goldemberg also addressed this issue studying among other things which economical activities of development were more deeply dependent on energy.

-The consumption behavior is in the origin of the energy efficiency gap which translates the difference between the technologic available energy efficiency and the one that actually exists. Under the focus light in the latest years Behavioral Economic Theory has mainly studied the irrational components of behavior. These irrational actions are options made by consumers that do not follow what is stated in the Traditional Economy Theory.”

Accounting GHG emissions in Shopping Centers

Ana Gonçalves, Ana Catarina Henriques, Ricardo Teixeira, Tiago Domingos

“Green House Gases (GHG) emissions is one of the most discussed issues about sustainability nowadays as more evidences of a possible relation to climate change are revealed. Following international agreements like the Kyoto Protocol companies started to show concerns of their impact on the environment and particularly on their GHG emissions.

In this work we have created and applied a methodology (based on “The GHG Protocol”) to calculate the yearly GHG emissions of a number of shopping centers owned by a real estate player in the Portuguese market. As proposed in the mentioned document we have divided the emissions into three scopes:

-Scope 1 relates to the emissions that are produced in site like the consumption of fuel and the emissions of the company fleet. To assess the value of the emissions there were used emissions factors found in the literature.

-Scope 2 accounts for the emissions related with electricity consumption. In this case it was important to take into account the energy sources mix necessary to produce the electricity as it varies significantly during the day. As the data provided only distinguished the monthly electricity consumption we created a methodology to find the daily profile of consumption.

-Scope 3 includes water consumption waste production and employees’ business travels. In this case we have extended the frame of the scope and also included the clients’ travels. The emission factors for the waste production were calculated using LCA software (SimaPro) and accounted the materials production recycling burning and disposal. The other emission factors used were taken from existing bibliography.

The results obtained showed that the most important factor to the emissions of GHG were the consumers’ travels. This means that shopping centers must pay a special attention to the transportation means of their clients in order to reduce their GHG emissions.”

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Sustainable Resource Management

Underground Thermal Energy Storage: A Review of Current Technologies

Ryan Zizzo, Christopher Kennedy, Alan S. Fung, Bill Wong, Bernie McIntyre

"Storing thermal energy underground for later use has been used extensively in Europe and is becoming increasingly recognized throughout North America. It is important that engineers and policy makers be familiar with the various types of systems available their associated costs and energy saving potential. Underground thermal energy storage (UTES) makes use of the thermal capacity of soil bedrock and groundwater as a storage medium. It can be used for inter-seasonal storage to store heat during the summer and use it in the winter and vice versa for winter chill. UTES is promising because it can store energy for long periods of time to better meet demand using less fuel. This was demonstrated in Okotoks Alberta where a new UTES development meets approximately 90% of energy requirements using heat which is stored underground and used throughout the year.

UTES technologies are subdivided depending on whether the ground itself (natural) or structures such as underground tanks (artificial) are used as the storage medium. Artificial UTES consists of buried steel or concrete tanks filled with water and can sometimes contain gravel. Natural UTES is further broken down into three distinct categories depending on how the energy is stored which is dependant on the geology of the site. Cavern (CTES) utilizes naturally occurring or man-made caverns to store hot water. Borehole (BTES) uses a field of soil and/or bedrock penetrating boreholes through which hot water is circulated. Aquifer (ATES) makes use of naturally porous deposits which can hold a significant amount of water.

Artificial systems can be fully constructed and operated with minimal unknowns however provide a relatively small storage capacity. Natural systems can provide massive capacity but introduce significant unknowns into system design. An overview of these technologies highlighting their strengths weaknesses costs and potential energy and greenhouse gas reductions is presented."

Energy Vs. Feedstock: An Analysis of the GHG emissions and the emission reduction strategies for the Chemical Sector.

Paulina Jaramillo, W. Michael Griffin, H. Scott Matthews

"We analyze the role bio-based feedstocks can play in reducing the GHG emissions of the U.S. chemical sector. We compare the emission reductions associated with substituting petroleum-based feedstocks with bio-based feedstocks to the reductions that might be obtained by mitigating the emissions associated with energy consumption. We identify the emissions associated with feedstock and energy consumption in key chemical sectors. We find that for the entire chemical sector emissions associated with consumption of carbon-based feedstocks are a third of the emissions associated with energy consumption. This implies that reducing the energy consumption or decreasing the carbon intensity of the energy sources for the chemical sector can lead to higher emission reductions than replacing some key feedstocks with bio-based sources.

A case study was analyzed using polyhydroxyalkanoates (PHA) as a bio-based replacement for polystyrene (PS) and high-density polyethylene (HDPE). The emission savings associated with replacing all PS and HDPE were compared to the emission savings obtained if the Petrochemical and Plastic Resin sector replaced their natural gas and petroleum fuel with bio-based energy. We found that the latter scenario could provide a GHG emission reduction of 30%. Producing PHA instead of PS and HDPE could at best results in a 10% emissions reduction. At worst an increase in GHG emissions could occur.

As we move towards a carbon regulated world and the reduction of GHG emissions from our industrial sectors become more pivotal. It will be essential to identify "best" strategies to maximize reductions. From this analysis it is clear that the chemical sector should make reducing the emissions associated with its energy consumption its number one priority in its efforts to reduce GHG emissions."

CO2 Life Cycle Inventory in an Enhanced Oil Recovery System.

Paulina Jaramillo, Sean T. McCoy, W. Michael Griffing, H. Scott Matthews

"Enhanced Oil Recovery (EOR) has been identified as a method of sequestering CO2 recovered from power plants. In EOR CO2 is injected into an oil reservoir to reduce oil viscosity reduce interfacial tension and cause oil swelling which improves oil recovery. The National Energy Technology Laboratory (NETL) estimates that there are 45 billion barrels of oil that could be economically recovered with EOR using 225 billion cubic feet of CO2. At a first glance these numbers suggest that substantial amounts of CO2 from power plants could be sequestered in EOR projects thus reducing the amount of CO2 emitted into the atmosphere. This however ignores the fact that oil a carbon rich fuel is produced and 94% of the carbon in petroleum is refined into combustible products ultimately emitted into the atmosphere. In this study we analyze the total life cycle CO2 emissions in an EOR system. We perform a life cycle inventory of a number of published CO2 EOR projects. The boundary of the system includes an IGCC power plant with CO2 capture transport of this CO2 via pipeline EOR field operations (which include CO2 injection into the reservoir CO2 recycling and ultimately sequestration) transport of crude oil crude oil refining and the combustion of the refined petroleum products. We find that the CO2 emissions within the system boundary are between 3.5 and 5 times larger than the CO2 injected and sequestered in the EOR field. However if we assume that oil and electricity produced within the system boundary replaced an equivalent amount of oil and electricity produced from conventional sources there would be a net reduction in emissions. This emission reduction however would be about a third of what is injected and sequestered in the EOR field. We explore a number of interesting allocation issues related to these results."

Implications of international trade in the Finnish forest industry carbon balance

Laura Saikku

“Renewable energy sources and growing stock of forests play an important role in reducing GHG emissions. Finland is a Northern country of Europe where forest growth emits around one third of the annual fossil emissions. Forestry plays an important role also in the Finnish economy. 21% of the annual energy consumption was met with wood fuels in 2005. Wood raw material is imported in great amounts - and many forest products are exported. The main wood product is paper of which around 90% is exported. In 2004 round wood and forest industry products represented 25% of the total value of goods exported from Finland. Due to increasing international trade the production and consumption are somewhat unconnected. Emission inventories report the production related emission. However around 10% of the fossil emissions in Finland in 2001 were due to products that were exported and consumed outside the Finnish boarders.

Goal of this study is to describe the carbon flows and the monetary flows in the Finnish forest industry. The study focuses on the consumption based emission estimates and addresses the role of forests and forest industries in this context. National consumption based CO2 emissions have been estimated by using input-output methods. Focus is on forest industries as many material flows on the forest sector such as forest residues and waste have little or no economic value and have therefore not yet been thoroughly included in the estimation methods for consumption based emissions. For example the pulp and paper industry produces electricity and heat for use outside of the pulp and paper mill and forest industry products contain embedded energy and carbon. The material flows of forest sector are very large especially in Finland and elsewhere in northern Europe.”

Analysis of the Current Status of Urban Mining of Metals in Japan

Kohmei Halada

“Urban mining from secondary stock provides us another good supply of resource for engineering material in addition to primary resource. Since respectable amount of energy is required in extraction of metals, urban mining of metal is also effective for reduce the environmental burden in processing. From the viewpoint of hazardous risk management, the development of urban mining reduce the environmental release of metallic element from dissipated material.

The paper shows the possibility of urban mining of various metals in Japan PS (potential of accumulation as secondary stock) and the evaluation of current status from material flow data. The evaluation is subjected with two essential parameters and one physical parameter. Two essential parameters are RP: reduction of primary resource and RW: reduction of the emission of waste element into environment. They affect the interaction between eco-sphere and techno-sphere. The physical parameter is RS: ratio of secondary resource, which is frequently used in discussion of recycling. RS is also considered as a kind of state quantity in recycling system. RS of each material in a product has a possibility of scientific analysis theoretically if technology is developed in future. However RS is useful to discuss the recycling system, higher RS does not always means higher sustainability.

As the result, PSs are very high in Japan but only a small amount is recycled. While several metals have higher RS values, small number of metals have effective in RP. Estimated RW values are small excepting several metals. More information is required to estimate RW. JOGMEC’s material flow data, METI’s industrial statistical data and some industrial trade data are referred.”

Breaks in trends of material flow indicators in the Czech Republic after joining the European Union

Jan Kovanda, Jan Weinzettel

“Over the last two decades economy-wide material flow analysis and indicators have become widely accepted tools for assessment of material basis of economies and sustainable resource management. The present research in the field of material flow analysis is among others focused on relating various driving forces such as GDP growth and structure consumption patterns or transport patterns to changes in material profiles of the economies. Besides these driving forces which are of more or less continuous nature there are also more abrupt ones. These might include implementation of various policy measures creation of strategic partnerships among countries financial crises wars etc.

Up to now material flow studies have been carried out for a large array of countries. In the Czech Republic economy-wide material flow indicators have been compiled for the years of 1990-2006 so far. This time span covers both transition period from the centrally planned economy to market economy and the accession of the Czech Republic to the European Union in 2004. Reflection of transition period by material flow indicators in the Czech Republic was discussed elsewhere. This contribution is focused on the accession of the Czech Republic to the European Union and related changes in its material profile. It will be shown that some material flow indicators and their components/material categories remained intact but others recorded a significant growth. For example the growth of trade flows was unprecedented compared to the whole 1990-2006 period. We will discuss why some material categories recorded larger increase in trade flows than others and suggest some ideas how the further development of material flow indicators in the Czech Republic (as a member of the European Union) might look like.”

Water resources and human health under global Climate Change – improved sanitation and sound public governance as main adaptive measures for sustainable resources management in the Brazilian cities

Silneiton Favero-Silva

“Global Warming potentially affects climate-sensitive hydrologic variables that influence the incidence of water-related diseases (WRD) whereas adaptation to global climate change (GCC) regarding water resources management and sanitation can importantly limit health negative water-related outcomes in the cities. Adaptive measures to the health impacts of more frequent extreme climate events in urban areas of developing countries (DC) will likely have to focus on current sanitation bottlenecks and additional human health interfering factors as to curb WRD incidence rates under a plausible GCC scenario – which also means dealing with the financial costs involved. The paper reviews a compilation of observed implications of extreme climate events on human health and analyses the associated results under climate scenarios that are similar to those projected for GCC. As the water-health relationship entails confounding factors and DCs typically lack efficient and encompassing sanitation systems and water management direct causation between both events cannot be indisputably asserted because non-climate factors in Brazil are more immediate to constraining WRD which are reliant on adequate public policy formulation and implementation beyond sanitation-related works and structural end-of-pipe approaches that have traditionally been in place implying higher and often unbearable financial costs . All-inclusive sanitation is in such a context an important limiting factor of the climatic impacts on human health given that business-as-usual health setbacks are necessarily tackled in the scope of improved water resources management in association with sound policy implementation. The precautionary principle thus strongly suggests that national environmental management do coordinate with public health-sanitation for adaptive purposes under good public governance schemes. GCC is a potential ecosystem stressor and may then represent an additional challenge for developing countries regarding human health and public policy response in the near future.”

Evaluation of Recyclability of Elements and Materials in Electric Home Appliances using Urban-ore TMR

Ryota Minamino, Eiji Yamasue, Hideyuki Okumura, Keiichi N Ishihara

“It is important to evaluate the recyclability of elements in “urban mine” such as e-waste as a new resource. We newly developed a framework of Urban-ore TMR (total materials requirement to recycle elements from urban ores UO-TMR)[1] which can be compared with Natural-ore TMR (total materials requirement to smelt the elements from natural ore NO-TMR).

The elemental recyclability for six electric and electronic home appliances (CRT-TV LCD-TV refrigerator washing machine air conditioner and microwave oven) has been evaluated using urban-ore TMR. Target elements are gold silver copper iron aluminum lead and indium etc. Besides urban-ore TMR of not only the elements but also stainless steel and plastics etc. are estimated.

For the evaluation three scenarios are considered. In scenario 1 only the components made of elementary gold silver copper iron and aluminum in the waste products are recycled. In scenario 2 in addition to scenario 1 the components of stainless steel and aluminum-based alloy are diluted by pure metals in order to be recycled as elementary iron and aluminum which partly reflects the current situation of recycling. In scenario 3 in addition to scenario 1 stainless steel is recycled as stainless steel and Al alloy is recycled as die-casting aluminum.

It is found that in scenario 1 UO-TMR of all elements for all products are lower than NO-TMR. In scenario 2 UO-TMR of gold silver and copper are lower than that in scenario 1 while those of iron and aluminum are higher than that in scenario 1 and are the almost same as NO-TMR. In scenario 3 UO-TMR of stainless steel is lower than NO-TMR and UO-TMR of die-casting aluminum are almost the same as NO-TMR. Based on these results the elemental recyclability of the waste appliances will be discussed.

[1] E. Yamasue et al.: Materials Transactions (under reviewing)”

Tools for Sustainability in Industry by Recovery of the Secondary Materials

Ecaterina Matei, Andra Stoica, Cristian Predescu, Andrei Predescu, Andrei Berbecaru, Mirela Sohaciu

“The paper contains recommendations on creating and operating procedures of the institutional framework to ensure implementation monitoring and reporting on the results of National Strategy for Sustainable Development. It also aims to adopt innovative solutions according to the Romanian industry features regarding the involvement of the authorities and the social factors in achieving the objectives of sustainable development.

The technological solutions are developed for the pollution diminishing especially for the recovery of the secondary materials resulted from industry in order to harmonize our environmental legislation with Union European environmental acquis.”

Building-Scale Alternative Energy: A Comparative Analysis for the Ontario Case

David Bristow, Chris Kennedy

"Building-scale alternative energy systems can be installed on or next to a building in order to provide heating or cooling or electricity. These systems generally offer the advantage of reducing the burden on centralized energy infrastructure while lowering greenhouse gas emissions. However thus far in many jurisdictions there have been far fewer installations of these technologies compared to centralized alternative energy. Part of the problem is a lack of information available to those ultimately responsible for the installation of these systems – the building owners. The industrial ecology approach which focuses on environmental impacts and economic competitiveness is ideally suited to address the lack of information for homeowners.

This work analyses the performance greenhouse gas emissions reductions and economics of building-scale alternative energy in the province of Ontario. The technologies considered are photovoltaic and small wind electricity generation solar air heating for building ventilation solar water heating for service hot water use and ground source heat pumps for space conditioning. The audiences examined are homeowners small to medium businesses large business institutions and investors. The performance and greenhouse gas analysis considers relative performance with respect to audience type and location within the province using geospatial climate data. The economics are analyzed using a full life-cycle cost analysis that considers system costs government incentives and the future price of natural gas and grid electricity.

The results indicate that ground source heat pumps generally provide the most energy savings greenhouse gas reductions and best economic returns for most audience types and regardless of location within the province. Solar air heating and solar water heating generally provide the least amount of energy savings and greenhouse gas emissions but do provide good economic returns for the non-homeowner audience types due to available government grants. The lowest returns tend to be for wind and photovoltaic systems."

Towards a Sustainable Recycling Society

Juha Kaila, Maria Törn

“The environmental problems we are facing today are more complex than ever. To tackle these problems we need creative sustainable solutions.

Our main focus is in environmental technology and waste management. At present we are working with the definition and indicators of a recycling society and formulation of relevant research questions from a multidisciplinary perspective. Some of the key issues we need to assess are the characteristics of material- and waste streams of the future and new technologies and business models for utilising industrial by-product streams. Other relevant research questions are: integration of material processes of different actors (production consumption recycling) in a recycling society interdependency between natural resources policies and a recycling society and integration of waste management and energy systems in a recycling society. Sustainable resource management is a key concept as well as a challenge of the recycling society.

Our research team is genuinely multidisciplinary and our means of achieving the aims of sustainable development in a recycling society include systems approach life-cycle approach material flow approach environmental policy and steering methods. The roots of the idea of a sustainable recycling society are in a resource policy based on sustainable use of natural resources in principles of sustainable production and consumption waste minimization and recycling.”

Life cycle analysis of ceramic versus painting materials applied to external walls

Surgelas Flávia Maria Achão, Marques Guilherme Fernandes, Rodrigues Conrado De Souza

“The environmental impacts of a building are present in diverse stages of its construction and use and are related to many factors including the use of energy emissions and hazardous materials. This work presents the application of life cycle analysis to study different building facades comparing the use of painting and ceramic lining technologies. The general objective of this study is to identify and organize the LCA components of building facades constructed with ceramic tiles and paint with the purpose of comparing the environmental performance through CO2 emissions and energy consumption. The study includes definition of LCA objectives scope the subsystems and their boundaries in order to compare emissions and energy consumption for the same durability criteria. The life cycle stages include raw material extraction materials manufacturing use and maintenance. The flow diagrams for the processes and their related emissions are presented.”

A model based study to explore sustainable resource management

Yogendra Shastri, Urmila Diwekar, Heriberto Cabezas, James Williamson, Norma Lewis

"The successful functioning our ecosystem depends critically on the availability of various resources both exhaustible as well as renewable to support human as well as natural activities. However the increasing consumption rate of these resources has become a critical issue for the overall ecosystem sustainability. Designing management policies to achieve sustainability requires a basic system-level understanding of the nonlinear and non-intuitive implications of different developmental scenarios. This basic understanding further includes a sense of the time scale of possible future events and the limits of what is and is not likely to be possible. With this understanding systematic approaches can then be used to develop policy guidelines for the system. The goal of this work is to conduct such an analysis using a model system. The system is represented as an integrated ecological-economic-social model which comprises various ecological (natural) and domesticated compartments representing species along with a macro-economic price setting model. The stable and qualitatively realistic model is used to analyze different relevant scenarios such as increased per capita consumption. The scenarios that lead to direct or indirect implications on resource sustainability are also included in the study. Apart from highlighting complex relationships within the system it identifies potentially unsustainable future developments such as increased human per capita consumption rates. Dynamic optimization is then used to develop time-dependent policy guidelines for the unsustainable scenarios using objective functions that aim to minimize fluctuations in the system\'s Fisher information. The results can help to identify effective policy parameters and highlight the trade-off between natural and domesticated compartments while managing such integrated systems. The results should also qualitatively guide further investigations in the area of system level studies and policy development."

Technologies products and strategies with resource efficiency potentials – results from current research studies

Holger Rohn, Michael Lettenmeier, Dr. Claus Lang-Koetz, Nico Pastewski

“In order to further enjoy prosperity without exceeding environmental social and economic limits it becomes necessary break the link between economic growth and environmental degradation by dramatically increasing the efficiency of the use of natural resources. Resource-efficiency has several benefits: using less raw-materials can reduce costs and uncertainties in terms of raw material supply. In addition environmental impacts can be decreased during different stages of the lifecycle of products and services.

For industry and other companies resource-efficiency can enhance innovation either in terms of processes products or services. Innovations are a key for opening new markets either by creating totally new applications based on new technologies or by substituting existing products services or technologies with better performing ones.

When assessing the resource-efficiency of a technology this should always be done from the perspective of its application but taking into account the whole life cycle of products or services. Only then technology solutions can really be compared and a shift of negative effects to other stages of the life cycle or other activities in the value chain can be avoided.

The authors are currently working on the analysis of technologies products and strategies with resource-efficiency potential in different research projects with a focus on recent developments in Germany the EU Japan and the USA. The presentation will focus both on the methodological framework for identifying analysing and assessing technologies products and strategies with high resource efficiency potential and on research results. The authors would like to present results from extensive desk research a nationwide survey in Germany and the involvement of expert interviews and discussions on technology fields with high resource efficiency potential. This will include an overview on different technologies products and strategies and will be supported by concrete examples.”

A conceptual framework for a multi-level analysis of the global aluminum cycle - linkage with international trade energy and emission

Gang Liu, Sebastiano Scacchetti, Daniel B. Mueller

"Aluminum is providing an increasing amount of services to society however this leads to large resources consumption and a variety of environmental consequences in mining and production regions in particular emissions of CO2 and PFC compounds. Considering the rising attention to issues as global climate change and resource efficiency it is of great significance to integrate all the parameters into a comprehensive mass flow system and to track global aluminum flows of its products through the full value chain from mining through use to recycling and reuse. The International Aluminum Institute's Global Aluminium Recycling Commission (GARC) developed a model for the global aluminum cycle with the primary purpose to estimate future global scrap availability. However this model is not suitable for informing regional policies of recycling and emission control. In this presentation we propose a conceptual framework for extending this model to include: (i) the entire lifecycle of aluminum (ii) international trade in all the relevant aluminum containing products (iii) the link of aluminum cycle with energy demand and emission of primary and secondary production. The extended model shall eventually be suitable to inform industry and government policies for aluminum recycling energy and pollution control."

Sustainability index of manufactured products based on exergy and life cycle approach

A. Tharumarajah, P. Koltun

“Sustainability of production is usually computed as eco-efficiency indicators. These remain important measures of performance in a world of constrained resources and reduced access to energy and raw materials. These metrics drive industries toward reducing the environmental or energy footprint of their operations thereby improving the environment without any loss of productivity or business value. Nevertheless the indicators in use differ in the emphasis of the aspect of the business they measure against such as sales profits production etc. This often leads to subjectively weighting one aspect against another thereby reducing the performance to a single value. This can result in inconsistencies in reporting and shrouding the actual environmental performance. To avoid these difficulties the concept of exergy is applied and extended to compute the amount of useful work that is consumed in production for energy and materials and the work required for abatement of environmentally damaging emissions using predominantly a whole of lifecycle approach. The proposed eco-efficiency indicator combines the computed exergy and economic performance of making and selling (i.e. value of product) a product in a dimensionless value. This way the indicator provides a sustainability index of manufactured products where if a product has an eco-efficiency value in the range from zero to unity it means that the product is unsustainable since exergy value spent for making the product is greater than exergy spent on the product as valued by society. If the value of indicator is above unity then larger the value then greater is the sustainability of the product from an economic-environmental point of view. Thus it is shown that using the developed indicator it becomes possible to assess different product services and even whole industries as well as to judge the different technological options. Application of the proposed indicator is illustrated for aluminium products including recycling.

The use of Biomass as an energy source in the energy mixture of a remote island and the sustainable resource management of the energy system

C.S. Ioakimidis, André Pina, Carlos Silva, Paulo Cadete Ferrão

”One of the main problems that remote islands encounter apart from the large dependence of the imported fuels is the lack of local energy renewable sources. Yet this is not the case of São Miguel (Azores) where a great potential in different renewable sources appears. Among these renewable sources one with a great potential is the biomass which can be either extracted by industrial Municipal solid waste animal or woody residues. Even better for the proper energy system of the island this renewable source can be constant without creating any perturbations to the grid system while it can substitute in a very efficient way a great percentage of the imported fuel while having a great saving on money and a less import oil dependence. There are a number of techniques to make use of the energy contained in biomass which has high potential energy content. The easiest way till nowadays is that of woody biomass via combustion. Most common technologies that have been developed are the pyrolysis liquefaction and gasification. The last one seems to be the most mature one to compete while in general the selection of the most adequate technique to be used to recover the energy from a particular type biomass/fuel is the most important step towards a profitable investment. In this study a first approach based on data collected regarding the potential of biomass and specifically on woody residues is presented during the integration of this potential energy supply source in combination with the other renewable and not sources (wind hydro geothermal Sea water pumped-storage fuel). The large diversification of the primary energy sources in an energy system is a great case study while also presents some questions regarding the proper energy integration and the efficient management of this sustainable system which is the objective scope of this paper.”

Developing a methodology to calculate a carbon life cycle analysis of mountaintop removal mining in the U.S.

Samir Doshi

The environmental effects of mountaintop removal coal mining (MTR) are well documented in the Appalachian region of the U.S. Over a million acres of land and a thousand miles of streams have been impaired during the extraction process of MTR mining while the combustion of coal for heat and electricity contributes significantly to greenhouse gas emissions. However these are only 2 components of the MTR mining process: extraction and combustion. In order for us to determine the true effect of MTR mining we must look at every component of the practice. This research project is developing a methodology to calculate a complete carbon life cycle analysis (LCA) for MTR mining from extraction to mine closure combustion and reduced future carbon sequestration potential of the changed landscape. The research will determine the availability and accessibility of current documentation related to carbon stocks and flows and will ultimately attempt to estimate the impact on carbon dynamics of the mining process."

Measurability of sustainable mineral resource management

Deborah J. Shields, Slavko Šolar

“Sustainable development according to a common definition strives to improve the economy environment and quality of life at present and in future. This broad consensus reflects international recognition of the need to deal with the problems and responses to growing concerns about the intensity and spatial extent of human impacts on the environment and is relevant to the minerals sector. An understanding has developed about the role of minerals in a sustainable future about how minerals can be managed sustainable in a way that maximizes their benefits while recognizing and controlling the costs of mineral activities. For this to occur stakeholders (nations regions communities and mining companies) must determine a priori what their sustainability goals are and how mineral resources can and should contribute to the achievement of those goals. They must then select principles and criteria relevant to their situation and carefully track actions on the ground to ensure that the mineral sector’s or individual mine’s contributions to society are net positive. All assessment methods have certain steps in common: defining the entity (country region firm operation) for which the assessment will be conducted selecting measures or indicators of states flows and processes interpreting and reporting results and adaptation. There are many different ways to conduct sustainability assessments and different times in the life of the operation when doing so is useful. No single indicator for a single time period can be used to determine the sustainability of an operation. Rather the indicators need to be considered as a set over time and in relation to the organization’s or government’s goals principles and criteria. We conclude that explicit recognition of competing interests and interpretations of indicators is an important part of the stakeholder engagement process and is a core aspect of corporate social responsibility.”

Polyester use and recycling in California- from bottles to fleece

Brandon Kuczenski, Roland Geyer

“North American production of polyethylene terephthalate (PET) the most common polyester is estimated at 5.5 million metric tons for 2007. Beverage packaging is the most abundant use of the polymer in the US and the only application for which there is an extensive recycling infrastructure. Technical and regulatory obstacles limit the use of recycled PET in food packaging and most PET is down-cycled into polyester fiber construction strapping and non-food packaging film. Since 1986 beverages sold in the US state of California have been assessed a deposit fee known as the California Redemption Value (CRV) to encourage collection for recycling. In 2007 the average California resident consumed roughly 600 beverages packaged in single-use containers of which 38% were made from PET. About half of those were recycled.

We present a time-dependent material flow analysis (MFA) of PET integrated with a life-cycle assessment (LCA) of PET beverage delivery for California from 2001--2007. By leveraging volume data collected to administer the CRV program we construct a detailed description of the current end-of-life scenario for plastic beverage bottles in California which we compare to several alternative scenarios. We use time-dependent commodity flow data for PET resin and products to situate beverage container recycling in the broader context of material resource management and assess the potential for closed-loop PET polymer cycling. Process inventory data is taken from the US National Renewable Energy Laboratory (NREL) database and the Swiss EcoInvent database.”

Life cycle energy and environmental assessment of a wave energy system

João Santos, Fausto Freire

“An environmental life cycle assessment combined with an energy analysis study has been performed to a wave energy converters system recently installed at 5 km off the Atlantic coastline of northern Portugal. Wave energy converters use the motion of ocean surface waves to generate electricity. The wave farm installed is constituted by three semi-submerged machines (3 x 750 kW) made up of an articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams which pump high-pressure oil through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity which is transmitted to shore through a seabed cable. There is great potential for the installation of wave farms however the overall energy and environmental performance must be evaluated and compared with other renewable energy systems particularly with alternative offshore systems. A life cycle model for the wave energy farm has been implemented and inventory data has been compiled. Many sources of uncertainty have been identified and a sensitivity analysis has been performed to enable conclusions to be drawn. The most relevant stage in the life cycle is the production of materials namely steel. The whole life cycle performance was found to be highly dependent on a number of factors: the most important is the materials recycling rate. Life cycle impact assessment results have been calculated and are presented together with energy and greenhouse gas emissions payback periods measuring the performance of the system. The results are compared with existing LCA studies of conventional offshore wind power and electricity from fossil fuels. Wave energy systems are in an early stage of the development but important energy savings can be achieved when fossil systems are displaced even that wave energy farms currently might perform worse than offshore wind farms.”

Material Flow Analysis of Phosphorus in Asia: Focusing on the secondary resources

Kazuyo Matsubae-Yokoyama, Hironari Kubo, Kenichi Nakajima, Tetsuya Nagasaka

"The demand for biofuels has recently increased because of rising prices of fossil fuels and diversification of energy resources. As a result, the demand for sugarcane and corn has been increasing, not only for food production, but also as sources of energy. In this context, securing supplies of phosphorus, required as an essential nutrient in agricultural production, has considerable implications that extend beyond food and agricultural policy. It is therefore important to consider the quantity and availability of phosphorus resources that remain untapped, because the demand and supply of phosphate ore is currently becoming very tight.

Concerning the restricted supplies of phosphorus resource, it is important to consider the quantity and availability of phosphorus resources that currently remain untapped. From that viewpoint, in previous study, we found that steelmaking slag would be expected to be a greatly potential resource for phosphorus.

To identify potential phosphorus resources and for better understanding of current state of phosphorus demand and supply, we have investigated the material flow of phosphorus in Japan and the other Asian countries, focusing on the steelmaking industry. In Asia, China is an important supplier of phosphorus ore, and Korea has a considerable amount of phosphorus demand for fertilizer production. Major phosphorus flow can be seen on the flow of phosphorus ore and fertilizer. Meanwhile, Japan, Korea and India produce a large amount of steel by using iron ore, coke and lime and generate huge amount of slag. Accompanying this amount of slag should be not negligible amount of secondary resource of phosphorus.

In this study, we clarify the phosphorus amount of secondary materials, and evaluate environmental effects of its recovery."

Assessing GHG benefits of Chains of Bio-energy

E. van der Voet, L. Luo, L. van Oers

“One of the arguments to propose a shift from fossil to bio-based energy is the assumed reduction in GHG emissions. Years of research have indicated that this reduction may not be significant in all cases. For that reason, calculators have been developed to assess specific bio-energy chains on their GHG performance, as a part of the energy policies of national and EU governments. The harmonisation of these calculators, which all are based on an LCA approach, is in progress. Already it has become clear that methodological aspects related to allocation are very important for the outcomes. We will show that this is especially important for bio-energy chains from residues and waste streams: depending on allocation choices their GHG performance, if compared with the fossil alternative, varies from enormously positive to wildly negative. A very interesting aspect of this discussion is that the allocation choices are not just methodological intricacies, but refer to the perception of the place of such chains in the total societal metabolism: are they chains of waste management, or chains of energy generation? This, then, seems to be a crucial issue for the judgment of such chains.”

Can Transportation Fuels Derived from Oil Sands be Sustainable?

Joule A. Bergerson, Alex D. Charpentier, Jennifer McKellar, Heather L. MacLean, David Keith

"High and unstable oil prices, energy security concerns as well as recent efficiency improvements have lead to accelerated development of the oil sands resource in Northern Alberta. This rapid development has brought significant economic benefits to the province and country but has raised concern globally due to increased environmental impacts compared to those associated with conventional crude production. However, oil sands companies and the governments in Canada feel confident that they can mitigate the environmental impacts of developing the resource while continuing to provide substantial financial benefits to Canadians. New technologies are rapidly being developed and deployed to increase efficiency of the processes, reduce consumption of natural gas as well as decrease GHG emissions. To properly evaluate the sustainability of the fuels derived from this bitumen resource a detailed LCA is required. However, several of the challenges commonly experienced with the implementation of LCA are particularly important when applied to oil sands operations including boundary issues, co-product allocation, end product definition, and treatment of uncertainty.

This paper will present several examples of transportation fuel pathways derived from oil sands resources and will demonstrate the importance of LCA method choices. A detailed sensitivity assessment will be conducted in order to evaluate the impact of different assumptions to deal with the complexities of the process being studied.

Examples of the types of issues that are critical to the discussion of the sustainability of this sector include which co-product allocation method is applied to the coke produced as a byproduct in the upgrading process (e.g. mass based allocation, energy based allocation, substitution or boundary expansion), the allocation of "credits" associated with the additional electricity produced and sold to the electricity grid in Alberta (dependent on the generation mix of the electricity being displaced) as well as the economy-wide implications of natural gas displacement with technologies which use the "heavies" as energy inputs.

This paper will demonstrate how the oil and fuels industry can provide a good example of addressing sustainable development through a more holistic approach to understand and mitigate the impacts. It will also contribute to improved data on oil sands processes in the public realm which will aid in future policy analysis. Finally, it will provide insights into the challenges and highlight the importance of choosing appropriate metrics when evaluating and comparing these systems to conventional and unconventional transportation fuels. "

Environmental impacts of different supply options of Lithium – implication for the LCA of a Li-Ion Battery for electric vehicles

Anna Stamp, Daniel J. Lang, Patrick Waeger

“The demand for geochemically scarce metals is increasing concurrent to the demand for emerging technolo-gies, which have functionalities that are significantly associated with these elements. Lithium is a geochemi-cally scarce metal, increasingly used in battery applications. Due to their high energy density and long life span, lithium-ion batteries are considered to be one of the most promising options to meet the future re-quirements of electric vehicles (EV). EV are expected to play a major role in the transition to a more sustain-able mobility.

In the present paper we take the example of lithium to appraise the implications of the geo-chemical scarcity of key elements on the overall environmental impacts of emerging energy technologies (e.g. lithium-ion bat-teries for EV).

Lithium can be extracted from lithium compounds that occur in brines and, at different grades, in mineral ores. Further, it can be recovered from seawater, where lithium occurs in trace amounts together with other salts. To meet the probably increasing demand for lithium, it is expected that in a first step easier accessible deposits such as brines will be used; however, other sources will gain in importance as the accessibility of these deposits will decrease.

Going along with differences in accessibility, speciation and grade, primary lithium supply options differ in their environmental impacts. We investigated these impacts using LCA methodology in order to quantify po-tential shifts in the overall environmental impact of an emerging technology, due to changing primary supply alternatives. This will provide further insights into environmental issues associated with the supply of geo-chemically scarce metals and their magnitude com-pared to overall impact of an emerging technology throughout its life cycle.”

5th International Conference on Industrial Ecology

2009 ISIE Conference

Visions on new IE-based paradigms toward Sustainability

Electronic Data Interchange (EDI) Enabled Sustainability Framework for Sustainable Value Chains of Forest-based Products

Anthony Halog

"A 21st century modern global economy is a sustainable and interconnected economy which optimally uses both renewable and non-renewable resources for sustainable production and consumption of goods and services. Industries are evolving to become bio-based and capitalizing the innovations in information and communication technology (ICT) in the development of industrial ecology-based supply chains under the overarching principle of sustainable development. Our existing economy which is based on financial economics bottom line has been the paradigm of development emulated by different industries in the past several decades. This economic oriented based economy has lost its grip as shown by the economic downtowns of US economy which has eventually impacted other regional economies. The time has come that any development pursuit should be holistic and benefit all global citizenry where the principles of sustainable development are aligned with this endeavor. Adopting industrial ecology approach towards sustainable development is definitely a good start also to embrace further the development of minds that has resulted to evolution of interdisciplinary sustainability-related courses and degree programs in higher learning institutions. The time for integrated holistic global and life cycle thinking has come to eventually shift our human actions and behaviors towards sustaining our development. This integrated systems approach can be supported by information and communication technologies (ICT) that have revolutionized the way we conduct businesses locally regionally and internationally. ICT is a significant enabler to the creation of global supply (value) chain networks which can assist us to attain the goal of sustainable development at different spatial levels over time. Regardless of scale our existing systems that involve the interactions of human society and environment are now transitioning towards sustainability. By using the idea behind electronic data interchange (EDI) the main objective of this project is to develop an integrated framework and conceptual design model that supports the creation of sustainable supply chain networks of forest bioproducts."

Territorial factors and Industrial Ecology

Bahers Jean-Baptiste, Julien Saint Amand Florian

“In France most of industrial ecology related projects are developed at a territorial scale. In those projects industrial ecology opportunities are often found between firms and other urban components or between firms themselves. Despite real economical and environmental potential benefits we observed that those opportunities rarely become reality.

We make the hypothesis that this is a due to the fact that industrial ecology’s paradigm and spatial planning representations are not always convergent. Complex phenomenon such as confidence between economical actors culture aspects political strategies... are at work on a region.

Considering this two doctoral thesis are ongoing at the “Université de Toulouse II – le Mirail” in the field of spatial planning. They both analyze the interactions between the industrial ecology’s paradigm and the socio-territorial systems behavior. Two different scales are studied: the regional waste management system level (Jean-Baptiste BAHERS) and the local authority level (Florian JULIEN SAINT AMAND).

This first observation shows that the implementation of the industrial ecology paradigm considering the spatial context is not straightforward and requires adaptation. Systemic approach goes against the fragmentation of the responsibilities between several territorial actor and the sectorization of governmental utilities within these territories. Considering this most of local actors have difficulties to implement industrial ecology tools and methods in their courant practices and beyond in public policies.

At the same time Industrial ecology’s engineers rarely consider territorial social and historical context while they seek eco-industrial symbiosis. A region is a system composed by environment experiences representations and socio-political organizations whose parts are interdependent. Human factors play a key role in their dynamics. This often leads to misunderstanding between engineers and local actors slowing down the concretization of industrial ecology projects.

Leaning on industrial ecology and social sciences the researches presented during this communication seek new perspectives to break into the social-territorial system complexity and contribute to industrial ecology concepts methods and tools.”

Fostering Industrial Symbiosis with Agent-Based Simulation and Participatory Modeling

David Batten

"The sciences of industrial ecology complex systems and adaptive management are intimately related since they deal with flows and dynamic interdependencies between system elements of various kinds. As such the toolkit of complex systems science could enrich our understanding of how industrial ecosystems might evolve over time. In this paper we illustrate how an important tool of complex systems science – agent-based simulation – can help to identify those potential elements of an industrial ecosystem that could work together to achieve more eco-efficient outcomes. For example we show how agent-based simulation can generate cost-efficient energy futures in which groups of firms behave more eco-efficiently by introducing strategically-located clusters of renewable low-emissions distributed generation. Then we explain how role-playing games and participatory modelling can build trust and reduce conflicts about the sharing of common-pool resources like water and energy among small clusters of evolving agents. Collective learning can encourage potential industrial partners to cooperate by exchanging byproducts and sharing common ssets infrastructure and expertise by dint of their close proximity. This kind of co-evolutionary learning aided by participatory modeling could help to bring about industrial symbiosis."

Modelling the sustainable development of different evolutionary pathways of industrial networks

Ruud Kempener, Jim Petrie

“Industrial networks are inherently open systems operating in a constantly changing environment. The products and services provided by the industrial networks or by the organisations operating within the system are subject to changes in resource availability customer demands competition and technology development. Accordingly what was once seen as a system contributing positively to sustainable development might be viewed as inefficient or undesirable ten or twenty years later. In other words how can one evaluate the sustainable development of an industrial system that is constantly changing over time and has to respond and adapt to changes in its environment?

This presentation uses a systems perspective to develop a framework for analysing the sustainable development of different evolutionary pathways. It consists of three elements. Firstly the framework adopts a set of normative criteria to assess the contribution of an industrial network towards the larger system in which it operates at a particular point in time. These criteria and their associated values are specific for each industrial network and might change over time. Subsequently the efficiency and effectiveness of the industrial network is evaluated reflecting the operational structure of the industrial ecosystem. Finally the resilience and adaptiveness of the industrial ecosystem is evaluated. Resilience is narrowly defined as the extent to which an industrial network is able to continue providing a particular functionality under temporary internal or external shocks while adaptiveness is the system’s ability to provide new functionalities when the network or its environment changes permanently. Measures for each of these indicators are suggested and a coherent method for relating these indicators to each other is suggested.

The framework is applied to evaluate the sustainable development of different possible evolutionary pathways of a bioenergy network in South Africa.”

Resilient socio-technical systems – Fit for turbulent environments?

Arnim von Gleich, Sönke Stührmann, Stefan Gößling-Reisemann

Facing Climate Change mitigation is increasingly combined with adaptation. In the cooperative research project “NorthWest 2050 Perspectives for Adaptation to Climate Change through Innovation Processes in the Bremen-Oldenburg Metropolitan Region” the focus is on four clusters: Logistics & harbor energy demand & supply agriculture & food industry and regional governance. Our project is about risks and opportunities about direct and indirect effects (e.g. along supply chains). The strategic approach following the question ‘What if..?’ tries to prepare regional socio-technical-ecological systems for expectable events of Climate Change (e. g. reducing vulnerability by building higher dykes). The approach called ‘Whatever will come …’ assumes the limited predictability of events in dynamic complex systems and thus tries to prepare the systems for the inevitable and the unexpected (e.g. enhancing resilience by building pontoons). Improving the fitness of regional socio-technical systems facing turbulent environments is taking the resilience of ecosystems as a role model. Based on a broad and intensifying debate about resilience of ecological and engineered systems on the one hand (1) (engineering resilience as guiding principle) and on a network of regional actors on the other hand the project aims at restructuring socio-technical systems so that they might maintain dynamic stability (i.e. their basic functions and capacity to (re)act) even in case of dramatic change.

A possible presentation will include: General reflections about resilience as a guiding principle in Industrial Ecology and about the role of guiding principles in system innovations some design (or lay out) principles of (more) resilient socio-technical systems two concrete examples from the regional energy system (low exergy solutions plus resilient electricity supply & smart grids).

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Brighton: STEPS”

Integrating Industrial Ecology and Industrial Dynamics: Implications for Sustainability Science

Yarime Masaru

”In our efforts to make transitions to sustainability recently sustainability science has been initiated to understand the fundamental characters of complex interactions and interdependencies between natural human and social systems. Relying on a wide range of academic disciplines previous work in this emerging field mainly describes the characteristics of various aspects of the coupled human and natural systems including reciprocal effects feedback loops nonlinearity thresholds legacy effects resilience and heterogeneity. Existing discussions however have not yet incorporated adequately the roles and functions of technology which will be crucial in making transitions towards sustainability. In this paper complex interrelationships between natural and social systems are analyzed through an attempt to integrate industrial ecology and industrial dynamics. Physical entities including materials and energy circulate between the natural and social systems which can be analyzed with materials/energy flow analysis and life cycle assessment established in industrial ecology. Non-physical entities notably money and knowledge also flow through networks linking many individuals and organizations and network analysis can be applied to analyze their structure and functions. A case study of the photovoltaic industry is conducted to examine industrial sustainability in terms of economic development and environmental protection. The process of innovation and technological change is emphasized in the integration of industrial ecology and industrial dynamics. Material flow analysis of cadmium for example is very important in assessing the environmental desirability of the CdTe type of solar cells. On the other hand the creation transmission and utilization of scientific and technological knowledge has supported the long-term industrial development whereas the recent expansion of investment through financial channels has influenced significantly the dynamics of industrial growth and competition. This paper is intended to develop concepts and methodologies for integrating industrial ecology and industrial dynamics to examine the possibilities and challenges in making transitions towards industrial sustainability.”

5th International Conference on Industrial Ecology

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Poster session 2

Designing Sustainable Cities - The Urban and the Social Metabolisms

Post-industrial redevelopment and the quest for sustainability

Luís Loures

"Changes accompanying urban growth often involve the destruction of characteristic built and natural elements eradicating the physical expression of former indigenous ways of life that are a very important part of people's culture (Whitmore 2003). This fact was particularly evident after the Second World War when industrial landscapes predominantly in industrialized countries faced deep transformations that in several cases contributed to its dereliction and to the disappearance of numerous industrial values commonly known as industrial heritage.

The expansion of this process associated with the demolition of numerous industrial buildings contributed to the elimination of several social historical and cultural values created by the industrial society with high technical and architectonic interest.

This phenomenon enlarged in the last decades by agglutinated fluxes of urban growth and urban sprawl and by the decline abandonment and relocation of industrial activity faced industrial landscape reclamation professionals with a huge dilemma: how to reclaim and develop those derelict landscapes without destroying the architectural and urban heritage? The answer is not simple and proving it is the high price that many cities have paid for modernisation and development in the name of progress.

For this reason this communication addresses a primary basic assumption that should be followed: in order not to "lose this heritage" which is that it is necessary to consider first the reasons behind the development certain industrial landscape second the relation of that landscape with its surroundings and third its meanings to citizens before performing any regeneration process.

This fact added to the necessity to reclaim derelict landscapes in detriment of consuming new landscapes (Loures and Panagopoulos 2007) increases the need to enlarge the interpretation of the term "patrimony" but also the need to develop new mechanisms to preserve it."

Urban Carbon Sinks - Potential in the Greater Toronto Area

Eugene Mohareb, Adrian Mohareb, Christopher A Kennedy

“In the effort to reduce greenhouse gas (GHG) emissions cities represent a great challenge and opportunity. With more than 50% of the global population residing in cities (UN 2008) the majority of emissions can be attributed to urban dwellers and their activities. In order for countries to meet international treaties urban infrastructure and activities must be analysed and their emissions addressed.

The Greater Toronto Area (GTA) has set an emissions reduction goal of 80% below 1990 levels by 2050. While emissions source quantification methodology is well established the net benefit urban carbon sinks might provide require consideration. Urban forests / greenery urban agriculture with CO2 fertilisation and landfills are all means of urban carbon sequestration within the GTA. In this research these three urban carbon sinks are quantified to determine how much they take off the carbon emission “bottom line” and what policies could enhance them.

Green space and solid waste disposal site (SWDS) sequestration capacity in the GTA are assessed using the Intergovernmental Panel Climate Change Protocol for National Inventories (IPCC 2006). USEPA Waste Reduction Model (WARM) and Urban Forestry Effects (UFORE) model data are compared with SWDS and green space calculations respectively.

It is vital to consider that when cities progress towards a closed-loop carbon system carbon waste streams must be employed to the fullest degree possible. Artificial carbon sinks can be created where high CO2 emission intensities facilitate capture and use. Considering the GTA imports a significant proportion of produce from surrounding communities and further abroad point source urban emitters represent an opportunity to utilize waste CO2 and heat to fertilize urban greenhouse environments for local food production while reducing transportation emissions. Compatibility of sites in the GTA are assessed for this function.”

Effects of Heat Island Phenomenon on Energy Consumption in the Commercial and the Residential Sectors

Yujiro Hirano, Hidefumi Imura

“In Japan, the urban heat island in summer has an important effect on energy demand, the livability of residential areas, and the peak electric power load due to the use of air-conditioning. This study quantified the impact of the heat island phenomenon on energy consumption in the residential and commercial sectors of metropolitan Tokyo. There are many indications that the heat island phenomenon increases energy consumption by air conditioners. However, these ignore the fact that energy consumption for heating and hot water supplies may decrease in winter. It is crucial to consider both in order to quantify the impact.

First, by expressing the unit energy consumption data as a function of temperature, estimation equations were created. Using monthly and hourly unit energy consumption data by building and energy use, and monthly and hourly average temperature data, we obtained 648 estimation equations. Then, the urban heat island phenomenon in metropolitan Tokyo was simulated using the Colorado State University Mesoscale Model (CSU-MM). In this study, simulations were conducted for two cases: the actual conditions and the absence of urban effects. Next, we estimated the energy consumption for space heating, cooling, and water heating corresponding to each of the temperature distributions by applying the estimation equations to each grid cell of simulated temperatures. Finally, we compared them and quantified the impact of the heat island on energy consumption.

The results revealed that the commercial energy consumption increased, while the residential energy consumption decreased. Overall, the total energy consumption increased in the center of Tokyo, in connection with the existing air temperature rise due to the heat island phenomenon.

This study was supported by the Global Environment Research Fund from the Ministry of the Environment, Japan, in FY2008 (Hc-086), □Study on the Strategic Urban Planning and Assessment of Low-Carbon Cities.”

Quantifying the relationship between local cool island intensity of urban park and its land use by IKONOS and ASTER data

Xin Cao, Akio Onishi, Jin Chen, Hidefumi Imura

“Urban heat island (UHI) greatly raises cooling energy consumption in summer which contributes to global warming. Urban park with dense vegetation exhibits local cool island (LCI) effect which is recommended as one of effective strategies to mitigate UHI effect. The magnitude of LCI is related to the park size meaning that larger parks have greater influence to surrounding temperatures. However the quantificational relationship between LCI and land use inside/outside of park are still not clear. Also the optimal scale and location of urban green areas for effective cooling has not been clarified.

The objective of this empirical study is to determine the factors affecting the microclimate inside the park and its influence to the surroundings. Totally 94 parks in Nagoya City of Japan were selected and the ASTER Land Surface Temperature (LST) products in spring summer autumn winter and summer nighttime were used to represent LCI. Based on IKONOS image the land use inside and outside of parks were classified to 10 types. To investigate the impact range of urban parks different buffers were assigned from 10m to 1000m. Other associated variables were also considered such as the shape of park (landscape shape index) and building characteristics (e.g. plot ratio). Finally the land use types inside/outside parks shape index and building parameters were related to LCI of parks.

The results show that park size and percentage of tree inside park are important parameters related to LCI in spring and summer. The impact ranges of parks are differentiated by the size and shape of the parks. On the basis of the statistical findings an empirical model was developed for predicting the maximum cooling effect inside the site and its range outside the site. The results may be useful in cost–benefit analysis in designing a cooling and sustainable city.”

Identifying the importance of local public services in designing sustainable cities

Hogne Nersund Larsen

“Most discussions concerning sustainable cities focus on private consumption and in some cases infrastructure investment and management. Several studies show that cities have a smaller Carbon Footprint (CF) per capita compared to more sparsely populated areas. This is explained by less need for transportation and energy use in cities’ denser infrastructure. However most studies neglect CF from the provision of public services which might offset some of this result. Clearly dense cities have a different need for public services such as public transportation and waste management compared to lesser dense areas. Our preliminary analyses performed indicate larger cities having a higher CF of public services per capita compared to other municipalities. In this paper we analyze the CF of public services in several Norwegian municipalities of different sizes ranging from Oslo (560 000 inhabitants) to municipalities of less than 5000 inhabitants. Relationship regarding the cities size and their CF is investigated in detail dividing the CF into several contributing sectors based on a hybrid-LCA model connected to the standardized municipal account system. Other parameters besides size are further investigated to explain differences found. We argue that the CF of public services needs to be taken into account in determining the design of sustainable cities.”

Sustainable urban metabolism scenarios for Japanese cities

Hiroki Tanikawa, Seiji Hashimoto, Yasuyo Matsubae-Yokoyama, Shigemi Kagawa, Ichiro Daigo, Hidefumi Imura

"As research has shown a very large amount of construction materials are required in urban areas for developing and maintaining buildings and infrastructure. The aging of construction material stock that has been built during a period of rapid growth in Japan in the 1970s and 1980s will cause large waste flows in the near future. For assessing the dynamics of urban metabolism and the related material flows for buildings and infrastructure we model the material accumulation from a spatial and temporal point of view to integrate the historical and social background. We employ a spatial urban material stock and flow model that is linked to population economy land and energy use to gather information to identify pathways for establishing sustainable low-carbon cities. By establishing spatially explicit scenarios for sustainable development of Japanese cities we wish to inform policy makers local authorities and citizens.

For our analysis we use a four-dimensional Geographical Information Systems (4d-GIS) to estimate the material accumulation for urban areas and metropolitan regions. The dynamics of urban material stock are compared with information for all 47 Japanese prefectures to show differences and interdependencies between urban and non-urban areas. We use a scenario approach to link urban material stocks and flows to social change and economic development. For doing so the Material Stock and Flow model that is based on a 4d-GIS database is linked to the distribution of population and of economic and business activities and the resulting land use. For modeling future construction waste flows we inform the 4d-GIS model with a regional waste Input-output model and for assessing the recycling potential of demolition waste.

In our presentation the 4d-GIS model will be applied to 4 cities in Japan namely Nagoya (population of 2.2 million in 2007) Kitakyushu and Sendai (population of 1 million) and Wakayama (population of 400000). Choosing cities of different population size will allow for identifying sustainability issues related to stock and flow dynamics of larger and smaller urban agglomerations.

In our analysis we estimate the urban metabolism of buildings roadways and infrastructure (such as sewer systems) historically (since WWII) and for future scenarios (2030) to assess the spatial distribution of construction minerals. Secondly to identify material accumulation for above and below-ground materials from the point of view of recyclability. Thirdly to estimate the future demand and supply of construction minerals as well as the availability of recyclable demolition waste. Finally to establish scenarios linking social and economic development with urban material stock and flow dynamics to identify low-carbon sustainable urban development future for Japan."

Economic feasibility of a residential energy services company

Joe Marriott, Kullapa Soratana

“Energy services companies or ESCOs exist today in the United States are supported by an industry group with large lobbying potential and are the subject of several research efforts. Generally these companies work with large government organizations like the military local municipalities or industrial and commercial entities – groups with large capital availability. But despite the huge potential for energy savings – and therefore recovered dollars – there is little penetration into the residential market either for private homeowners or for management companies with large rental property holdings especially low-income homeowners or land-lords. Our hypothesis is that there is a market failure in the residential energy savings market: due to the lack of capital and the high risk of lending to those without capital there is unrecovered savings. With this research we investigate the economic potential for energy service companies in the residential market first by investigating the reasons for the failure by modeling the economic and physical systems and then by studying options for changing the market. The key issue here is who can provide the capital and at what level of risk. If the market for these companies could be established either by recommending home improvements or policy changes for the residential customer the payback is immediate following the installation of energy saving improvements. This paper presents the initial findings of a round of seed funding.”

Study on CO2 emission of households sector by different future scenarios of spatial distributions in Nagoya city

Yosuke Takahira, Akio Onishi, Hiroki Tanikawa, Hidefumi Imura

“Nowadays, both national and local governments began considering concrete measures, aiming for realization of low carbon cities in response to global warming and climate change from urban perspectives. Particularly in Japan, the house, building and infrastructure sectors are entering the update phase in their lifecycles, thus the significant reduction of energy consumption and consequently CO2 emissions can be achieved by reorganizing the urban structure. However, previous and current urban planning by local governments has not given sufficient measures to reduce energy consumption and CO2 emission. The major reason of this ineffectiveness is that analysis techniques to evaluate long-term effects of such measures have not been well established. This study aimed to develop a framework to analyze the impact of changing of the city structure on energy consumption and CO2 emissions. The study focused on households sector in Nagoya city. Because the energy consumption and CO2 emission from the household has been a severe issue. The simulation was performed under two scenarios: centralization which assumes rebuilding in the center of the city, and; distributed concentration which assumes that around subway stations. Changes in housing structure, population density etc. were also taken into consideration and compared between the scenarios. The results of energy consumption and CO2 emission from 2000 to 2050 by different scenarios were shown. By comparing the results of different scenarios, appropriateness of the urban structure and importance of urban planning for reducing of the energy consumption and CO2 emission was indicated.

This study was supported by the Global Environment Research Fund from the Ministry of the Environment, Japan, in FY2008 (Hc-086), “Study on the Strategic Urban Planning and Assessment of Low-Carbon Cities”

Influences of Building Characteristics to Land Surface Temperature in Centre of Nagoya City Japan

Akio Onishi, Xin Cão, Masafumi Morisugi, Hiroki Tanikawa, Osamu Higashi, Hidefumi Imura

“In recent years changing of structures of cities is urgently required to create the low environmental load cities. On this process the improvement in a living environment is necessary with redevelopment of urban structures.

It is known that a main cause of heat island phenomenon of cities is artificial structures. These artificial structures include buildings such as houses office buildings communal facilities and so on. However it was difficult to evaluate the relationship between building characteristics and land surface temperature (LST) because such data was not available with good quality especially the building data. Recently it becomes possible to obtain the data of building characteristics because the municipalities have maintained the building GIS data. Also fine land surface information now can be easily acquired by using satellite images with improving spatial resolution.

In this study influences of building characteristics to LST in centre of Nagoya city was studied by using the building GIS data IKONOS data and LST data. In detail the influence to LST by difference of characteristic of buildings was analyzed by using information of building area usages height and materials. The data of building area usages and height were obtained from the building GIS data. The data of materials were used from the land cover information classified by an IKONOS image. The LST data was calculated by using the satellite images.

This study showed the ways to mitigate the heat island phenomenon in cities by measures of the building characteristics and it could be useful for new urban planning.”

Influence of Land use Change on River Discharge in River Basin of Nagoya City Japan

Minami Sugimoto, Akio Onishi, Kaoru Inoue, Akito Murayama, Hiroyuki Shimizu

“In Japan, the expansion of the urban area and the change of the land use had taken forward in order to support the rapid growth of the population and the economy. However, nowadays, population has been decreasing and social infrastructures are required to renew. With the situation facing, the function and the role of land use are reviewed against an increasing heavy rain owing to global warming.

The main purpose of this study is to verify the effect of the flood control by the land use operation in future aiming at proposing another barometer urban planning.

The study calculated the area of building in the future from the increase of the population, and set some scenarios by changing the disposition of land uses at unbuilt area. The outflow reactions of each scenario to the heavy rain were calculated by the runoff model. As to running the model, the heavy rain was set to the actual rain happened on 11th-12th September 2000. The heavy rain is assumed it declared the influence of the land use change comparing them.

The study showed the relationship between river outflow and land use plan. Great influence was observed especially at the maximum outflow from heavy rain. This result defined the effect of the land use plan from the viewpoint of the flood control. Practicing application in the future to the city planning is expected.

This study was supported by the Global Environment Research Fund from the Ministry of the Environment, Japan, in FY2008 (Hc-086), “Study on the Strategic Urban Planning and Assessment of Low-Carbon Cities”

Evaluating Climate Change Mitigation Projects and Programs on a Local Level - Results from the Stockholm Climate Investment Program 2004 - 2008

Stefan Johansson, Nils Brandt, Ronald Wennersten

“When discussing the issues of global warming and climate change the global perspective is the one most commonly adopted despite that mitigation efforts needs to be made locally. Stockholm the capital of Sweden gathers its mitigation projects into mitigation programs to ensure comparable results and to help the evaluation of the projects and programs. In 2004 the city received funds from the Swedish government’s climate investment program to carry out a number of projects. The department of Industrial Ecology at KTH received funding to do a scientific evaluation of these projects and of the program as a whole.

Two main goals were formulated:

1) To determine if the projects and program had been a success in terms of mitigation of greenhouse gases (GHG) and if they have helped the city achieve its long term mitigation goals

2) To determine if the projects that received funding are the correct ones seen from a cost benefit perspective.

To answer the questions an evaluation methodology for the projects have been developed and tested on the previous projects carried out in the city. Roughly 50 projects that have been carried out and 10 that did not receive funding are compared to each other and the results both in terms of GHG mitigation and cost-benefit are presented as well as the methodology in general.”

Urban environmental responsibility

Alexandra Marques, Tiago Domingos

“In 2008 the world population reached a turning point: urban population equaled for the first time rural population. According to United Nations (UN) this tendency will continue and in 2050 about 70% of world’s population is expected to live in urban areas. Sustainable development strategies have to consider urban sustainable development.

Measures promoting economic performance environmental quality and social fairness are being taken aiming for sustainable development. Presently there is a sound need for tools measuring the progress towards sustainable development which can effectively aid policy making (prospective) and assess policy implementation (retrospective) at several different levels (supra-national to national regional or even individual). These tools are commonly named sustainability indicators. The generally accepted framework to assess sustainability performance is the pressure-state-response model that links the causes of environmental changes (pressure) to their effects (state) and finally to the actions and policies (response) designed and undertaken to tackle these changes. In the present work we focus only on the environmental pillar of sustainability and will adopt a general environmental responsibility indicator to assess the environmental responsibility of a city. This methodology aims to assign both direct and indirect flows affecting negatively the environment to the economic agents (countries cities regions firms…) that are in fact responsible for them. With an input-output framework it is possible to distinguish upstream embodied flows of final demand of a city (which we interpret as the “consumer” responsibility) and the downstream embodied flows of primary inputs necessary to run the city (which we interpret as the “producer” responsibility). Environmental responsibility is thus shared between “consumers” and “producers” allowing for most cost efficient environmental policies and better understanding of environmental performances.”

The Water-soil Issues Related to the Urban Ecosystem of Dongying City College of Environmental Sciences and Engineering

Ling Han

“Dongying City is located on the estuary of Yellow River which is only 30 years old. Unlike the other estuary areas in Pear River and Yangz River the presentation of human activity happened only 200 years ago. Large amount immigrants began in late 1970s because of the exploitation of oil. Most of the land here is salina a kind of wetland with very flat topology. Some has been converted to built land. The land use conversion dramatically changes the water form and the soil evolution process. The main problems caused by the land use conversion are as the following:

• Drainage problems in downtown mainly happening in the flood season

• Water pollution

• Flood control from the upstream in the flood season

• Salty trend of the top soil

• Landscaping problem due to the lacking of trees.

According to the literatures which are written in Chinese few cities in china has practices similar planning which also try to find a holistic solution to integrate the flood control waste water treatment and landscaping design together. But rarely there is examples talking about the salty problem of the top soil.

Through re-allocation the special and functional distribution of water body and wet land according to the problem-solved needs including defining the new constructed wetlands and their functions unifying the water movement in the whole system and finding ways to reduce the salty level in the top soil the planning will not only solve the ecological problems mentioned above but also contribute to the local social-economic development.”

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Eco-Design: Products and Services of the Future

Greenhouse Gas Emissions Payback and Economic Assessment for Lightweighted Vehicles using Aluminum and High Strength Steel

Hyung-Ju Kim, Greg Keoleian, Steven J. Skerlos

"In this paper we consider life cycle emissions paybacks and costs associated with lightweighting (LW) automobiles. Both aluminum and high strength steel (HSS) are considered with LW ranging from 6% to 23% based on literature references and input from industry experts. First we compare the increase in greenhouse gas (GHG) emissions associated with producing lightweight vehicles with the saved emissions during vehicle use. This yields a calculation of how many years of vehicle use are required to offset the added GHG emissions from the production stage. GHG savings for aluminum LW varies strongly with location the aluminum is produced and whether secondary (recycled) aluminum can be utilized. HSS is less sensitive to these parameters. However achieving intense LW with HSS requires achievement of secondary LW by downsizing other vehicle components. In principle payback times for vehicles lightweighted with aluminum can be shortened by closed-loop recycling of wrought aluminum. However over a 15-year time horizon it is unlikely that this could significantly reduce emissions due to the need for wrought aluminum recycling infrastructure and end-of-life vehicle returns.

Second life cycle GHG emission costs are evaluated associated with vehicle LW options. The results show greater GHG savings derived from greater LW and added manufacturing costs as expected. However the associated production costs are disproportionately higher than the fuel cost savings associated with higher LW options. A sensitivity analysis of different vehicle classes shows that LW is more cost effective for larger sized vehicles. Also the cost of GHG emissions reductions via lightweighting is compared with alternative GHG emissions reduction technologies such as diesel hybrid and plug-in hybrid electric vehicles. The results find intensive LW to be a favorable approach relative to the technological alternatives but more costly than GHG mitigation strategies available to other industries."

Life Cycle Thinking applied to an Ecodesigner Innovative Process

Armando Caldeira Pires, Sandra Maria da Luz, Paulo Manuel Cadete Ferrão

"This current work is concerned with the application of Life Cycle Thinking-LCT approaches as innovation process on the product development by an ecodesigner. Ecodesign aims to develop new products and processes that will fulfill the needs of customers in a most Eco-efficient way. In this context product and process design is one part of a systemic approach towards sustainable development. Moreover eco-efficient product design requires the balancing of economic environmental ethical and social issues. Therefore ecodesign requires creativity innovation and the participation of different actors involved throughout the product life cycle such as policy makers business strategists managers designers engineers marketing managers and consumers. Otherwise LCT is a sustainable production strategy based on the utilization of less energy and raw materials on the minimization of pollution and wastes produced and on the development of resources recover and recycle technological pathways taking into account the life cycle perspective. A number of tools and models have been developed to support the process of ecodesign however most of the existing ecodesign models don't address the idea generation process. This paper presents an overview of tools available to structure the results of creative sessions and analyses the inclusion of life cycle thinking within the innovative process by mind mapping technique. This approach is briefly explored at the development of a thermoplastic-based automotive component reinforced with natural fiber. In this way the innovative ideas are diagrammatically represented depicting a powerful graphic representation of the outcomes from the creative ecodesign sessions."

Synthesis and characterization of a novel iron carbonate cement that can utilize waste steel dust and trap CO2

David A. Stone, Janick Artiola, Joan Curry

“The oxidation of iron is commonly associated with the breakdown of cohesive structure at the surface of both ferrous metals (corrosion) and natural Fe(II) minerals such as olivine (weathering). However under certain conditions this process can strongly cement particles together. Here we report a novel type of iron-based cementation process in which oxide formation is blocked by adsorbed silica but acidic dissolution of the metal and carbonate mineral precipitation still readily occur upon exposure to CO2. The resulting iron carbonate mineral siderite binds together the particles of undissolved iron and silica. Optimal cementation is promoted by oxalic acid catalyzed by calcium carbonate and stabilized by polymerizing oils. We characterized the material using compressive strength XRD SEM-EDS and TG/DTA. These methods reveal that a dense layer or ‘shell’ of precipitated iron carbonate forms around the iron particles and the shells grow together into an interstitial matrix that cements the aggregate of particles. The cured material is approximately 10% trapped CO2 by mass. Compressive strength is in the same range as regular Portland cement-based concrete (35 to 55 MPa) and over 70 MPa (10000 psi) has been attained. This carbon negative process has the potential to produce a building material from multiple industrial wastes including steel dust fly ash exhaust gases and contaminated water. A by-product of the process is hydrogen gas which is generated by the reduction of water when the metallic iron is oxidized. This aspect of the process might also be exploited if a sufficient quantity and purity of hydrogen can be produced in large-scale systems.”

ELCD and eco-design tool in a CAE environment

David Cebrian-Tarrason, Alex Paris, Rosario Vidal

“The growing importance of environmental criteria and the competitiveness of product design today create the need for an effective way to incorporate LCA into early design phases. It is thus essential to provide an integrated life cycle assessment approach that considers environmental impacts of product design in CAE (Computer-Aided Engineering) programs. This is especially important in a world where the economical system is based on a constant rise in industrial production consumption and disposal of products. The true ecological performance of a product can only be determined by considering of the impact arising from its entire lifecycle thereby including all known impacts into the assessments.

In this study we present a tool designed to integrate lifecycle information into CAE systems. The research carried out demonstrates the feasibility of incorporating environmental criteria into design without the use of specialized software. The fact that the proposed analysis is almost entirely automatic implies that tedious and manual analyses can be avoided and yet the effects of improvements on a design are instantly visible.

Based on the information that manages the product and process representation the tool applies the calculation of Eco-Indicator 99 using the European Reference Life Cycle Data System (ELCD). The results are displayed in the graphical user interface of the CAE system SolidWorks. As a practical illustration the evaluation of an underwater camera is provided.”

Utilizing ecological design to restore natural and social communities in Appalachian coal mined landscapes

Samir Doshi

“Nearly a million acres of central Appalachia has been mined for coal. Studies from Virginia Tech have determined that the majority of these lands have been left as unproductive scrublands. The two largest hindrances to reestablishing the original biologically diverse eastern oak hickory forest are compaction and nutrient deficiency of mine spoils. On field sites in southwestern Virginia we are analyzing the effects of biochar (charcoal produced from vegetation at low temperatures and exposed to limited levels of oxygen) coupled with low input high diversity native grasses on soil aggregate formation. We produce the biochar via a pyrolysis gasification process that creates a topical amendment with high stability nutrient adsorption rates in the form of cation exchange capacity (CEC) and carbon sequestering properties. The large root systems of the perennial grasses increase porosity and soil aggregation which leads to formation of soil organic matter (SOM) and decreased compaction. As a product of our research we have developed a land use model that social communities can implement to help restore existing mine spoil scrublands to the native eastern hardwood forest while simultaneously producing biofuels to offset the startup costs of the restoration model. Additionally the model will also provide a medium for carbon offsets through sequestration properties as well as other ecosystem services such as wildlife habitat development and water filtration. The model looks at the transition of the scrubland to a productive forest at years 1 6 and 14.”

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Environmentally Extended Input Output

Application of input output analysis in calculation of external costs of electricity consumption within EU

Jan Weinzettel, Miroslav Havránek

“In the area of industrial ecology an input output analysis is widely applied in calculation of environmental pressures related to international trade of goods and services. The input output model usually consists of several product groups and environmental extension represented by environmental pressures in question. In contrast we present an input output model consisting of one product (electricity). The goal is to calculate externality cost of electricity consumption in contrast to the externalities of electricity production since electricity is exchanged among countries with different external costs of production. Therefore the external costs of consumption are influenced by external costs of production in the country of origin. For example suppose that there is a country with very low external costs of electricity production but importing significant amount of electricity from a country with high external costs of production. Therefore the external costs of consumption differ from the external costs of production. In order to account for all electricity exchanges between EU countries an input output model was developed and used for the calculation.

The model is based on an analogy with ordinary regional environmentally extended input output models. The monetary flows are replaced by the flows of electricity individual sectors are replaced by countries intermediate consumption is replaced by losses and international trade and final demand is represented by the consumption of other industries and households.

This contribution is not focused on the calculation of external costs but it is focused on the methodology of application of input output approach on international trade with electricity within EU and subsequent calculation of external costs of electricity consumption. The intended audience are people with background in input output analysis.”

Raw Material Equivalents of Austrian Trade Flows

Anke Schaffartzik, Dr. Nina Eisenmenger, Assoc. Prof. Helga Weisz

“Identifying the potential environmental pressure associated with a given level of consumption requires accounting for all flows which in the production of the goods and services consumed. Wit”

Offshoring impact on the growth of freight international transportation and CO2 emissions

María Ángeles Cadarso Vecina, Nuria Gómez Sanz, Luis Antonio Lopez Santiago, Maria Angeles Tobarra Gómez

“The growing offshoring process has increased final and intermediate imports from low-wages countries. This increases the distance merchandises travel in different stages until they reach the final consumer and the volume of CO2 emissions generated in transportation. We propose a new methodology to quantify by sector the importance of freight international transportation on the total of contamination and to assign the responsibility to consumers. In order to do so, we combine data from input-output tables, imports from the Cámaras de Comercio database, and CO2 emissions from the Satellite atmospheric emissions accounts. “

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Industrial Ecology in Developing Countries

Application of Life Cycle Assessment to the Solid Waste Management and Treatment in Santa Clara, Cuba

Ivan Rodriguez Rico, Teresa Cárdenas Ferrer, Elena Rosa Domínguez, Ronaldo Santos Herrero, Ana Margarita Contreras Moya, Jorge Dominguez

“In the present work it was realized an analysis of solid wastes management and treatment in the Santa Clara City Cuba, using the tool of Life Cycle Assessment by means of Eco- indicator 99 method, which allowed to describe and to evaluate the environmental impacts of all the stages of the process, from the generation to the final disposition of the solid wastes.

The main results show that for the specific case of the Santa Clara city there is a deficient management of the solid wastes and the most feasible routes for its solution, is the recycling of the paper cardboard, glass, plastics and metals; chemical treatment to the organic fraction and the land field as final disposition.”

Cumulative effect assessment of Industrial State: an approach toward sustainability in developing countries

Saideh Rasouli

"In this study cumulative effects of intensive industrial activities have been assessed by using two different approaches of impact assessment methods overlay (Macharg 1969) and degradation model (makhdoum 2002) in a case study. Amol industrial estate by an area more than 100 ha is located in margin of valuable hyrcanian forest ecosystems in north of Iran. All of the ecological & socio – economic resources in study area (about 7.5 kilometers around the industrial estate) were surveyed. In overlay method ecological capability of the area for industrial land use has been evaluated based on industrial development model (Makhdoum 2003). Also the rates of vulnerability of micro eco systems of industrial estate have been estimated.

In degradation model the estate area is classified in to grids. Indeed I made a network of industrial units to assess the impacts of industrial development in each of them and finally whole of the estate. I did this assessment in three different temporal phases (last presented future). Of course I had to make some change in degradation model to achieve the rate of cumulative degradation in the industrial complex.

The result in overlay technique shows that the industrial area does not have enough capability for such kind of development. Result of degradation model shows that the rate of degradation in study units are high and it will increase in future surely. From ecological point of view operation of this industrial complex and its development can not be sustainable in selected ecosystem. It will make some stress on ecosystem health and reduces its vigor organization and resilience. But because of its positive socio-economic impacts in developing countries there is a force to accept developments like this but obviously mitigation plan should be exactly implemented. In the end of this study some general and special suggestions in cumulative effect assessment are proposed for sustainable development in industrial complexes."

Industrial Pollution of Voronezh River Basin

Sergey Popov

“Many countries continue putting into commission new chemical enterprises and expanding already working ones. This leads to the chemical pollution of the environment in the industrial zone and adjoining area by numerous toxic combinations. This is a particular in the Voronezh River Basin (Central Black Soil Region of Russia) due to the pollution created by large-scale industrial enterprises .Within the Voronezh River Basin there are 29 chemical and petrochemical companies. In 2007 water pollution caused by these companies was observed in 16 districts of the Voronezh Region. Russian scientists and local social organizations are promoting the broad spectrum of activities against chemical pollution of the Voronezh River Basin such as establishing the Centre for Ecologic Adversity Counteraction providing local TV and newspapers campaign devoted to conservation of the Voronezh River implementing the effective system of medical monitoring of population in the districts with polluted water establishing the independent water quality research laboratory empowering local democratic institutions in environmental field. Organic synthesis enterprises are the most significant sources of chemical pollution of the Voronezh River. To considerably improve the ecological situation of organic material production community activists initiated the following actions: carry out certification of wastewaters and production wastes revise the current norms in all areas of production including treatment facilities and make the necessary amendments and changes to meet maximum permissible emission and maximum permissible concentration levels and provide for the reduction and utilization of wastes introduce the latest achievements and physicochemical water treatment methods at the stage of basic tertiary wastewater treatment using ozone before water disposal into the water bodies to meet current sanitary norms and regulations. We consider the common efforts in environmental field as the key point for maintaining the ecological balance in the Voronezh River Basin for a long period.”

An Evaluation Method of Eco-Factor of Economy Growth

Yadong Yu, Shanying Hu, Jingzhu Shen, Dingjiang Chen, Yong Jin

"There have been a lot of researches on sustainable development evaluation indexes since 1980s. However most index systems are quite complex and difficult to be implemented. In China Green GDP was ever experimented in 2004~2005 but it was paused at present for its difficulty and imprecision. Hence a new index Eco-Factor of Economy Growth (EFEG) is proposed in this paper. EFEG is defined as a proportion of economic growth ratio and eco-consumption increasement ratio where eco-consumption is the overall synthesis of resource energy and environment consumption. EFEG can effectively reflect the change trend between economy and eco-consumption in a relative degree. As a fundamental quantitative assessment index EFEG focus on the health trend of economic growth from ecological perspective and based on which a series of quantitative indicators are derived such as resource ecological indicator energy ecological indicator and environment ecological indicator. Case studies which concern with EFEG performance in a series of time span in China and US are presented and discussed. The average value of EFEG in China is 1.047 in the period of 1982-2006 which is more than the Alarm Value (1) but still less than the National Standard Value (1.0714). In the Tenth Five-Year period (2000~2005) the average value of EFEG of China dropped to 1.0047 due to rapid development of heavy chemical industries and the trend of economic growth is unhealthy. But in recent years this problem had aroused great attention and is being gradually solved. Results show that the data for the calculation of EFEG is easy to be obtained based on the current national economy accounting system. With clear physical significance and good robustness EFEG can be used to help the government with making policies to promote sustainable development."

UNECE Protocol on Pollutant Release and Transfer Register as mechanism for the implementation the provisions in chapter 19 of Agenda-21 and the Plan Implementation of the 2002 World Summit on Sustainable Development

Nune Hovhannisyan, Diana Selipanova

"Sustainable development is impossible without right to have access to reliable environmental information. Republic of Armenia as part of international community is interested in progress on information system development and global chemical safety achievements.

In 2001 the Republic of Armenia ratified the UNECE Convention on Access to Information Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention). In 2003 during the fifth "Environment for Europe" Ministerial Conference held in Kiev the Republic of Armenia signed the Protocol on Pollutant Release and Transfer Registers (PRTR Protocol).

The objective of the PRTR Protocol is to enhance public access to information through the establishment of coherent integrated nationwide pollutant release and transfer registers which could facilitate public participation in environmental decision-making as well as contribute to the prevention and reduction of pollution of the environment.

It is obvious that broad public involvement in the development and implementation of policies in various social-economic sectors is essential for achieving any significant progress on the way to sustainable development.

Pollutant Release and Transfer Registers in an important part of the Decision Implementation Project adopted by the World Summit on Sustainable Development and will support the country's hazardous chemicals management human health and environment conservation process. Creation of National PRTRs register is an important starting point with regard to implementation of the provisions of the World Summit on Sustainable Development Decisions."

Journey to world top emitter – an analysis of the driving forces of China's recent CO2 emissions surge

Dabo Guan, Glen P. Peters, Christopher L. Weber, Klaus Hubacek

"China's economy has been growing at an accelerated rate from 2002 to 2005 and with it China's carbon emissions. It is easier to understand the growth in China's carbon emissions by considering which consumption activities – households and government capital investments and international trade – drive Chinese production and hence emissions. This paper adopts structural decomposition analysis a macro-economic approach using data from national statistical offices to investigate the drivers of China's recent CO2 emissions surge. The speed of efficiency gains in production sectors cannot cope with the growth in emissions due to growth in final consumption and associated production processes. More specifically Chinese export production is responsible for one-half of the emission increase. Capital formation contributes to one-third of the emission increase. A fast growing component is carbon emissions related to consumption of services by urban households and governmental institutions which are responsible for most of the remaining emissions."

Industrial Ecology in Developing Countries
Study on the Relationship between Waste Emissions and Economic Growth

DU Tao, LU Zhongwu

"China is a developing country which started its industrialization later. In the process of economic growth developing countries should avoid repeating the industry-environmental mistakes of Industrial Revolution. Environmental study should be carried out in connection with development unless it is impossible to understand the problems concerned clearly.

In this paper we will carry out the theoretical study on the quantitative relationship between waste emissions and economic growth. The variation of GDP will be used as the indicator G of economic growth. Then equation I'GTX (that is I'=GTX) is established. Where I' is a waste emissions T is the volume of waste generated per unit GDP X is the rate of waste emissions. It can be seen from equation I'GTX that if T and X keep constant during economic growth the relationship between I' and G will be simple. However if T or X varies during economic growth the relationship between I' and G will be complicated.

The analysis indicated that waste emissions and the GDP increase rate are closely related. Further the critical value xk of decrease rate of waste emissions per unit GDP can be determined. Take x as a criterion there are three possible cases of the variation of waste emissions during GDP growth. If x<xk then the waste emissions will increase year by year If x=xk then the waste emissions will keep constant If x>xk then the waste emissions will decrease year by year.

The long-term plan of development and environment should be worked out in line with local conditions. The target values of G X T for each stage of the plan should be determined scientifically. According to equation I'GTX and other formulas which derives from it all kind of waste emissions can be determined in the planning period."

Sustainable Development in China- Challenges for Research and Education

Zhichang Cai, Xingqiang Song, Ronald Wennersten

“Sustainable Development in China- Challenges for Research and Education

China experienced a fast and large-scale urbanization along with its incredible economic growth in the past thirty (1978-2008) years. However this urbanization is far from a sustainable urbanism and has caused a series of problems which conversely become the challenges for the continuing urbanization. These challenges exist in nearly all aspects and could be summarized as:

1. Energy and resources scarcity because of large population and low efficiency of utilization

2. Comprehensive and severe environmental degradation caused by complicate reasons

3. Social inequity&#65292which raises severe conflicts between different social classes

4. Imbalance of development between the west and the east the rich and the poor the urban and the rural etc which aggravates the social inequity.

5. Tension between centralized political system and further economic development which could generate uncontrollable conflicts.

Interdisciplinary research and sustainability education are crucial to create pathways towards sustainable societies in China. It is especially important to promote institutional capacity building and facilitate paradigm shifts towards adaptive and integrated natural resources management for example topics on integrated sustainability assessment decision making and planning and policy analysis for SD. Since the scope of SD education is still limited in both technical and humanistic universities in China it’s urgent to develop educational strategies to incorporate SD in the existing systems. One feasible way is to introduce courses in university for example on Industrial Ecology Eco-efficiency and Design for Environment as well as education programs for people in industry and authorities. Besides China as well as the other developing countries can benefit substantially from building international research and education networks on SD in Higher (engineering) Education.

This paper will highlight both the challenges for Sustainable Development and the needs in Research and Education with a focus on the contribution from the discipline Industrial Ecology. The results that will be presented are partly derived from a EU project SDPROMO - Promoting European Education in Sustainable Development.”

A Comparison of Instruments for Chinese Greenhouse Gases Mitigation

Bo Xu, Ronald Wennersten, Nils Brandt

“Reducing greenhouse gas (GHG) emissions from human activities is an effective measure to mitigate climate change. In order to reduce GHG emissions without causing negative impacts on the national economy possible policy tools include “command and control” instruments and economic instruments. However China used to prefer much to the “command and control” instruments which were proved not enough to control the growing GHG emissions. Therefore an increasing number of concerns have been focused on economic instruments and taxes and subsidies among others have been applied.

The aim of the paper is to compare different instruments based on Chinese experiences. The paper firstly reviews the history of “command and control” and economic instruments. Various types of “command and control” instruments include: (1) setting up an overall cap at the national level (2) distributing quotas to provinces from the cap and also setting up a bonus-punishment system to guarantee the achievement of the quotas. Categories of economic instruments include: (1) various resource tax regulations (2) contrived price system in the energy sector and (3) subsidies. The paper then specifically discusses the implementation of “command and control” and economic instruments in Shandong province which is one most industrialized province in China. Effects of the instruments will be further analyzed to show the potentials of different combination of reduction instruments.”

Life-cycle based comparison of the reuse of agricultural residues as fuel and feedstocks in South India

Weslynne Ashton, Ariana Bain, Trisha Shrum

“The reuse of agricultural residues as fuels and feedstocks for industrial applications is commonly practiced throughout India. The use of these materials as fuels has recently increased due to the rising costs of fossil fuel sources as well as interest in reducing greenhouse gas emissions from production processes. This paper presents a life-cycle assessment agricultural waste reuse in the South Indian states of Karnataka and Tamil Nadu by profiling the activities at three facilities. Bannari Sugar Mill in the Nanjangud Industrial Area (Karnataka) uses the bagasse residue from sugar production as its primary fuel while Seshasayee Paper Mill in Erode (Tamil Nadu) uses bagasse as its primary feedstock for paper-making with imported coal as its primary fuel. Meanwhile South Indian Paper Mill located close to the Bannari facility uses waste paper (some of which is imported from outside India) as its feedstock for making cardboard and agro-waste (coconut shells rice husks) for its fuel. Comparisons are made in terms of energy and water consumption greenhouse gas emission and further uses of remaining wastes. These modern industrial uses are also compared to traditional uses of these materials within the farming communities in these regions.”

5th International Conference on Industrial Ecology

2009 ISIE Conference

Industrial Ecology tools for Sustainability

The impact of bacteriophages in bacteria removal associated with Soba Stabilisation Station efficiency

Ahmed Abedallah Elshayeb

“The existence of bacteriophages in wastewater of Soba Stabilisation Station was determined by isolating and identifying methods for their activities against Escherichia coli and Staphylococcus aureus isolated from the anaerobic facultative and maturation ponds. The general viable count of the bacteria showed an average of 2.0x 106 cfu/ml. In broth media the affection of the bacteriophage interactions with bacteria showed increasing of the bacteriophages and decreasing of bacteria due to culture clearance where the readings of the turbidity for the first and second infection showed statistical significant of light transmission among E. coli phages&#8217 samples due to place of samples collections as followings from the anaerobic and facultative ponds P>0.05 facultative and maturation P<0.05 and anaerobic and maturation P>0.05. Whilst the S. aureus phages samples&#8217 light transmission from the anaerobic and facultative P<0.05 facultative and maturation P<0.05 and anaerobic and maturation P>0.05. On solid media the affection of the bacteriophage was recognised by the phage plaque formation on bacterial cultures. The linear equations of phages&#8217 densities and distributions according to their wavelength were y = 0.0008x + 0.0303 for E. coli phage and y = -0.0102x + 0.2438 for S. aureus phage. This study concluded that phages naturally present where their hosts where present and in this case the presence of phage contributed in naturally destroying of their bacteria which aid their recovery from environment.”

System Analysis of Integrated Biorefineries

Lin Luo, Ester van der Voet, Gjalt Huppes

“Facing the threat of oil depletion and climate change a shift from fossil resources to renewables is ongoing to secure long-term supplies. Several studies on life cycle assessment (LCA) of bioenergy and materials were conducted focusing particularly on two main impacts: reduction of fossil resource extraction and greenhouse gas (GHG) emissions. However LCA as it stands has limitations in allocation issues and variable multi-input multi-output systems as in the integrated biorefineries. A broader approach for the analysis of biorefinery systems with regards to energy conservation environmental impact and cost-benefit will provide general indications on the sustainability of bio-based productions.

Among the potential large-scale industrial biorefineries lignocellulosic feedstock (LCF) biorefinery will most probably be pushed through with the highest success. This study focused on a LCF biorefinery which integrates biomass conversion processes and equipments to process power fuels and chemicals. Collected agricultural residues such as corn stover wheat straw or sugarcane bagasse undergo pretreatment fermentation and purification to produce ethanol together with organic acids like succinic acid fumaric acid or acetic acid. The advantages of cellulosic feedstocks include a much higher ultimate supply lower purchase cost potential reduction of energy input and GHG emissions and avoidance of competition with food and arable land. By producing multiple products and integrating waste treatment the biorefinery complex has maximized the values derived from cellulosic feedstocks.

The aim of this study is to quantify the environmental performances of a designed LCF biorefinery mainly focusing on energy use and GHG emissions. The biorefinery is designed using (bio)chemical engineering knowledge and process simulation tools like ASPEN and SuperPro and then the system is analyzed using LCA tools. Once the designed biorefinery is analyzed successfully the model system can be expanded to a product-nonspecific framework in which different production pathways in biorefining are evaluated in order to measure and minimize the energy consumption and GHG emissions. The important factors in different process routes are pretreatment of feedstocks fermentation mode (aerobic or anaerobic) product yield and the energy required for product recovery. Results can vary greatly with regard to the changes of the factors. When all these factors are favorable significant reduction of energy consumption and GHG emissions are achieved which provides the possibilities to turn the biorefinery concepts into real opportunities when some of them are unfavorable the model gives indications on to what extent the reduction can be achieved. Such a framework provides the following opportunities:

1) Bridging technical process and product design to environmental analysis

2) Manipulating process and product options to achieve an optimized design

3) Optimizing biorefineries in terms of technologies energy efficiency and environmental performances.

The model system in this study can be further expanded to include a complete set of environmental impacts profitability measures and techno-economic metrics which can then be used to optimize bioprocesses to specify the types of product systems that favor bioprocess and to provide the methodology for system analysis beyond LCA in integrated biorefineries."

Thermodynamic Analysis of Ethanol Production from Corn Stover

Wenjie Liao, Gjalt Huppes, Reinout Heijungs, Lin Luo

“Fuels from biomass are widely proposed as substitutes for fossil fuels to offset the imminent decline of oil production and to mitigate the emergent increase of GHGs emission. The proposal however is based on a simple analysis only providing one piece of the whole mosaic of the complex bio-fuel system or controversial claim involving ideological bias and political preference. This study basically defined the whole bio-fuel system on three scales i.e. the foreground production system the background economy and the supporting Earth biosphere. Thermodynamic concepts of energy exergy and emergy are introduced to measure various flows such as natural resources energy and materials products labour and services of the system on the multiple scales. The environmental sustainability of the system in terms of resource uptake system efficiency and physical feasibility are analyzed from a viewpoint of the life cycle of the final bio-fuel product in the case ethanol from corn stover in the US. Results are compared with other literature values to draw the system characteristics of typical bio-fuel alternatives. Consequently energy analysis exergy analysis and emergy evaluation jointly provides comprehensive indications of the sustainability of bio-fuel system. This thermodynamic analysis can provide helpful theoretical guidance in the sustainability decision-making process.”

Water consumption Greenhouse Gas and Economic Implications of Oil Shale in the United States

Aweewan Mangmeechai, H Scott Matthews, W. Michael Griffin, Paulina Jaramillo

"The future petroleum supply to the U.S. is uncertain. A decline in conventional crude oil production together with a growing dependence of the U.S. petroleum imports would stimulate unconventional fuels production including heavy oil oil shale and oil sands. The U.S. oil shale reserves exceed the world's conventional fuel proven reserves. Most of the oil shale is within the Green River Formation in Colorado Utah and Wyoming. This study explored the potential impacts of greenhouse gas emissions and water consumption of the oil shale resource base using a life-cycle analysis approach. We estimated life-cycle emissions and water consumption of synthetic crude oil derived from oil shale. The study boundary includes the extraction transportation refining and fuel combustion. The life-cycle emissions of oil shale were 1350-1770 lbs CO2/barrel of oil equivalent which are 20-50% higher than those of U.S. petroleum status quo and 10-30% higher than those of oil sands. Its emissions however are 30-70% less than those of coal-to-liquid. The life-cycle water consumption oil shale was 140-310 gallons of water per barrel of oil equivalent. Water availability in local supply is a challenging factor that may limit oil shale production. The natural flow of rivers which has not yet allocated to the lower Colorado River basin near Piceance Basin a study location cannot maintain above one million barrel per day of oil shale production because the flows greatly fluctuate from month to month. We created a water trading scenario between lower and upper Colorado River basin that desalination plants were built near West Coast (a lower basin) to allow more water accessibility in Piceance Basin (an upper basin). The capital and operating costs of infrastructure required for oil shale production and utilization were estimated. The levelized costs of oil shale production were in a range of $30-$80 per barrel of oil equivalent. Although a key issue the costs of building water systems (e.g. pipeline and desalination plant) are not a big portion in total levelized costs."

Construction of Methodology and Tools for the Coordination Processes Analysis in the Implementation of Industrial Ecology

Muriel Maillefert, Paul Schalchli

“Construction of Methodology and Tools for the Coordination Processes Analysis in the Implementation of Industrial Ecology

Industrial ecology can be understood under diverse registers going from the optimization of material and energy flows to a context of trade regulation until a systemic representation calling rather for a quantitative regulation.

Beyond the technical specifications we think that processes of coordination occurring in the governance of experiments constitute a major stake in success or in failure of the experiments. From this point of view the various regulation processes probably underlie specific coordination processes which are far from market coordination processes. Nevertheless even if the plurality prevails certain methodological principles can appear and constitute control levers for the implementation of experiments.

One part of our project research (as a part of the COMETHE* research project) aims at identifying the reasons why the question of the coordination processes is essential in terms of success or failure of IE projects. We want then to focus on the incapacity of analyses only based on market processes and point out the interest of mobilizing “heterodox” approaches. A first sketch of methodology to analyze processes of coordination is then proposed.

We aim at understanding the relations between stakeholders on the various territories of the COMETHE project which means identifying the strengths and the weaknesses of each case study and the relevant variables driving collective action. A second step consists on testing the assumption that these coordination processes may carry out specific - and sometimes opposed - visions concerning the development strategies of the territory within a sustainable approach.

The main scientific goal of this project is to develop methodological and assessment tools integrated in a global decision-making tool to help the stakeholders implementing industrial ecology in industrial parks within the French context.

* Conception of methodological and assessment tools for industrial ecology.”

A comparative modeling study on metal pollutants in urban waters between Beijing China and Stockholm Sweden -Diffuse sources and fate analysis

Qing Cui, Nils Brandt, Maria E. Malmström

“Nowadays diffuse sources are dominant contributors of metals to urban waters in most cities because the point sources have been well controlled (e.g. Sörme and Lagerkvist 2002). Despite the decrease in the point sources heavy metals in the urban environment still maintain at an enhanced level in the urban environment (e.g. Sörme et al. 2001). Understanding of the coupling between the pollutant load and the monitored environmental status is critical for managing urban emissions of pollutants. In this study we assess the dominant types of urban diffuse sources of Cu and Pb and their distribution along with the environmental fate of the released metals.

We combine a material/substance flow analysis (MFA/SFA) as a source model with a lake mass-balance model as a fate model to simulate the metals from the technosphere and in the surrounding environment on the local level following a previously developed approach (Cui et al. 2008). The combined model is applied to Lake Trekanten in Stockholm Sweden and to Lake Shicha Hai in Beijing China with these cases representing lakes in urban areas with several differences for example different climate water resource availability and developing status. This enables identification of discrepancies and similarities in metal sources of fates between different conditions thereby providing important information concerning environmental action plans on the urban level.

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Solution Spaces for Decision-Making - A Transdisciplinary Assessment of Sustainability along the Global Uranium Value-Added Chain

Michel Maiorano, Prof. Dr. Claudia Binder, Prof. Dr. Andrea Schenker-Wicki

“This poster shows the conceptual framework of the sustainability assessment of the human-environment system “uranium value-added chain”. Furthermore it presents first results of the first step of the integrative approach the material flow analysis for Uranium. This integrative approach is based on the Sustainability Solution Space for decision-making (SSP). SSP is a trans-disciplinary approach integrating environmental process models expert knowledge and decision-making models. The sustainability assessment along the global uranium value-added chain helps to implement strategies establishing sustainable energy paths. The global uranium value-added chain is represented by an integrated model which provides a consistent set of ecological social and economical indicators their systemic relations and sustainability ranges. The integrated model discloses potential target conflicts between indicators by constructing SSP rendering awareness of synergistic and contradictory effects of decisions. With simultaneous consideration of the prioritization of the indicators and the trade-offs between the indicators it supports sustainable decision-making. The first phase includes a material flow analysis and a risk assessment along the uranium value added chain which identifies and estimates sources and sinks. This results combined with expert knowledge (expert panels) provide the basis for the quantification of the predefined indicator set. The second phase involves a normative module that defines the targets concerning the sustainability ranges. The third phase integrates the previous studies and defines the SSP. Target conflicts are anticipated between financial targets (e.g. return of assets) and environmental targets (e.g. nuclear waste) or social targets (e.g. public acceptance). To meet the conditions for sustainable energy paths strategies have to be developed in order to address these target conflicts.”

From Laboratory to Industrial Scale a case study on the environmental impacts of a novel biobased material

Daniel Kellenberger

“Background: The aim of novel biomaterials is often to have a reduced environmental impact compared to conventional materials. However all aspects of production must be considered in order to minimize the overall environmental impact of a biomaterial. One aspect is scaling up the production from laboratory to industrial scale which usually changes the production processes and therefore potentially related environmental impacts significantly. Scion a Crown Research Institute in New Zealand has been designing novel biomaterials on a laboratory scale for many years. This experience has provided the basis for applying Life Cycle Assessment (LCA) methodology on this scale as well as the larger production of biomaterials.

Approach: Our goal was to produce a guideline to minimise the overall environmental impact of a biomaterial. This involved:

- calculating the environmental impact of wood-fibre reinforced plastic produced on laboratory scale

- developing different scenarios to get a better understanding of possible changes to the environmental impact when transferring the process to industry scale and

- translating the LCA results into a list of recommendations to be considered when planning industrial-scale production.

Benefits: This guideline will make potential investors aware of the critical production steps involved in transferring wood-fibre reinforced plastic technology from laboratory to industrial scale and how to minimise the environmental and related economic impacts. Indirectly there will be the benefit of using the knowledge to market the final product.

Outlook: The aim of this study was to apply LCA to a specific novel biomaterial developed by Scion in order to retain a low environmental impact. The guideline produced will be extended in the future to the environmental impact assessments of other novel biomaterials at Scion. Developing such guidelines will help raise the awareness of environmental issues through the whole organization and more importantly at the beginning of the design process.”

Multi-values of Evaluating Sustainability: the case of climate change mitigation projects

Qie Sun, Ronald Wennersten, Nils Brandt

"Categories of values related to sustainability can be generally classified as environmental social and economic impacts. Making development more sustainable necessitates practical decision-making to be able to realize synergies and avoid conflicts of different impacts. With the unequivocal climate change a great number of studies and activities have been contributed to understanding of the nature and reacting to the impacts. It is widely recognized that addressing climate change is an important integral element of sustainable development policies and that there are good possibilities for reinforcing sustainable development through climate change mitigation (CCM). CCM projects have been increasingly adopted as crucial efforts to fight against climate change since day-to-day activities hold the major responsibility for energy consumption and related greenhouse gas emissions. Due to the fact that a CCM project has significant impacts on the environmental-social-economic system it is necessary for a decision to be made based on a holistic evaluation of relevant multiple values.

The aim of this paper is to improve the effectiveness of decision-making of CCM. Firstly the paper will discuss what values should be considered. It is argued that the multi-values of a CCM project should be obtained on the basis of a system analysis and thus various environmental social and economic impacts will be taken into account. Basic principles for getting the values are: transparent objective accurate and comprehensive. Secondly the discussion will focus on how the values are used in various evaluation tools and the implication of values on different evaluation tools. Applicable tools for evaluating CCM projects include cost-effectiveness analysis cost-benefit analysis and multi-criteria analysis. Finally how evaluation results could be applied on decision-making will also be discussed."

Analyzing Potential of Industrial Pollution Reduction by Bottom-up Technology Model: Case Study of China Pulp Industry

Chao Zhang, Zongguo Wen, Jining Chen

“Pollution reduction (COD & SO2) is one of the major concerns of industrial environmental management in China. Chinese government has implemented strict COD gross control policy in the 11th five year plan. Phasing out backward technologies, promoting clean technologies and implementing effective end-of-pipe treatment are basic approaches to fulfill the pollution reduction target, as well as to realize sustainable development of key industrial sectors. This paper developed a technology selection model for industrial COD reduction by bottom-up modeling methodology, linear programming and scenario analysis. Industrial technology structure is constructed by matching products, processes and technologies, based on the thought of technological input and output. With objective function of minimizing the total cost and constraints such as product demand, technology penetration, technology elimination and substitution, balance between COD produce and discharge, the model can forecast clean technology prospect and COD discharge trend. A case study of China pulp industry is carried out, which account for the largest industrial COD discharger,. Totally, 32 technologies within 8 processes are selected. Taking 2005 as the base year, COD reduction potential and technology structure in 2010, 2020 and 2030 are calculated under three scenarios: business as usual, market scenario and total amount control scenario. Result shows that under market scenario, compared with the base year, the percentage of COD reduction is 1.8%, 3.4% and 3.2% respectively. Under total amount control scenario, clean technologies such as elemental chlorine free bleaching will spread to larger extent. As can be induced from this study, the bottom-up technology model is a useful tool for sustainable industrial technology selection and analyzing the potential of pollution reduction of industrial sectors. “

Performance and evolution of a biorefinery cluster

Igor Nikolic, Catherine M. Chiong Meza, Gerard Dijkema

“The performance and evolution of a biorefinery cluster were examined using our agent-based modeling simulation engine.

Biorefineries are envisioned as a distributed production facility consisting of many processes that are tightly integrated and act as a single unit. The optimal performance of such a biorefinery cluster is dictated by the technical characteristics and requirements. We setup a modeling exercise to determine under what economic conditions emerging biorefinery clusters will be profitable. Since any biorefinery consists of a number of processes possibly owned by different firms a rational strategy for evolving a biorefinery was examined.

The use of latin hypercube sampling was tested as a technique to examine the very large parameter space of the economic environment. This allowed us to examine the clusters economic fitness under different conditions. Multi Criteria assessment (MCA) was tested as a method to rationalize the RDAs decision making process when selecting which firms to invite to join the cluster.

The main result from the exploration of the economic environment parameter space was that the cluster if developed in a single exercise or project at once is likely to be successful in the majority of economic conditions. In the case of growing the cluster through rational decision making it was found that increased rationality of the RDA through MCA does not improve the performance of the cluster. This was thought to be mainly caused by the limited number of technological options available to the RDA is this case study.

The case study model setup and results will be presented. Directions for future research such as introducing a dynamic economic environment in the model a greater diversity of agents and a more sophisticated economic reasoning by agents.”

Transformation innovation and adaptation for sustainability – integrating natural and social sciences

Helga Ögmundardóttir, Brynhildur Davíðsdóttir

"Human life is a constant interaction between what we want – the subjective – and what is available – the objective. This can be thought of as a continuum of needs. Needs can crudely speaking be divided into two groups placed on each extreme of the continuum: 1) subjective ideas of what we need mediated by cultural values and thus contestable socially constructed subject to constant change and relative and these needs can be termed "wants" or "desires" 2) objective real physical and psychological needs that we must satisfy in order to survive as organic and social beings and thus given and determined by our physical and psychological status these can be termed "requirements".

A transition in energy- and fuel-use is one of the most necessary steps which have to be taken if we are to move closer towards sustainability. The oil-economy has to be abandoned with new fuels as replacement. However the mere existence of an alternative fuel is not sufficient as society needs to consider such a transition necessary. This paper presents some insights to consider when placing new fuels on this continuum about potential social openness or the introduction of new fuel(s) in a relatively affluent society. The methodology was qualitative based on deep extensive interviews and participant observation which are the methods extensively used by social scientists to investigate social and cultural phenomena. Research illustrates that most don't see it as necessary to take up a more sustainable life-style and that people's filtration of the idea of 'Quality of life' (Qol) through their cultural value-system renders different meanings of the term and it is only when a critical mass of the population equates Qol with 'sustainable way of life' that they will change their conduct and move towards a sustainable future."

Economic evaluation of sectoral objectives of mitigating greenhouse gas emissions in Iceland

Brynhildur Davidsdottir, Daði Már Kristófersson

"Net greenhouse gas emissions in Iceland increased 9.4% between 1990 and 2006. The Icelandic government has proposed to reduce net emissions by 25-40% by the year 2020 yet comprehensive assessment of mitigation options has not yet been performed. The objective of this analysis is to identify by sector mitigation potentials and to perform a comprehensive cost-benefit analysis of the costs and benefits of sector based GHG mitigation measures. Sector based and aggregate nationwide GHG mitigation cost curves are developed ranking alternatives based on net cost of mitigation per ton of Carbon Dioxide eq. Preliminary results illustrate that net emissions can be reduced by 39% below 1990 levels by the year 2020 for less than $20 USD per ton CO2 eq."

Measuring Sustainable Energy Development (SED): linking SED indicators to dynamics of change

Brynhildur Davíðsdóttir, Dan Basoli

“Energy use is central to all three dimensions of Sustainable development (SD) and sustainable energy development (SED) is a necessary component of global sustainability. SED is broadly defined as the provision of adequate energy services at affordable cost in a secure and environmentally benign manner in conformity with social and economic development needs. If the global community considers SED a priority sustainability indictors should be developed that measure progress towards SED in the three dimensions of sustainability simultaneously. This paper presents (1) a dynamic vector-based indicator measuring movement towards SED based on the DSPIR framework using the Bellago principles (2) the implementation of this indicator for 6 different countries – Iceland USA UK Sweden Brazil and Mexico (3) preliminary efforts to link the indicator to the economic and social dynamics of change. Creating such a link reveals possible policy leverage points that drive the energy system towards sustainability in all three dimensions simultaneously.”

Economic and environmental comparison of alternatives of transitioning towards domestically produced biofuels in Iceland

Elisabeth Unger, Brynhildur Davíðsdóttir

"Currently 99% of Iceland's heating and electricity is produced by renewable energy sources and in February 2007 a new climate strategy was released stating its goal is to reduce net greenhouse gas emissions in Iceland by 50 – 75% by 2050 compared to 1990 levels. All petroleum products are imported and the transportation sectors accounts for nearly a third of all emissions. Technological transition in the transportation sector is therefore necessary. Yet alternatives need to be compared. To compare alternatives associated with Iceland potentially producing its own biofuels based on environmental and economic implications results from previous life cycle assessments were standardized into a format that presented the burden in a specific quantity (g) when one MJ was delivered to the tank. Under this criterion results indicate that in either case of advanced biofuel conversion technologies timber in comparison to MSW newspaper manure winter wheat and rapeseed is the most advantageous yielding the least impact to global warming potential (7.32 g/MJ) acidification potential (.14g/MJ) eutrophification potential (.05 g/MJ) and photochemical oxidation potential (.001 g/MJ). Despite these environmental advantages due to high production cost and other cheaper options to produce first generational biofuels this option is not cost effective. But more importantly a looming question arises when comparing Iceland's current consumption patterns for the transportation sector and its potential ability to fill roughly only 2% under conservative estimates from domestically produced biofuels."

Scenario development for sustainable deployment of renewable power sources - A case study focusing on photovoltaic systems introduction scenarios in Taiwanese power

Yu-Ming Kuo, Yasuhiro Fukushima

“Achievement of a reliable secure and cleaner power supply system is one of the keystones for constructing a sustainable industrial ecology. This paper explores capacity extension strategies of power generators with focus on enhancement in emerging renewable power sources leveraged by the technology development catalyzed by promotion methods. Various technology projections assumptions on penetration conditions and promotion policies of renewable energy were assessed. As a case study photovoltaic systems (PV) introduction potentials and its consequences on emission reduction was evaluated for various scenarios. A mathematical programming model was constructed to simulate hourly power mixes satisfying seasonal demands throughout a year in Taiwanese power market. The power mix and installed capacity of PV is determined by minimizing the sum of 1) operation cost 2) installation subsidies for PV and 3) operation subsidies (feed-in tariff) for PV.

An important characteristic of energy system relying on renewable energy is to embrace varying availability of resources at different seasons in a year. The developed model considers such aspects from both supply and demand sides. For PV variations in solar irradiation and weather conditions are taken into account on both an hourly and a seasonal basis.

Another characteristic of the developed model is its capability to consider introduction of renewable power sources by the public end users installed on roofs of residential buildings instead of the power company. The model calculates monetary payback time for given a) technology projections b) subsidization and c) seasonally varied load curves for several representative patterns of household. In this way distribution of potential installed capacity over varied payback time is obtained. By assuming payback being the key criteria for consumers’ decision on installation of PV subsidization strategies and capacity enhancement scenarios are generated for a given target on environmental impact reduction modeled as constraints in the mathematical model.”

The Norwegian Households' Perception: Will Wood-pellet Heating Systems be less Adopted in the Future?

Bertha Maya Sopha, Geir Skjevrak, Edgar Hertwich, Christian A. Klöckner

"The availability of abundant and low-cost fossil fuel has significantly changed the quality and way of life in many countries. However it also leads to a number of environmental concerns such as global climate change which is now focused as one of the most important and challenging environmental issues faced by the world community. A number of options have been suggested to minimize these problems. Replacing fossil fuels with wood pellet for use in heating system is one of the suggested options. Even though wood pellet seems as a promising alternative with its advantages e.g. clean environmentally friendly natural and renewable fuel resource etc. its market diffusion has however been rather slow till now. Therefore a need for understanding its slow growth is a must. The present paper studies on Norwegian households' perception of wood pellet heating system and factors that influence its adoption among the other existing heating systems such as heat pump and electric resistance. Those types of heating system i.e. wood pellet heat pump and electric resistance are then examined and compared. This study was conducted through a questionnaire survey of 958 Norwegian households. The innovation-decision model by Rogers (2003)* is adopted as a model to discuss various factors that determine households' choice of a new heating system. The barriers and supporting factors of adopting wood pellet heating system are then discussed further. The most preferred potential heating system type by Norwegian households is highlighted. The potential future research is briefly presented.

*Rogers E. M. 2003. Diffusion of Innovations Free Press New York"

Facilitating Industrial Ecology Systems Understanding through Fostering Collective Intelligence

Chris Davis, Igor Nikolic, Gerard Dijkema

“One of the challenges of Industrial Ecology is realizing the ambitious desire to have a holistic systems view in order to understand and shape the linkages between the economy social concerns and the environment all of which form the basis of sustainability. Integrating these is difficult due to the complexity of our urban industrial and infrastructure systems and due to the fact that information and knowledge relevant for analysis and development of these systems is often dispersed among different communities such as engineers economists environmental and social scientists that each have their own vocabulary perspectives theories and tools.

Incorporating a holistic systems view ultimately means we need to get better at systems learning across disciplines and communities. We need to increase the effectiveness by which individual learning contributes to information and knowledge that can be reused by those seeking an understanding of parts of the whole. Just as our socio-technical systems have emerged as a result of the collective actions of millions with useful parts being reused in ways unanticipated by the original contributors we should actively facilitate a similar type of evolution of the collection of information and knowledge.

Despite the breadth of IE these challenges are not unique to IE and similar problems are already being addressed in other academic fields through various projects employing collective intelligence techniques. Notable examples include biodiversity monitoring and the mapping cellular metabolic pathways. These projects leverage trends in internet technologies facilitated by tools such as machine learning and the approach taken to define standards for the semantic web meant to ameliorate the world wide web. These are employed to help foster communities that are able to share information connect it in meaningful ways and achieve results that are impossible to realize by a single contributor working alone.

Different examples of these projects will be discussed focusing on the means of facilitating user involvement curating data extracting patterns from the data and providing information for modeling. From these examples discussion will be given of how these tools and trends could be used for furthering the goals of Industrial Ecology.”

Integration of assessment tools

Tatiana Raquel Alves Valada, Ricardo Teixeira, Alexandra Marques, Tiago Domingos

“In order to evaluate the sustainability of a system or product we need to pay attention to three different aspects: the environment the economy and social welfare.

Theoretically the concept of sustainability is simple and easy to understand but in practice it is very difficult to measure sustainability. There are several methods that can give us a measure of environmental social or economic sustainability such as direct indicators Life Cycle Assessment Input-Output Analysis Ecological Footprint Material Flow Analysis Living Planet Index City Development Index Human Development Index Index of Sustainable Economic Welfare/ Genuine Progress Index. However few of these provide an aggregated measure of how sustainable a product or system is.

Our goal is to find a way to measure the sustainability of a system or product. In order to do this we perform an exhaustive revision of the literature and analyse the indicators and models proposed.

We also need to know all the characteristics of the system or product including all the inputs and outputs as well as the boundaries of the study. It is also crucial to understand the context of the system or product. That means that we must start by defining the characteristics of the environmental resources social and economic structure that may be affected by the system or product.

With all that information is now possible to understand which is the best way to assess sustainability. That can be done with some of the methods already described using weighting factors. Those factors are not static and depend for instance on the relevance of the parameter analysed. We defined criteia to choose from different indicators and methods. These criteria have a specific time and space resolution and so are sector-specific.”

Extended Exergy Accounting of products

Laura Talens Peiró, Gara Villalba Méndez, Enrico Sciubba

“Extended Exergy Accounting (EEA) is a System Analysis method that calculates on the basis of detailed mass-and exergy balances the total amount of primary exergy resources that is embodied in a commodity (good or service). The method requires a disaggregated knowledge of the mass- and exergy fluxes within a Society (here illustrated in Catalonia) and “builds up” the “extended exergy” content of a product by properly adding up successive contributions to its formation process. EEA incorporates also the so-called “externalities” namely Labour Capital and Environmental Remediation Costs which are incorporated in the global budget of the process by means of equivalent exergy contents computed on the basis of the actual workhours generated in the Society and of the monetary circulation therein. Thus the “extended exergy cost” of a commodity is expressed in kJ/unit (kg kJ unit service) and represents the cradle-to-grave exergetic burden that the Society must bear to produce that commodity.”

Application of Substance Flow Analysis to Assess Three Commercial Manufacturing Processes of Glyphosate

Jinping Tian, Lvjun Chen

“Although there have been intensive assessments of the environmental and health impacts of the most commonly used herbicide – glyphosate the environmental pollution caused by its expanding production activities has been virtually overlooked. As the world largest producer of glyphosate China employs three commercial production processes (i.e. the DEA process Glycine process and CH4-HCN-IDAN process) which result in very different performances in terms of resource efficiency waste generation and energy consumption.

We combine a substance flow analysis and an assessment of the atom efficiency of carbon phosphorous and chlorine in order to comprehensively evaluate the eco-efficiency quantities and nature of wastes energy consumption costs and sustainability of main raw materials for the three glyphosate production processes. A multi-criteria economic and environmental assessment based on the above SFA results concludes that the CH4-HCN-IDA process is more favorable for future glyphosate production expansion in China.

Our approach builds upon the E factor methodology which is widely used to assess the environmental footprint of chemical industry processes and mitigates its deficiency by taking into account the nature of production wastes. The findings of our research can inform both Chinese government policy-makers and business leaders to make more environmentally benign economic decisions about the glyphosate production technology.”

Opportunity Cost Based Analysis of Corporate Eco-Efficiency: A Methodology and its Application to the CO2-Efficiency of German Companies

Tobias Hahn, Frank Figge, Andrea Liesen

“In this paper, we present the return-to-cost-ratio (RCR) as a new eco-efficiency measure based on the notion of opportunity costs. The RCR expresses eco-efficiency relative to a benchmark. Most importantly, RCR can be used to identify and quantify three different components of changes in corporate eco-efficiency. Such an in-depth analysis reveals the drivers behind changes in corporate eco-efficiency and shows if and to what degree such changes are induced by a return effect, an environmental impact effect or a benchmark effect. This allows us among others to address the frequent concern that increases in eco-efficiency might cover up higher environmental impacts (rebound effect). The new measure and the in-depth analysis are illustrated using several examples from German industrial companies.

Topic 1:

Industrial Ecology tools for sustainability

Topic 2:

Sustainable Resource Management”

5th International Conference on Industrial Ecology

2009 ISIE Conference

Industrial Symbiosis

Applying the Cohen-Rosenthall Matrix of Potential Synergies to the Devens Eco Park

Peter Lowitt, Neil Angus

“We propose to apply Ed Cohen Rosenthal\’s matrix of potential by-product exchanges both social and material to the existing Devens Eco Industrial Park. The authors will report on the tuility of these applications based on their experience within the Devens Eco Industrial Park industrial symbiosis network.”

Evaluation of Innovative Municipal Solid Waste Management through Urban Symbiosis: A Case of Kawasaki

Yong Geng, Fujita Tsuyoshi, Mr.Chen Xudong

“Industrial symbiosis encourages establishing a broad eco-industrial network so that more synergy opportunities could be identified. By linking municipal solid waste (MSW) management with local recycling industries namely developing urban symbiosis new industrial symbiosis opportunities will be generated from the geographic proximity of urban and industrial areas. Such a transfer can deliver the physical resources from urban sources to industrial applications so as to improve the overall eco-efficiency of the whole city. This makes special sense in Japan as proximity principle namely disposing of waste close to its origin has been a central value for MSW management for years. This paper provides an innovative evaluation method on such an initiative through cost-benefit analysis by employing a case study approach. Results show that obvious economic and ecological benefits could be gained through urban symbiosis especially helping establish a low carbon city in those population dense cities.”

Building-up eco-industry park in an integrated iron & steel enterprise

Weijun Bao, Huiquan Li, Yi Zhang

“The traditional BF-BOF process is a typical iron & steel production process with high energy consumption as well as materials consumption. Most of the integrated iron & steel enterprises in China were still predominated by BF-BOF process and it resulted in a great amount of resource and energy consumption. The ferro- & carbon flow in iron and steel making process are the main form of the resource and energy transformation so the main purpose for the building-up eco-industry park in an integrated iron & steel enterprise is improving the utilization efficiencies of iron and carbon resource and make them reached the maximum values.

Based on the development of recycle economy and construction of eco-industrial park in a large integrated iron & steel pant the iron flow in the iron and steel making process was studied firstly and the resource utilization efficiencies of iron in each unit process were analyzed. The design of ecological industrial chain in an integrated iron & steel enterprise was conducted with the object of maximizing the resource utilization efficiencies of iron. Moreover the carbon flow in the iron and steel making process had also been deeply analyzed and the energy integration network in an integrated iron & steel enterprise was established. Besides the iron and steel making process the energy integration network was comprised of gas utilization sub-network power conversion sub-network and waste heat recovery sub-network. It can be concluded that the resource utilization efficiencies of iron will be increased by 0.5% via the optimal design of ecological industrial chain in an integrated iron & steel enterprise. Moreover the energy conversion efficiency will be greatly improved by the implementation of the energy integration network. It can be realized that the comprehensive energy consumption of per ton steel will decrease by 74kgce and CO2 emission will reduce by 1.5 million tons per year.”

Applying Industrial Ecology Criteria to Farming Systems in Mexico

Gemma Cervantes Torre-Marín, Jenni Arce López, Penelope González Zenteno, Fabián Robles Martínez

“The aim of this project was the application of Industrial Ecology (EI) criteria to farming systems. Two farms were studied one in Mexico D.F. and the other one in Estado de México in order to show them as industrial ecosystem models. A complete indicators system was design with more than 60 social environmental and economical indicators. This indicator system measures the performance of both farms in terms of sustainability.

The Rural Production System Xochimancas (Mexico D.F.) was chosen because it operates under the vision of Organic Agriculture and the exchange of wastes as raw materials. It may be seen as an industrial ecosystem model because of the great number of material and energy exchanges and synergies existing in this farm and also because the social network that has been created. Xochimancas produces organic vegetables and biofertilizers by means of vermicomposting Bocashi type composting and by anaerobic decomposition. There are also some animals in the farm and a Temascal (a traditional vapour bath). A social diagram was also developed and the possibilities of waste and information exchanges among Tochtli and Xochimancas farms and other similar systems were studied.

The rabbit production farm \Tochtli” (Estado de México) was chosen as a case study for the application of IE criteria. The main actions developed in the farm were: optimizing data collection drawing quantitative flow charts improving fly larvae and biogas production process from rabbit dung and determining sustainability indicator values. The aim of improving fly larvae production process was the assessment of their nutritional properties and their use as food for chicken. Physical and chemical analyses (protein content humidity organic matter pH T) were made to determine the quality of this waste.”

How to implement industrial symbiosis in France?

Sabrina Brullot

“Many programs aiming at implementing industrial ecology have been developed all over the world. However only few by-products exchanges became operational. Applications that aim at rounding up material and energy flows between companies located in the same area are more often potential than real. This fact is especially true in France where industrial ecology implementation is really weak. To improve it we will present a decision-making tool called STRATIS (STRATegy for Industrial Symbiosis) in this paper. Before developing this tool we surveyed a critical analysis of methodological propositions and recommendations used in industrial ecology projects. Thanks to this review we can show that existing tools and methods are not adapted to local or/and national conditions of a specific territory. Lessons from a successful strategy used in one project cannot be transferred in another area where the context is different. This paper aims at describing our decision-making tool that indicates what the best procedure is to achieve an industrial symbiosis according to the French territorial economical political social and organizational context. Our tool is composed of four iterative steps: local diagnosis achievement definition of the best strategy according to the local diagnosis project achievement success assessment. Within the framework of future works we would like to improve industrial symbiosis implementation in France and in other developed countries creating a software tool based on our methodology.”

Ulsan Eco-Industrial Park initiative: Implementation of industrial symbiosis with locally devised strategies

Hung-Suck Park, Jung-Hoon Kim, Sang-Yoon Lee, Shishir Kumar Behera

“Many companies in Ulsan have established one to one industrial symbiosis exchanges by the shared use of industrial wastewater by-products and energy since mid-1990s. Ulsan Eco Center established in 2007 by Ulsan Eco-Industrial Park (EIP) project devised three-phase strategic plan: data collection symbiosis identification and feasibility study and implementation to retrofit the existing industrial parks into EIPs. The implementation phase is further classified into negotiation and contract design and construction and maintenance. Based on this strategy three industrial symbiosis networks were successfully developed and are operating very smoothly. The development of industrial symbiosis networks in Ulsan Mipo-Onsan industrial parks offers a potential regional platform to contribute to sustainable development by bringing together key stakeholders such as local authorities regulators regional developers and sustainability groups. This paper highlights the indigenous strategies for implementing industrial symbiosis in order to convert the existing industrial parks in Ulsan into EIPs.”

Success Stories of By-product Synergies in Demonstration Projects for Eco-industrial Development in Korea

Ban Yong Un, Jeong Hurnkun, Hwang Gyu Hwan

"Since designated as demonstration projects for EIP development the industrial parks such as Ulsan Pohang Yeosu Cheongju and Sihwa-Banwol in Korea have been building a few networks to recycle by-products wastes and waste energy. Achievements started to emerge especially in Ulsan and Yeosu where mostly huge petro-chemical and steel companies are located. The high price of energy and law materials in recent years raised industries' concerns of the reuse of waste heat and by-products. Also stricter environmental regulations such as the ban on dumping waste into the ocean made companies more interested in the reuse of their sludge thus creating new issues for EIPs to discuss in Korea. This interest was particularly high in the following regions: in Ulsan where large scale automobile shipbuilding petrochemical and machinery companies are located in Pohang the hometown of Steel powerhouse POSCO and in Yeosu a hotbed for numerous petrochemical companies. Given the fact that a large amount of steam and water is used by the companies in these regions the potential for exchange is thought to be huge.

Thus this paper has intended to provide success stories of by-product synergies in demonstration projects of eco-industrial development in Korea since the projects were launched in 2005 and to draw further tasks to establish expanded resource circulation networks for the forthcoming years. The success stories include exchange project of waste heat and wastewater reuse project of acid waste alkali waste dye wastewater synthetic resin waste metal plating by-products petrochemical wastes. In the process of recycling these wastes a lot of new technologies of waste reprocessing are being tested for use and new types of companies that deal with by-product processing are cropping up."

Accelerating the Use of Inorganic By-Products in Infrastructure Projects

Albena Bossilkov

“Various mineral processing operations produce large volumes inorganic residues that are currently stockpiled at designated locations within the Kwinana Industrial Area (KIA) in Western Australia. A significant number of these contain coarser sand-sized particles that have potential value as useful by-products for various commercial particularly infrastructure applications. Many of the inorganic residues generated within the KIA could be utilised as alternative or supplemental sources for the growing demand for construction materials providing these meet specific environmental criteria and technical specifications.

The Centre for Sustainable Resource Processing (CSRP) launched a research project to develop practical ways for the reuse of these by-products. The project reviews the KIA generated inorganic by-products and ten different residues are discussed outlining there potential uses. The residues identified are: fly ash bottom ash direct iron making slag phosphogypsum foundry sand construction and demolition debris cement kiln dust lime kiln dust red lime and red sand. Their impressive assortment of application ranges from concrete additives through use variety of civil engineering work to agricultural application.

A recent market assessment undertaken as part of the same project has identified a number of imminent and planned infrastructure residential and commercial development projects within a reasonable distance from KIA (approximately 20 km) to assure economic viability for the potential reuse of inorganic materials generated within the KIA. In the view of escalating shortage of construction material in the region the total estimated requirement for the projects that can be quantified at present is in the excess of 40000000 tonnes of imported fill and in excess of 10000000 tonnes of construction materials. It was also assessed that one of if not the biggest potential issues related to the reuse of inorganic by-product/waste materials as useful substitutes for virgin materials however is the lack of a regulatory frameworks and suitable standards to enable the routine utilisation of these by-products in commercial infrastructure and development projects.”

Study on eco-industrial composite symbiosis network for oil-chemical industrial park and evaluation for its stability

Ling Xu, Hongbo Zheng, Chong Chen

“Eco-industrial composite symbiosis network for oil-chemical EIP is constructed in this paper. Considering complexity of stability on the constructed network evaluation indicator systems for stability are established by Extensive-Entropy Weight-AHP models and the network stability is evaluated by Catastrophe theory quantitatively. An oil-chemical EIP in Dalian is taken as an example.”

Industrial Symbiosis in Australia – Years in the Making

Albena Bossilkov, Karin Schianetz

“In the past decade in Australia significant progress has been made to advance the development of industrial symbiosis projects all around the country. Apart from the continuing effort of the researches at the Centre of Excellence in Cleaner Production (CECP) the Curtin University under the umbrella of the Centre for Sustainable Resource Processing there are research groups in Brisbane Sydney and recently in Adelaide interested in pursuing further research and hands-on collaborative projects with local industries.

The conference presentation will give an overview and update on developments and research associated with the following industrial symbiosis projects including the challenges and opportunities for the way forward:

• Gladstone Queensland – project carried out by the Sustainable Minerals Institute (SMI) at the University of Queensland (UQ) featuring by-product exchanges between 8 industry operations located within quite large geographical area.

• Port Melbourne Victoria – project carried out by the Institute for Sustainable Futures (ISF) at University of Technology Sydney and CECP at Curtin. The project is mainly focused on water synergies however there is promising effort to advance the present collaboration to include other synergies.

• Geelong Victoria – project carried out by CECP at Curtin and SMI at UQ focusing on the advancement of synergy opportunities between large number of industrial operations.

• Brisbane Queensland – features the establishment of a Greenfield eco-industrial park.

• The most advanced of all the Kwinana Synergies Project has been in development for decades by the companies themselves followed by the involvement of Kwinana Industries Council and then CECP at Curtin. Resent development feature spin-off project focusing on reuse of inorganic residues and wastewater as well as research into the utilisation of flue gas heat for evaporative treatment of process effluent and/or seawater.

• The most recent project in Whyalla South Australia is in its planning stage by the Institute for Sustainable Systems and Technologies at the University of South Australia and CECP at Curtin.”

A study on the spatial scale of recyclable organic resource circulation

Minoru FUJII, Tsuyoshi FUJITA, Shizuka HASHIMOTO

“The purpose of this study is to propose an efficient recyclable resource circulation system in terms of its spatial scale. In this study we assume the resource circulation system consists of two different spatial scales of circles for the utilization of recyclable organic resources such as plastics wood kitchen waste. For the recyclable resource which is easily recycled mechanically and reworked as material a narrow-area regional circulation is considered to be suitable because a mechanical recycling has little advantage of scale and the material (product) recycled locally will be help in raising of environmental awareness of consumers. On the other hand for the recyclable resource which is unfit for mechanical recycling a wide-area regional circulation composed of chemical recycling or energy recovery is considered to be suitable. Under the system of wide-area regional circulation it is possible to utilize existing facilities of arterial industries whose location is limited to industrial zone. In such facilities recyclable resource is used efficiently with large amounts of natural resources. The system combined with arterial industry has several side benefits. For instance it can mitigate imbalance of supply and demand caused by season variation of waste generation. We investigate the cost and benefit of the proposing resource circulation system with two different spatial scales of circles for several kinds of recyclable organic resources in terms of GHG emission and economic cost. For the calculation transportation process is included in its system boundary.”

Industrial ecology as strategy for regional development: Case study of the canton of Valais Switzerland

Benoit Charriere, Suren Erkman

“Even though there are many so-called industrial ecology projects all around the world only a few are designed for economic development by local authorities. The Canton of Valais Switzerland by its development Agency started in 2008 an analysis concerning the regional potential for industrial ecology projects.

Industrial ecology became therefore a concrete decision making tool for an integrated economic development complementing traditional compartmentalized strategies (land-use energy wastes management etc.)

Integrated into the new regional development policy the entire cantonal project of industrial ecology is based on a participative basis involving 3 specific levels: a direction led by the development agency a steering committee composed of influent regional actors and work groups. Goals of this project consist of attempting to raise actors and public awareness of industrial ecology by mediatisation workshops meetings etc. valuing international and local case studies supporting projects implementation.

Through particular selection criteria an action plan has been elaborated with strategic (i.e. industrial estates management regional resources management etc.) and local pilot (i.e. specific supply chain industrial estate wastes recovering etc.) projects. One of them concerns the chemical estates of Monthey. The main specificity of this estate lies in the fact that there are already some industrial symbiosis elements. Energy production and supply waste management and several others services are provided by a joint venture of two chemical elements producers. There are various interests for Canton of Valais for this estate: development of the estate through intern and extern partners’ awareness to industrial ecology potentials and settlement of guidelines for other industrial estates improvement of the understanding of the estate metabolism through flows analysis and industrial symbiosis detection.”

Role of Japanese Eco-town Projects in Regional and National Material Circulation: the case of Kitakyushu EIP

Toru Matsumoto, Tadashi Tsuruta, Atsushi Fujiyama

“The Eco-town project was created in fiscal 1997 under national government of Japan. It was founded on the basic concept of \zero-emissions.\” Kitakyushu Eco-town is one of the biggest and the most successful one and over 20 enterprises are located there. This study aimed to conduct a comprehensive assessment in order to quantitatively and fundamentally understand the role of Japanese Eco-town projects in the aspect of material circulation. For this objective contribution of Eco-town in regional and national material circulation was analyzed by using material flow data passing through Kitakyushu Eco-town. At first material flow in Kitakyushu Eco-town was examined. Data from the oral survey conducted for each enterprise were utilized in the calculation process. Based on the aforementioned data it was understood that the rate of intra-city flow as input side was 42 % and was 70 % as output side. In addition inputs into Eco-town classified by distance from origins and outputs from there classified by distance to destinations. As a result it was clarified that construction waste from 50 km iron and other inorganic matters from 300 km and 1000 km and plastics from 300 km and 1000 km had large volume at input side. On the other hand “20 km” range had large volume especially transportation of construction waste and iron within 20 km were large. As the next step the structure of material circulation of the whole city of Kitakyushu including Eco-town was analyzed. Based on this result four indicators were set for evaluation of contribution of Eco-town in regional material circulation. These were resource productivity usage rate of recycled material rate of final disposal and recycling rate. As for whole city of Kitakyushu usage rate of recycled material is 22 % rate of final disposal is 13 % and recycling rate is 56 %. It was also clarified that Eco-town contributed 2.3% in usage rate of recycled material 0.8 % in rate of final disposal 4 % in recycling rate.”

Quantifying the Potential of Industrial Symbiosis to Mitigate Climate Change

Han Shi

“While there is a fast growing body of literature on how and to what extent industrial symbioses (i.e. inter-firm exchange and cascading of waste materials water and energy) affect sustainable industrial development empirical research on their potential contributions to mitigate climate change has so far been very limited.

Our research aims at a systematic quantitative assessment of the extent to which industrial symbiosis mitigate greenhouse gas (GHG) emissions in the Tianjin Economic-technological Development Area (TEDA) one of the three national demonstration eco-industrial parks in China.

Existing symbiotic relationships to mitigate GHG emissions in TEDA can be classified into 3 categories: intra-firm energy cascading (e.g. condensate recycling desalination) park-wide utility sharing (e.g. co-generation carbon-black flue gas utilization) and regional waste-to-energy initiatives. The energy sources of TEDA are dominated by fossil fuels (coal natural gas electricity and transportation fuels) with very limited use of geothermal and solar energy. Therefore industrial symbiosis that may save energy significantly would substantially reduce the park-wide GHG emissions due to the carbon-intensive energy supply structure of TEDA.

Our research first quantifies the park-wide energy-related GHG emissions. Then we take stock existing energy-related symbiotic relationships and quantify their impact on GHG emissions. We further carry out a cost-effectiveness analysis of various symbiotic relationships to reduce GHG emissions at the eco-industrial park against existing intra-firm energy efficiency efforts. The research also evaluates the overall impact of industrial symbiosis on mitigating GHG emissions by contrasting with the overall GHG emissions of TEDA.

The findings show energy-related symbioses at a larger geographic scale have greater potential for mitigating GHG emissions despite their higher initial capital investments. On the other hand intra-firm energy conservation and co-located inter-firm energy cascading efforts turn out to be more cost-effective in but have smaller potential for reducing GHG emissions.”

Quantifying life cycle environmental impacts of the beneficial use of secondary industrial materials in Pennsylvania USA

Matthew J Eckelman, Marian R Chertow

"Local reuse and recycling of waste materials from industrial processes has many potential environmental benefits but these have been difficult to aggregate and measure across industries on a broad geographic scale. Non-hazardous industrial waste is a high volume flow principally constituted of wastewater with some solid materials. This waste stream vastly outweighs municipal solid waste in the USA in mass terms. The state of Pennsylvania USA produced some 20 million metric tons of solid non-hazardous industrial waste in 2004. An innovative reporting requirement for industrial generators in the state has resulted in a rich database of what is termed "residual waste" generation detailing the fate for more than 100 materials. By combining these records with life cycle inventory (LCI) data the current and potential environmental effects of residual waste use have been assessed. Results for Pennsylvania indicate a savings in 2004 of 9.4 PJ of primary energy 1.2 million metric tons of CO2eq 3300 tons of SO2eq and 4700 tons of NOx emissions from reuse of residual waste. While these energy savings constitute less than one percent of total industrial primary energy use it is a greater quantity of energy than that generated by the state's non-hydro renewables program. The legal framework and other constraints surrounding reuse of residual waste in Pennsylvania are discussed."

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Managing End-of-Life Products

Pre-recycling and recycling behavior. Case study: Belarus and Sweden

Monika Olsson, Sviatlana Mefodieva

“Aspects concerning the problems of public acceptance public participation in planning and implementation consumer behavior and changing value systems are equally important to technical and economic aspects in waste management and related decision-making. Although greater household participation in recycling is essential for household waste recycling schemes our understanding of householders’ motivation and its possible influences on waste management is incomplete. Given the aim of motivating householders to behave in a recycling-friendly manner there is a need to understand and predict recycling behavior and how it can be influenced. In order to investigate these issues a comparison was made between pre-sorting behavior of Belarusian citizens and the recycling behavior of Swedish citizens.

The specific objectives of the study were to:

1) Identify the socio-demographic characteristics reasons motives and role of information for waste sorting in Belarus by determining and analyzing i) acceptability of implementing separate waste collection ii) motivation for recycling due to pressure created by technical measures and iii) acceptability of recycled material.

2) Compare the results with existing studies of recycling behavior in Sweden.

3) Determine the importance of pre-sorting behavior analysis and public acceptance for successful implementation of recycling schemes.

The study was done on a residential area in Minsk and a questionnaire was presented to 6336 whereof 5832 responded. The results showed acceptability for recycling and source separation and that the majority of the respondents understand why they should sort but they still have not decided if they are going to do it. This uncertainty creates good potential to influence them positively towards recycling. Comparisons of Belarusian pre-sorting behavior and Swedish recycling behavior showed that socio-demographic characteristics had direct links to household participation in recycling while lack of previous recycling habits had no direct influence on recycling acceptability.”

Evaluating the interest of making a road safety device with recycled plastics by LCA

Carla L. Simões, Susana M. Xará, Carlos A. Bernardo

"The production of waste has been increasing worldwide in quantity and diversity in the last decades as a result of changes in economic activities demography technological innovation life style and production and consumption patterns. Therefore waste management represents an environmental social and economic challenge at the global European and even national level. Incorporation of recycled plastics obtained from household plastic waste (selectively deposited in specific containers) in the manufacturing of new products can be a strategic move towards a more sustainable development.

This work assesses the potential environmental impact of using post-consumer High Density Polyethylene (HDPE) in the production of a road safety device specifically an Anti-Glare Device (AGD) traditionally manufactured from virgin polymer (not recycled). The environmental impact assessment is performed using the Life Cycle Assessment (LCA) technique which includes all stages of the product life cycle. Two road safety devices are compared: (1) current AGD manufactured from virgin HDPE and (2) optional AGD manufactured from recycled HDPE. The production of the raw material was found to be the main responsible for most of the impacts in both types of AGD. Globally the optional AGD is environmentally more advantageous than the current AGD.

A study was also performed on the influence of the definition of the Life Cycle Impact Assessment method on the results obtained. It was concluded that the selection of the methodology has a significant influence on the results and corresponding conclusions. Therefore in this type of analyses it is vital to use and compare several Life Cycle Impact Assessment methods before drawing any conclusions or taking an executive decision."

The making of Thai WEEE policy: what can be the role of EPR?

Panate Manomaivibool

"Waste electrical and electronic equipment (WEEE) has been identified as an environmental policy problem in Thailand. The so-called Thai WEEE legislation has been drafted with an intention to establish and promote a nationwide WEEE recycling programme in this non-OECD country. The draft law includes a proposal to charge product fees from the manufacturers and the importers of selected products. We present a study on the potentials and limitations of the extended producer responsibility (EPR) principle in the Thai situational and policy context. The research is based on a careful analysis of key policy documents and policy processes and 26 stakeholder interviews –18 were prearranged and semi-structured. Principally we find that the capacities under the existing responsibility regimes which place collection of post-consumer WEEE in the hands of local governments and recycling on treatment factories are far from sufficient. Mobilising resources from producers thus holds a promise to improve the capacities. In addition the problems of grey market's products and illegal imports of WEEE identified as the most serious challenges to EPR in non-OECD contexts in our previous research have been controlled rather successfully in Thailand. However the proposed institutional arrangement of the Thai WEEE law can limit the role of producers in the end-of-life management to only paying the fees to the governmental fund. There is also a doubt over the efficacy of this proposed system that will be administered by the national and local governments considering implementation and law enforcement records in the past. Based on these considerations we propose a co-evolution strategy which allows the governmental system to co-exist with producer's voluntary schemes. The performance benchmarking between the governmental and producer's systems will be a criterion to include/exclude certain product groups or producers into/from the national programme i.e. paying the fees into the governmental fund. We also encourage more participation and consultation among key stakeholders in the policy making processes."

Territorial approach for WEEE management system

BAHERS Jean-Baptiste

“Sustainable development’s injunction is implemented by legislative frameworks and operational concepts. “Extended Producer Responsibility” and “precautionary principle” are values which are increasingly integrated in European policies (ROHS Directive WEEE Directive Reach EuP Directive) and in the new patterns of public policy (Local Agenda 21). Legislative frameworks impact the industrial sector. New skills emerge in order to respond to new constraints. Finally the current regulation is structured by the local authorities at multiple spatial scales.

“Sustainable production and consumption” is part of the French National Sustainable Development Strategy. The management of this program is linked to waste production and collect indicators. It means that products life cycle reintroduced the idea of integrated waste management. Finally sustainable development revisits waste management policies and stakeholders strategies.

Considering this context a PhD project started at the “Toulouse Le Mirail”. It aims at analyzing a Regional waste management system in an industrial ecology perspective: the WEEE industrial chain. Fourth dimensions of the system and their interactions have been implemented with UML (Unified Modeling Language) models:

• Chain of production’s metabolism through Material Flow Analysis: What are the different kinds of materials and energy flows?

• Industrial sector through the firm strategies and organization: Which innovation has been implemented to introduce the system management?

• Economical and social networks: What is the configuration of the “waste’s sector”?

• Public regulation: What is the reality of this public regulation in local action?

Searching links between industrial ecology and territorial management a prospective evaluation is suggested. UML models are implemented to identify exogenous and endogenous variables which impact the territorial development of waste management system. Thus industrial ecology when associated to a relevant analysis of region put forward solutions for skills coordination and new relations of proximity. It will participate in the emergence of an endogenous sustainable development.”

Environmental benefits analysis of wastewater treatment

Qiong-hua Zhang, Xiao-chang Wang

“In order to illuminate the economic and environmental effect of wastewater treatment and reuse project the authors tried to use the tool of life cycle assessment (LCA) for a comprehensive project evaluation by taking a wastewater treatment plant (WWTP) in Xi’an China as a demonstrative case. The WWTP with a capacity of 150 000 m3/day has been treating domestic wastewater from the city area since it was implemented in 1996 and recently 50 000 m3/day or 1/3 of its secondary effluent was further treated and supplied to the surrounding area for urban reuse such as gardening and forestation.

The model established for the LCA took the whole process of secondary treatment and tertiary treatment in the WWTP as the system for analysing. A hybrid LCA method with a combination of input-output analysis and process analysis (Suh et al 2004) was applied in the analysis and commodity flows were expressed in energy unit as GJ (Casler and Wilbur 1984). Regarding both the secondary treatment (by oxidation ditch) and tertiary treatment (by coagulation + sedimentation + filtration) processes the input items included the material/energy consumed for manufacturing transportation construction work etc. in the construction phase direct and indirect material/energy consumption in the whole service period (20 years in this case) and material/energy to be consumed for demolishment work in the future. The output items of LCA should generally include gaseous emissions liquid discharges and solid wastes generation. However because the main objective of analysis was to compare the effect of wastewater treatment and reuse with that of only wastewater treatment for discharge to a natural river effluent discharge from the WWTP was taken as the main output item in this study.

Proper evaluation of the environmental effect of effluent discharge is often a difficult task. In this study the authors proposed a method of ‘required dilution volume’ (RDV) calculation for this purpose. The framework of evaluation by RDV calculation is as below:

(1) To establish an equation for calculating the required volume of source water e.g. head water of the river under consideration for diluting the discharged effluent to maintain the river water quality at an acceptable level based on the principle of material balance of a ‘maximum weighting pollutant’ (MWP).

(2) To calculate the weighting factor of a group of selected water quality parameters (SS NH3-N TP COD and BOD5 for this study) based on an assumption that the hazardous impact of a pollutant is reversely proportional to its acceptable limit according to the environmental water quality standard and on this bases to find the MWP.

(3) To calculate the volume of the source water required for dilution and to evaluate the negative environmental effect by transferring the required source water volume to energy unit.

As a result of LCA analysis of the secondary wastewater treatment process (150 000 m3/day) and the tertiary treatment process (50 000 m3/day) and an evaluation of the positive effect of treated wastewater reuse for urban purposes in comparison with the negative environmental effect of effluent discharge it was obtained that the total energy consumptions for the secondary and tertiary treatments in the 20 years' service period were 2.25 x 106GJ and 1.07 x 106GJ respectively and treated wastewater reuse rather and effluent discharge gained positive effect in two aspects: one from river water quality conservation which was equivalent to 0.29 x 106GJ and another from saving tap water for urban gardening and forestation which was equivalent to 1.60 x 106GJ. Therefore if the energy consumed for distributing the treated wastewater for reuse purpose was neglected then the net benefit of the project of tertiary wastewater treatment and reuse was evaluated as (1.60 + 0.29 – 1.07) x 106 = 0.82 x 106GJ.

The study indicated that from a view point of production of reclaimed water to replace tap water for non-potable reuse significant benefit can be gained by implementing wastewater treatment and reuse project. Further study is needed to include distribution system into the LCA model and analysis. However it can be considered that onsite reuse will be more profitable for its lower energy consumption due to shorter distance transfer and distribution of the treated wastewater to application locations."

Modeling the Economic and Environmental Performance of Recycling Systems

Elsa Olivetti, Jeffrey Dahmus, Susan Fredholm, Jeremy Gregory, Randolph Kirchain

"As recycling systems for complex durable goods (CDGs) and in particular for waste electronics become more widespread understanding the economic and environmental performance of such systems becomes critical both to enable improvement of existing systems and to inform the design of new systems. However with the range of possible system architectures and the important role of locational characteristics (context) understanding the determinants of system performance is challenging. Environmental performance including the trade-off between the environmental burdens of collecting and transporting waste electronics and the environmental benefits of recovering and recycling materials is also affected by system architecture.

A general model for evaluating the economic and environmental performance of electronics recycling systems has been developed. This model comprehends the three main functions in a recycling system – collection processing and system management – and aims to quantify the impact of context and system architecture on the economic and environmental performance of electronics recycling systems. The model inputs include contextual information – including population geography average wage and participation rates – and architectural information – including the number of collection facilities to be sited and the product portfolio to be processed. These inputs map to economic and environmental performance outputs including the cost of collection and processing the environmental benefit of material recovery from processing and the environmental burden based on the vehicle miles traveled.

One important aspect of the model is its ability to site collection and processing facilities. Calculating transportation distances requires the location of persons owning end-of-life CDGs the collection facilities and processing facilities. Given demographics and population distribution information the model sites collection and processing facilities using a clustering algorithm paying particular attention to the distance a consumer must travel to reach a facility. Overall model results suggest that optimal architectures exist but are a strong function of demographic and social contextual conditions."

Establishing of Joint Eco Factory Development and Training Platform for Managing Problems in End-Of-Life Materials Sustainable Re-Use

Petri Peltonen

"More effective sustainable re-use of recycled materials in re-designed products has become through latest EU´ s waste directive really obtainable challenge for near future both for industry development and education and training in societies. In sustainable resource management we speak now about the predominant time of the sc recycling society in EU. This means increased regional eco-action plans for communities increased international networking inside sustainable education programmes of universities and industry. It means also increase in sustainable and green entrepreneurship. Recycling society is however still full of unsettled problems. In Helsinki University of Technology autumn 2009 forwards new Aalto-university we have been establishing and planning the work of new kinds of joint-operational development and education platforms named Design Factory and Eco Factory. In this article described Eco Factory is a platform which is constructed under the joint project umbrella. Platform is aimed to solving key problems of recycling society. Eco Factory has several co-operational partners both inside universities as well as in companies experts regionally involved in sustainable technology and in waste management or in consume technology. Eco Factory is an interactive and innovative development education and training platform which is common and open for student teams mentoring professors educators experts and researchers. The learning and problem solving will proceed in Eco Factory teams.

Basic objectives of Eco Factory deal with development research education training planning and other activities such as objectives for sustainable eterprise aims and activities. Educational objectives consist of basic continuing and supplementary education. This involves developing the entrepreneurship in area of sustainable environmental technology as well as enhancing business opportunities and know-how for industry. To objectives belong also planning of recycling and end-of-life products for sustainable usage in consume and enhancing the methods of using natural resources and materials in a conserving manner with a minor ecological foot print. In Eco Factory such advances will be planned which have as small stressful effect on environment as possible. Recent research on industrial and solid waste flows again has been directed to such wastes which can be very difficult to manage.In Eco Factory there are an attempt to find a logistic utilization chain and re-use for these problem wastes as well. As essential part in modeling and creating new Factory-typed operational platform is at the same time to construct the international Factory collaboration network for sustainable development. In this article the more detailed objectives activities of Eco Factory design of working means planning of pilot projects by multidisciplinary manner as team work for enterprises Factory resource and staff planning and communication activities like seminars for release of Factory results will be shown as text figures and references."

Technical and economical aspects concerning the management of electronic waste

Paula C. Oliveira, Filipa Charters Taborda, Marta Cabral, Fernanda Margarido, Carlos Nogueira

“Consumption growing and technological advances led to the rapid increase in generation of electronic scrap in domestic wastes which ended in incineration plants or landfilling. The problems were faced by technical and political issues namely by attribution of waste management responsibilities and rules to the involved stakeholders and definition of recycling targets. Generally informatics and telecommunication equipment and specifically computers play an important position in global electric and electronic wastes (WEEE). It was estimated that more than 80 kg per habitant of computer wastes will be generated in EU in the next 20 years corresponding to 20% of the total WEEE weight. Computers have very complex devices with different materials and assemblies. Besides major components which include steel low-alloyed (50-60%) and plastics (25-30%) many other materials and substances can be found such as non-ferrous metals (Cu Al Sn about 6%) precious metals (Ag Au Pd about 140 ppm) heavy toxic metals (Pb Cd As Bi Hg about 0.05%) and some ceramics and glass. Electronic residues have therefore simultaneously environmental concern and economic interest. Management systems include collection sorting physical separation and chemical/metallurgical processing. Manual dismantling is essential to allow separation of components by material composition and also to remove potentially dangerous components. Shredding of separated components and physical separation are the following steps to allow production of fractions with similar properties (such as steel non-ferrous metals plastics) for further specific treatment. Recovery yields in chemical processing and subsequently the overall recycling rates are very dependent from the success of physical separation and therefore new developments in such field are strongly recommended such as the recent technologies involving sensor-based automated sorted devices. In the recycling chain the physical-chemical processing steps have simultaneously larger costs but higher incomes when compared with the other steps (collection dismantling sorting shredding).”

From Paradigm to Policy: The extent to which the WEEE Directive has fulfilled the objectives of Sustainable Development.

Mark Dempsey, Dr Lauren Basson, Dr Kirstie McIntyre

"Directive 2002/96/EC on Waste Electrical and Electronic Equipment ('The WEEE Directive') is part of a new generation of environmental policy measures entitled 'Producer Responsibility' aimed at delivering sustainable development by making producers responsible for the end of life management of their products. The WEEE Directive stems from growing concerns regarding the amount of WEEE within the EU with the volume of waste increasing at 3-5% per year almost three times the rate of other municipal waste streams.

This paper will reflect on the extent to which the WEEE Directive is aligned with principles associated with Sustainable Development in particular through implementing the polluter pays principle encouraging eco-design consistency with the waste hierarchy (where appropriate) and consideration of the life cycle performance of products.

Does the WEEE Directive merely perpetuate unsustainable systems and practices or does it indeed promote sustainable development? If so to what extent has the Directive promoted sustainable development in its implementation and what lessons can be drawn from the experience of designing and implementing the WEEE Directive for the future policies and legislation aimed at promoting sustainable development?

The above questions will be answered by examining the implementation of the WEEE directive within Member States of the EU both in terms of the approach taken the extent to which this is considered successful and why.

The paper will identify the types of environmental and other sustainability benefits and drawbacks of the Directive suggest means by which this can be measured and provide suggestions as to how the benefits might be maximised through future changes to the legislation. Finally the paper will discuss the future of the WEEE Directive and producer responsibility policy more generally and will make suggestions on how policy can be reformed in order to promote sustainable development."

End-of-Life Management: The Role of Consumers

Vered Doctori Blass

“Consumers play an important role in the success of product’s End-of-Life management programs. Relatively little attention was given to the consumer side of EoL management. Scholars form economics and marketing disciplines have attempted to suggest models of consumer behavior and participation in disposal programs mainly engaging consumers in recycling systems. Understanding what motivates consumers to get engaged in take-back programs and how we can increase their participation and therefore collection rate is an important part of improving the performance of EoL networks. Providing incentives to participate that better match with the consumer motivation can help to increase participation and therefore collection rate. In this presentation we discuss consumer motivations opportunities for consumers and performance of disposal systems specifically electronic waste systems. We then use the case of cell phones to demonstrate the different motivations and incentives to participate in such programs discuss the opportunities consumer have to participate and demonstrate the direct effect of certain programs and incentives on the economic and environmental performance of EoL programs.”

The Value of Information for Product End-of-Life Management

Vered Doctori Blass, Roland Geyer

“The economic and environmental benefits of reuse and recycling have been widely researched in recent years. Although theoretically promising relatively few recycling and reuse activities are in practice self-sustaining without government intervention. This does not reflect the poor potential of resource cycling but rather indicates the barriers for implementation of such systems. In this research we combine the principles and methods of industrial ecology information and management science to investigate the role and value of information for product end-of-life (EoL) management. We provide a generic framework for evaluating economic and environmental values of information for strategic product end-of-life management decisions. Then we apply the framework to the case of cell phones and provide examples of the practical applications of this research. We include models for measuring the effect of information availability on the overall performance. Lastly using the calculated values of information we suggest an information prioritizing tool that is based on the contribution of the information to the economic and environmental performance.”

Information exchange on substances in electrical and electronic equipment for safe and efficient end-of-life treatment

Magnus Bengtsson, Chika Aoki, Shiko Hayashi, Yasuhiko Hotta, Yoshiaki Totoki

"Hazardous substances in waste electrical and electronic equipment (WEEE) are receiving increasing attention worldwide and policies such as the RoHS and WEEE Directives have been introduced. The current project focuses on how relevant product information can be provided to actors involved in end-of-life treatment of WEEE. The rationale is that improved knowledge on embedded substances (including both hazardous chemicals and rare metals) can make these operations safer less polluting and more efficient (larger number of materials recycled and higher recovery ratio). This requires that the information is available on a suitable format tailored to the specific needs and circumstances of each actor.

The project also studies information sharing systems for other products such as vehicles and supply-chain information systems which are not currently targeting the end-of-life stages. It is expected that the project thereby will be able to generate more realistic proposals.

The project analyses the current situation on recycling and information exchange in Japan in-depth and carries out preliminary investigations on Korea and China. In addition the situations in the EU and the United States are surveyed. The empirical research in Japan consists of document analysis and a number of face-to-face interviews with representatives of the recycling industry electronics manufacturers and industry associations and other experts. These investigations concentrated mainly on the following tasks: (1) Describing in detail the recycling chains for the selected products and identifying the actors involved (2) Clarifying the current situation concerning availability and needs for information on the composition of the products at different stages of the recycling chain and (3) Analyzing existing systems for product information management in the upstream part of life-cycles.

Based on these empirical investigations the study proposes a set of issues that need to be considered in the development of information sharing schemes and gives policy recommendations."

Transboundary Movement of End-of-Life Electrical and Electronic Equipment for Reuse and Recycling

Atsushi Terazono, Aya Yoshida

"More and more countries in Asia and Europe have their recycling legislations for end-of-life electrical and electronic equipment (EEE). Those legislations are expected to recover and recycle domestic EEE but in practice there are many invisible flows in the country. In Japan we estimated the domestic material flows for home appliances and personal computers and found that many fractions are exported for reuse purpose and that some for recycling. In order to explore environmentally sound management of EEE for international material cycles we discuss the current status and issues on transboundary movement of EEE from Japan for reuse and recycling.

Firstly we estimated the number of home appliances (CRT-TVs air conditioners refrigerators washing machines) exported from Japan for reuse purpose using domestic material flow and trade statistics. Secondhand exports for reuse purpose were estimated to be 4.6 4.7 and 4.8 million units in FY2005 2006 and 2007 respectively. Among four items TV is the largest item with more than 2 million units. For other three items trade statistics is considered to give underestimation. Hong Kong has been the major destination of secondhand TVs until 2006. Due to Hong Kong's import control however the destination has been changed to other countries such as Vietnam.

Secondly we investigated the mixed metal scrap for material recycling purpose in order to find the fraction of EEE. Huge amount of mixed metal scrap is exported from Japan to China although very recent export is decreasing. Air conditioners and other home appliances could be often found from our investigation.

Based on those investigations for reuse and recycling we discuss the background and reason why EEE is exported from Japan. Also we consider the environmental and legislative issues from the domestic and international viewpoint and discuss the future tasks and possible cooperation with importing countries."

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Sustainable Consumption

Quantifying the Potential of Secondary Mass Savings in Vehicle Mass Reduction

Catarina Bjelkengren, Jeffrey B. Dahmus, Theresa M. Lee, Richard Roth, Randolph E. Kirchain

"Among automobile consumers and manufacturers alike, there is an increasing emphasis on fuel efficiency. This focus has been driven by a variety of factors, including cost concerns, legislative pressure, and environmental issues. One approach to improving vehicle fuel efficiency is through reducing vehicle mass. While the exact improvement in fuel efficiency varies, a reasonable rule of thumb is that for every 10% reduction in vehicle mass, fuel efficiency improves by approximately 5%.

This paper focuses on an important issue related to vehicle mass reduction, that being the concept of secondary mass savings. This concept derives from the qualitative understanding that as vehicle mass decreases, the mass of wheels, suspensions, brakes, structure, and other parts of the vehicle may also decrease while still providing the same level of performance and function. Moreover, as vehicle mass decreases, the engine size and drivetrain torque capacity may be decreased while still maintaining equivalent acceleration performance and functionality. The work presented here describes a quantitative method to estimate the secondary mass savings that can be realized following a primary mass reduction.

Establishing how the masses of the different subsystems of the vehicle depend on the total mass of the vehicle, allows for a more accurate calculation and prediction of the amount of secondary mass savings that can be realized following primary vehicle mass reduction. Understanding and accurately quantifying the overall mass savings can in turn greatly affect the economics of vehicle mass reduction. This work provides a detailed statistical analysis to quantify the interrelationship between the masses of various subsystems and, using this information, to provide an estimate of potential secondary mass savings. Results indicate that, on average, secondary mass savings can be on the same order of magnitude as primary mass savings, a result that clearly shows the importance of quantifying secondary mass reductions."

Diet trade and land use. The Social Ecology of the food system. Case study olive oil.

Arnim Scheidel

“The paper examines the development of consumption trade and production of olive oil in the EU since 1972 with a particular focus on the case of Spain by applying the concept of social metabolism to the commodity olive oil. Ecological impacts associated with changes in olive production and land use intensity are assessed and economic and institutional drivers behind the observed changes in consumption and production are investigated.

Since 1980 olive oil consumption in the non-producing European countries (NPC) has increased fifteenfold at an exponential growth rate from 0022 to 034 l/cap/y. A large share of olive oil is exported from Spain the world\’s largest producing country where intensity of olive production has changed drastically: Olive-cultivated area grew by roughly 20% to 2.5 mio ha in 2006 driven by the vast extension of irrigated plantations that grew from around 100.000 ha in 1980 to currently more than 400.000 ha. The increasing industrialization of olive groves relates to severe ecological impacts primarily soil erosion and desertification unsustainable water use pollution of surface and groundwater and loss of biodiversity due to the decrease of ecological infrastructure. Production for exportation requires nowadays around 40% of olive-cultivated area.

Analyzing the temporal development of export volume and NPC consumption in the EU15 shows that increased consumption in the NPC was the effect of increased export production rather than being its initial cause. The process was triggered by dismantled trade barriers and export- and production subsidies of the CAP olive regime which fostered at the same time intensified production. Therefore institutional factors played a crucial role not only in the evolution of land use- and production systems but as well in the development of individual consumption patterns. Hence institutional settings have to be considered as a major target of action towards sustainable consumption and resource management.”

Who is afraid of Sustainable Consumption? Business models for the most underrated phase of product life

Renate Huebner

“Sufficiency and efficiency are the two principles most commonly employed in achieving sustainable consumption. While sufficiency strategies touch social and political questions require sophisticated decisions and take a long time to be implemented efficiency strategies offer a wide range of options for their implementation in the short or medium term. This is apparent from the production-oriented approaches of ecoefficiency such as clean production ecodesign or recycling which have been successfully realised within the last two decades. In comparison consumption-oriented efficiency approaches are rare and mainly focus on energy savings and reuse strategies. Under the new EU waste directive however reuse is becoming more important ranking second after waste prevention and ahead of recycling in the five-stage waste (strategy) hierarchy.

A recently completed project analysed 66 initiatives for sustainable consumption of which 73% were reuse solutions. The FUTURE project (From Use to Use by Redistribution) was carried out in a medium-sized town in western Austria producing some important findings for research into in-creasing the attractiveness and practicality of reuse-strategies:

- Many very different institutions offer a wide range of reuse services. Many of these cover only a few niche markets and do not reach the critical number of consumers to survive without subsidies.

- Three types of motives for offering reuse services have been identified: social conscience com-mercial motives ecological improvements.

- Reuse based on these motives has already been integrated into manifold business-models which all require a new role for the user: that of supplier.

Characteristically reuse business models relate more to utilization patterns than to product-sale-models. To increase the competitiveness of reuse businesses we need to know more about both the use phase which is comparatively neglected in theory and practice and about the contradiction of reuse businesses being embedded in the current economic system.”

Organic food consumption and its determinants: Czech case study

Jan Urban, Iva Zverinova, Milan Scasny

"The main objective of this paper is to analyze empirically determinants of organic food consumption using data on a representative sample of consumers. The data were collected in an original survey conducted in 2008 in two regions in the Czech Republic. Structural equation modeling is used to test an extended model based on theory of planned behavior complemented with variables capturing habitualization of behavior and general pro-environmental norms.

Conceptually the model presented in the paper draws from the theory of planned behavior (TPB) as originally proposed by Ajzen (1991). Further the model complements TPB by including variables capturing purchase habit and general pro-environmental values (revised NEP scale). The purpose of the modeling is to explain probability of purchase of organic food by respondent. This probability is explained by joint influence of attitudes perceived social norms perceived control over behavior habit and general pro-environmental values.

Technically structural equation modeling (SEM) is used to test formalized model. This type of modeling technique allows for inclusion of latent variables in the models that are not directly measured. Thus this model allows for inclusion of perceived social norms attitudes and perceived control as latent variables that are indicated by empirical indicators.

The results of the study suggest that social norms and health-related attitudes as well as general pro-environmental values are significant drivers of organic food consumption. On the other hand perceived monetary costs and poor knowledge of organic logo and the certification process and low trust in certification of organic food are the main barriers to organic food consumption."

System Analysis of Sustainable Artisanal Fisheries Case Study in Abang Island of Batam Indonesia.

Jayadi Kamrasyid, Apendi Arsyad

“The main focus of this study is to explore the typological characteristics of artisanal fiseheries. The case study in Abang Island of Batam Indonesia is used to analyse the interrelationship among stakeholders in affecting the institutional system of artisanal fisheries and the process of maintaining a sustainable fishery management.

The result of the study suggests the need to establish access right withdrawl right and management right for artisanal fisheries in order to maintain a sustainble fishery management. Using Interpretative Structural Modeling (ISM) it shows that there are 3(three) important factors must be considered: First government protection will play a significant role for artisanal fisheries to maintain its access right and management right in developing a sustanable fishery management. Second government policy is needed to provide spatial planning of the fishing ground in which can create a condusive environment in supporting a sustainability management of fishery resources for artisanal fisheries. And third decentralized policy approach is an important factor in integrating 6 (six) elements of artisanal fishery management systems: fish resources social systems technology regional infrastructure market integration and financial resources.”

Sustainability assessment of diesel and agrodiesel including social aspects

Mario Sedlak, Dan Jakubowicz, Petra Bußwald

“The project \Futuro\” aims to label goods with their \”true\” (sustainable) prices and is used here to compare fossile and renewable fuel. This is meant to be a support for individuals and decision makers to find the optimal way towards a sustainable lifestyle regarding environmental protection and fair trade. We will present in detail the results of our analysis of conventional diesel and agrodiesel. The Futuro price is made up of six components: #???????# The Futuro concept extends the concept of life cycle analysis and ecological footprint by social aspects. It intends to judge the ecological and social impact of production transport use and disposal of goods and services. Every impact is converted to Euro per unit of the good or service. The resulting amount is given in the fictious monetary unit “Futuro”. While “Euro” measures the market price “Futuro” measures the sustainable price which should be added on top of the market price. Hence the final result of each Futuro analysis is easy to understand for everybody and shows how much better a good or service is compared to another (what labels and rankings are not able to show). The Futuro project was started in 2001. In co-operation with scientists the calculation methods were finished in 2003 and applied and demonstrated on first products. In the following years the algorithm was fine-tuned. Several papers about the Futuro project have been published and presentations at conferences have been made. Project partners are NGOs companies and universities.”

Extended Producer Responsibility (EPR) Policy in East Asia in consideration of International Resource Circulation

Yasuhiro Hotta, Shiko Hayashi, Chika Aoki, Magnus Bengtsson

"The paper summarizes the main findings of an international collaborative study/survey titled "EPR Policy in East Asia in consideration of International Resource Circulation" which will be published as a report in summer 2009. The study mainly focused on the application of EPR principles to the management of used electrical and electronic products (e-products).

The study consisted of three parts: 1) analysis of the current situation of EPR-based policies in Asia (mainland China Thailand India Japan Korea Taiwan Malaysia Singapore and Hong Kong) 2) identification of emerging challenges for EPR-based policies related with international resource circulation and 3) transformation of the principles and applications of EPR and implication to Asia. The first part of the study examined the applicability of the EPR principle in developing Asia through several case studies of Asian countries. The second part mainly discussed that waste and recycling related challenges are now internationalized especially in the developed countries through international movement of secondary materials and goods as a response to increasing demands of resources and products from developing countries. A possible response to the challenge posed by the internationalization of waste and recycling is voluntary actions by the private sector. A case study examines how a multinational corporation is promoting the EPR principle through its international product supply chains. Finally in the third part the report introduced some examples of transformation of the principles and application of EPR in response to internationalized waste and recycling issues by assessing the discussion in OECD and EU. The report concludes by summarizing the challenges faced by the existing EPR systems casued by the expansion of international resource circulation and argues that there is a need for a revision of the EPR principle taking into consideration the new international situation."

Paradigm Found: Use-oriented Industrial Ecology

André Reichel

“In this contribution it is argued that Industrial Ecology (IE) needs to adopt a “use-oriented view” embracing the consumer consumer wants and their use behavior. IE products and process need the IE consumer a materially sustainable industrial metabolism can only work if the IE system as a whole is working. The use of products or more abstract: the use and application of technology is at the heart of industrial material flows and those cannot be made sustainable without a change in patterns of use.

In adopting a cultural view of the firm ecological impacts can be connected to a certain technology. Depending on the employed technology different ecological stresses result. The decision which technology to take is formed within the socio-cultural context the given value system of a society which transforms abstract needs (e.g. freedom) in specific wants (e.g. mobility). These wants however do not “choose” a technology or a single technological artifact like a car. A car alone cannot provide mobility it needs road and fuel infrastructure a car manufacturing industry with skilled workers and a regulatory framework for individual mobility. In brief: it takes a so-called “utility system” in order to provide a bundle of technologies and infrastructures. Cultural wants do not select products and processes directly but mediated through utility systems and the design and appeal of these utility systems then determine ecological impact and material throughput.

Thus it appears to be fruitful to turn both theoretical and practical interest towards the design of utility systems as central element of any industrial metabolism. A reduction of material throughput requires not only production processes modeled along the lines of natural ecosystems but different utility systems with different (and above all: less) products which enable a change in consumer behaviour.”

Criteria for preliminary assessment and precautionary design of engineered nano materials

Arnim von Gleich, Christian Pade, Michael Steinfeldt

“Engineered Nanomaterials in Consumer Products and the Methodology of Precaution

A growing number of products containing engineered nanomaterials is already on the market with little knowledge about their potential health and environmental effects. As in the case of new chemicals innovation is quicker than risk regulation. Considering international competition it is hard for companies to wait until all / enough is known about possible effects before marketing new products. There is no innovation without risks but consumers must not be misused as guinea pigs. There is need for a quicker a preliminary assessment and the operationalization of the precautionary principle.

In an early innovation stage when the data about (eco)toxicological effects and exposure are still missing technology assessment must change its direction of view from the ‘targets’ (from (eco)toxicological endpoints) to the ‘agents’ (the nanomaterials themselves) as main sources of knowledge.

The ‘German NanoCommission’ has developed such an approach for a ‘preliminary assessment’ of engineered nanomaterials. The Commission comprised in its deliberation process stakeholders from industry trade unions NGOs (consumers and environment) state agencies (environment occupational safety health risks) and academic. They gained consensus about a list of criteria for ‘preliminary assessment’ indicating ‘concern’ as well as ‘relief’. Among the criteria suggesting ‘relief’ are those that indicate the loss of nano functionalities by solubility or degradability. The list of criteria suggesting high ‘concern’ covers a) criteria indicating high exposure because of e. g. purposeful release and/or persistence b) criteria indicating possible problematic effects because of reactivity and/or problematic morphology c) criteria indicating problems in risk management like lack of traceability.

A possible presentation will include: General thoughts on transition innovation and precaution the list of criteria and a discussion about their scope and limits and some remarks about possible consequences for precautionary risk management including the precautionary design of nanomaterials.”

A difference of the way of thinking for sustainability and the influence of the environmental news Nippon Institute of Technology (NIT)

YAGITA Hiroshi, SAKAIRI Satoshi, SATA Tatsuya, SAKAI Yasutomo

“Every person has their cognition to the environment and sustainability. It is supposed that the difference of the cognitions come from knowledge of sustainability such as education income food environment and nationality. Also environmental news reported in mass media supposes to influence those knowledge formations. In this study differences of the way of thinking for sustainability were evaluated and the relation to environment news was also examined. The data was obtained from a survey of 100 Japanese and Chinese students who go to college in Japan. Analytical Hierarchy Process (AHP) method was applied to analyze the difference of individual way of thinking for sustainability. In the questionnaire each student answered the order which country is the most sustainable in Japan China and the United States. Those students answered the questionnaire twice. The individual idea on the sustainability was evaluated by the first questionnaire without any information. After the quantitative information about education income food and environment was presented the potential idea on the sustainability was evaluated by the second questionnaire. In addition it was tried to quantify the appearance frequency of various environment keywords in articles of Japanese newspaper and magazine during last 25 years. Those keywords include global warming gas CO2 reduction recycle energy saving environmental problem ecology and so on. Based on these observations it was tried to analyze the relationship between knowledge and awareness of environment in Japan.”

Food choices: A model for sustainability

Anne Sibbel

"At the simplest level sustainability can be achieved if all consumers moderate consumption in ways which conserve resources and minimise waste. This approach seems obvious yet it has not led to significant progress towards achieving sustainable states on a global scale. There are many reasons for this lack of success. In the first instance an effective consumer driven approach to sustainability relies on individuals becoming aware of the consequences of their consumption patterns and being accountable for them. It places considerable demands on personal competence for making informed and responsible decisions about ways they can meet needs. This model also assumes that consumers are aware of the range of options available to them and that they are motivated to make choices which contribute towards achieving sustainability. It also relies on their access to relevant scientific information interpreted in ways which can be applied each time they make a decision in daily life.

Setting the analysis in the context of decision-making about food assumptions about this consumer centric model are challenged. Some of the external factors which can influence consumer food choices such as technological development regulation economic incentives and socio-cultural norms are considered. By identifying the criteria for sustainable food choices an alternative model is proposed which integrates both internal and external factors. The principles governing this model are universally relevant so could be adapted and applied in other contexts to bring about the changes necessary for sustainability. Some of the implications of implementing this model through public policy are examined."

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Sustainable Resource Management

Studies on Competitive Interaction and Management of Wild Oats (Avena Fatua L.) in Spring Wheat (Triticum aestivum L.)

Imtiaz khan, Gul Hassan, Muhammad Ishfaq Khan

"Wild oats (Avena fatua L.) is one of the most widespread noxious and harmful weeds in wheat. In order to quantify the impact of wild oats on wheat two separate experiments were conducted at Agricultural Research Farm NWFP Agricultural University Peshawar Pakistan for two crop seasons i.e. 2004-05 and 2005-06. First experiment was concerned to find effect of wild oats populations and nitrogen levels on some agronomic and quality traits of wheat while in the second experiment wild oats biotypes were subjected to different oats killers to find out the effect of herbicides on biotypes and the impact on wheat. The first experiment was laid out in Randomized Complete Block (RCB) design with split plot arrangement having four replications. Three nitrogen levels (75 100 and 125 kg ha-1) were kept in main plots while five wild oats densities (0 10 20 30 and 40 plants m-2) were assigned to the sub plots. The sub-plot size measured 5x 1 m2. The effect of nitrogen was not significant on different parameters of wheat and wild oats while oats density and interaction of density with nitrogen levels were significant for all the parameters studied. The two year data revealed that less than one wild oats plant m-2 inflicted 1% reduction in wheat yield while 30% reduction in yield was computed with the infestation of 16 18 and 17 plants m-2 under 75 100 and 125 N kg ha-1 fertilizer regimes respectively. It was further discovered that there existed a wild oats density related reduction in grain protein content. About one and a half wild oats plant m-2 reduced protein content by 1% which is alarming in vegetable based diets like Pakistan. Judicious control measures for wild oats are recommended to be adopted for harvesting better quantity and quality of wheat."

Working with environmental issues in SMEs – Microteaching as a method to overcome barriers

Monika Olsson

“SMEs are often burdened by much to do and not much time/personnel for doing it. Even if there is an interest in working with environmental issues not much is done due to a low priority. What could be done to increase this priority and in spite of little time improving the environmental work? One option is to prove to the company the economic benefits of working with environmental issues. This was the idea behind a case study made in a rubber company where the amount and source of solid waste was investigated and a cost analysis of different waste prevention options was made and presented to the company. Even though the company was very interested the suggested options were not implemented. It turned out that the investigation was much too ambitious for the company so the personnel did not get the point. Obvious just from an academic way “telling” the company what is the best solution is not working. The learners are not participating actively they do not feel included in the process and therefore the suggested solutions will not be implemented. In order to overcome these barriers and at the same time make the personnel feel as a part of the learning activity the model of Microteaching was suggested. Microteaching means an informal learning consisting of short sessions (15-30 min) where all learners are active. It is problem based learning and the topics of the sessions are based on the need of the company. Thus the method is not a traditional learning but more a method to develop an interest for the personnel to work actively with sustainable issues like waste prevention. The conference presentation will describe some case studies of where Microteaching was used.”

Sustainable production - Environmental Policies Legislation and Incentive-based Economic Policy instruments

Nani Pajunen, Helena Mälkki

“The products become more complex from the point of view of materials used and later recycled. These materials need to be recycled to become valuable useful raw materials again in order to achieve saving of the primary raw material. Most often after a primary treatment phase the recycled materials are refined in the same processes as primary raw materials are produced and refined. It is economically more feasible to refine materials only from primary raw materials. Increasing the use of secondary materials and by-products needs new policies that not only dictate goals but also promote research and innovations needed to make use of recycled raw materials.

The great challenge faced by economies today is to integrate environmental sustainability with economic growth and welfare by decoupling environmental degradation from economic growth and doing more with less. Social economical and ecological way to think can be the opportunity to all the actors. Saving the raw-material using the by-products reduce the waste might be the win-win-win situation for company shareholders and community.

The impacts of economic policy instruments have been assessed in concentrated principally on energy and climate policy and the emphasis has been on evaluating the reduction in emissions and the overall economic impacts. The research on the impacts of economic policy instruments should consider also sustainable development and material efficiency issues.

The EU encourages the member states to increase the use of economic waste policy instruments which has resulted in a gradual move towards using a combination of regulative and economic instruments in the member states. We will try to propose some effective instruments related to material cycles: legal sustainable and economical means to control and manage the material flow and by-products.

Our case study is located in the Gulf of Bothnia industrial region in Finland and Sweden. Our objective is to find the new ways to use by-products in forest chemical and metallurgical industries in present situation and in future. In this study the main objective of the policy and legal research is to outline new ways to extend policy instruments regulate and control industrial by-products find the balance between legislation and incentive-based economic policy instruments approaching case study Gulf of Bothnia. And what is the difference if the scale of the Industrial Park is local regional or global?”

Assessing and Optimizing Feed Environmental Impacts for Finishing Beef Calves in Portugal

Ricardo Teixeira, Ana Simões, Oriana Rodrigues, Tiago Domingos

“Most software for animal feed optimization uses a linear programming method which yields the choice of the quantity of each ingredient. The inputs are the availability of the ingredient its price and the intended nutritional value of the feed which depends on the type of animal. But they do not consider the global environmental impact of the feed as an optimizing parameter. In this paper we determine the life cycle impacts of typical feed ingredients thus building a database to compute the impacts of most animal feeds.

We started by determining the impacts of the production of each ingredient commonly used in Portugal. We used Life Cycle Assessment namely software SimaPro 6.0. Several production options and regions were evaluated for each ingredient. Then we apply this database to calculate the impacts of three alternative feeds for beef calves: an optimized grain maize-based feed an optimized silage maize-based feed and an average national feed. This requires scenarios for transportation of ingredients industrial processing and transportation to farms.

We found that the ingredients with the highest impact are soybeans and barley. In the case of soybeans used as protein sources a good substitution option may be found in alfalfa. The ingredients with the lowest impacts are by-products or forages.

As for the application of the impact database to specific feeds we were able to conclude that the feed based on silage maize has a generally lower impact. The average feed has a larger content of imported products and therefore transportation impacts are high. Industrial processing is irrelevant.

Finally we tried to compatibilize our analysis with standard feed optimization methods. Since optimized feeds must still satisfy the animals’ needs we tested the nutritional characteristics of the feeds determining which ingredients are environmentally better for each nutritional parameter.”

Economic and Environmental Assessment of Sown Biodiverse Pastures

Ricardo Teixeira, Tiago Domingos

“Sown biodiverse permanent pastures rich in legumes (SBPPRL) are a semi-intensive grassland system. It was developed in Portugal in the 70s and it is estimated that more than 70.000 ha of these pastures are actively being used today. This system consists on the use of biodiversity to increase productivity since up to 20 site-specific species or varieties of grasses and legumes are usually sown. Legumes fix atmospheric nitrogen which is then consumed by grasses disabling the need for synthetic fertilizers. But the most well-known effect of these pastures is the capacity to sequester high quantities of carbon. Carbon is stored in soils due to root incorporation in the soil structure.

In this paper we try to calculate and integrate the most important environmental effects of SBPPRL. Carbon sequestration was estimated according to an empirical model obtained from field data for 5 years and 8 locations in Portugal. But almost all of the other effects require a life cycle approach. For example the higher productivity implies a higher share of direct feed for grazing cattle decreasing the need for commercial feeds.

We determined that SBPPRL have an average carbon sequestration potential of about 4.7 t CO2/ha during the first 10 years which is much higher than the alternative which are natural pastures. As for other effects animal emissions never represent more than 20% of sequestered carbon and the decrease in concentrated feed consumption more than compensates increased nitrogen emissions from legumes.

We also compared the economic performance of natural pastures and SBPPRL. We studied both direct and external effects of animal production in each type of pasture. To that purpose environmental impacts previously determined were monetised. We determined that SBPPRL are for most stocking rates and area classes the most profitable. Both internal and external (environmental) costs are lower for SBPPRL.”

Integrating forest carbon modeling and life cycle assessment to evaluate harvested wood-based fuels

Jon McKechnie, Yimin Zhang, Steve Colombo, Heather MacLean

"Forests provide multiple pathways to reduce atmospheric greenhouse gases (GHGs). Utilizing wood-based products such as construction lumber and biofuels avoids emissions associated with more GHG-intensive alternatives. The benefit of harvesting needs to be weighed against the potential of forests to continue storing and sequestering carbon if left unharvested. The Intergovernmental Panel on Climate Change recognizes the importance of both storing carbon in forests and emission avoidance through the utilization of wood-based products to meet GHG objectives [IPCC 4th Assessment Report 2007].

Using harvest residues and wood processing wastes as a biofuel feedstock has a minimal impact on forest carbon storage. However interest exists in using currently unmarketable trees as a feedstock for biofuel production. In the Great Lakes-St. Lawrence forest region of Ontario Canada over 40% of the annual sustainable harvest has not been undertaken during the last 8 years. Increasing harvest to provide biofuel feedstock would contribute to reducing GHGs from fossil fuel use. However this resource could alternatively be harvested for other products or remain unharvested to increase forest carbon storage. Describing the optimal GHG mitigation strategy requires the application of life cycle assessment to all resource utilization options.

This work investigates the net GHG emissions associated with harvesting currently unutilized trees in the Great Lakes-St. Lawrence region for wood pellet production. Substitution benefits of wood pellet-fired electricity generation are evaluated on a life cycle basis relative to coal and natural gas alternatives. Forest carbon modeling is employed to quantify the effect of increased harvest rate on forest carbon stocks. It is expected that the relative merits of these alternative forest uses will be dependent upon two dominant factors: the effectiveness of achieving GHG reductions with harvested wood-derived fuel substitution and the carbon sequestration potential of the forest as dictated by rates of natural disturbance and forest regrowth."

How to assess social sustainability of renewable energies?

Gudrun Lettmayer

The sustainable use of technologies depends beyond economic and ecological aspects notably on the so-called third pillar of sustainability that is a technology's social component or social compatibility. Therefore when assessing the sustainability of generating and using renewable energy this must not be limited to economic and ecological parameters. Social sustainability of a technology to a considerable extent depends on the "social anchoring" expressed by the society's attitude to perceive it as useful and accept it. Especially renewable energy as it is largely generated at the regional level considerably intervenes into the region's structure and interests.

The following questions remained unanswered so far: How sustainable in their social aspects are renewable energies (regarding their way of generation and their regional impact)? What are valid and measurable indicators to describe and monitor their social sustainability? What methodological instruments to choose in order to secure their social compatibility?

We are answering these questions taking the example of two Austrian „ renewable energy regions". Together with regional stakeholders and representatives from the energy sector a practical set of criteria and indicators of social sustainability (social compatibility) is being developed elaborating on a concept for the methodological use of this instrument in planning and running renewable energy plants as well as in establishing energy strategies and concepts. This instrument is designed for decision makers and administration as well as plant operators.

The methodology and interim results of this ongoing project will be presented."

Climate Change and its Impact on Nepalese Agriculture

Bhandari Govinda

“Exponential growth of CO2 and other greenhouse gasses in the atmosphere is causing climate change. It affects agriculture forestry human health biodiversity snow cover and aquatic to mountain ecosystems. Changes in climatic factors like temperature solar radiation and precipitation have potentials to influence crop production. Despite many efforts possible on combating impacts of climate change there are still difficulties in Nepalese agriculture. With an average of 0.06oC/year a rise in temperature from 1975 to 2006 by 1.8oC has been recorded in the country. Problem of frequent drought severe floods landslides and mixed type of effects in agricultural crops have been experienced in Nepal because of climate change. Study done on CO2 enrichment technology at Khumaltar revealed that the yield of rice and wheat increased by 26.6% and 18.4% due to double CO2 17.1% and 8.6% due to increase in temperature respectively. A crop simulation model (DSSAT) to study the effects of CO2 temperature and rain in NARC showed positive effect in yield of rice and wheat in all regions but negative effect in maize especially in Terai. In Nepalese agriculture the time has come for the authorities to find out adaptive measures to mitigate the effects to reduce untold natural calamities and miseries due to recent erratic weather pattern.

APIX-SEP Zero-Waste Zero-Carbon Business Model

Hariharan PV

"AGRO-POLYMER INDUSTRY COMPLEX-SUSTAINABILITY ENGINEERED PROJECTS (APIX-SEP) involve ZERO-WASTE ZERO-CARBON BUSINESS-MODEL wherein economic/ industrial activities are centered in village/ farm areas utilizing available Renewable Resources – agro/ animal/ organic/ waste resources rain water sunlight and nonfarm vegetation resources (grasses weeds shrubs). The multifarious processes lead to non fossil based Biopolymer and Biorefinery systems. The products are: energy processed foods engineering materials petro-chemicals biofertilizers and carbon-sink engineered products. About 50% of the processed materials (water inclusive) are recycled back into surroundings through SELF REGENERATIVE RECYCLING improving soil increasing local resource values and creating more local jobs.

The operational Objective is to spread thousands of APIX-SEP systems worldwide in one thousand ha farmlands/ village modules named APIX_1000 designed for output valued $20 million/ module. The socio-economic Objective is to uplift the struggling village communities (estimated worldwide @ 3500 million people) from their present annual earnings of $150 to reach $400/ individual. Dilapidated villages would become wealth creation centers through sustainable self-perpetuating economic activities.

APIX-SEP has UN MDG built into them countering Global warming and Poverty simultaneously negating shifting populations and reducing GHG emissions. Business is redefined wherein profits are proportional to closing the "rich-poor" gap (reversing mainstream economics model of maximizing/ concentrating wealth) leading to equitable sustainable wealth distribution – one billion poorest people earning @ $400 = $400 billion within parallel GREEN businesses worth $4 trillion enhancing earnings of all stake-holders. APIX-SEP creates Zero-Waste economy and reduces poverty wastage conflicts environmental degradation and time-entropy effects – impacting livelihood of 3.5 billion villagers worldwide.

The "spirit" of economics thrust is on local needs using local resources directed by local wisdom tempered by modern science. The dramatic changes in erstwhile sleeping villages would improve the livelihood qualities of local people easing pressures on cities and towns"

Lignocellulosic biomass-to-electricity systems for Portugal: Life cycle energy and environmental benefits

João Miguel Nunes, Fausto Freire

"Advanced technologies efficiency GHG life-cycle Lignocellulosic biomass has received recent attention in Portugal as a key renewable energy source to play an important role in electricity production and advanced technologies are being considered as a promising high efficiency pathway. However the actual benefits of biomass-to-electricity systems have not been previously assessed in a life cycle perspective. This paper presents the development and implementation of a comparative life cycle model aiming at assessing the full cradle-to-grave energy and environmental performance of alternative lignocellulosic biomass-to-electricity production pathways for Portugal. Twenty-four alternative scenarios have been defined considering different combinations of: i) forest biomass types (residues and energy crops) ii) biomass collection and transportation processes and iii) electricity production technologies (gasification and direct combustion). An extensive data collection has been carried out in Portugal to build the life cycle (LC) inventory for the 24 scenarios. A LC model has been developed based on a systemic description of the various scenarios with the aim of evaluating and finding the most sustainable solutions throughout the various LC stages. The primary energy fossil requirement and the Greenhouse Gas (GHG) emissions associated with the production of 1 MJ of electricity are presented for each phase of the life cycle. The results calculated for the 24 scenarios show that the fossil energy requirement can vary from 0062MJ to 0166MJ per MJ of electricity produced. The most efficient pathway is obtained with gasification of forest residues. The processes that require more fossil energy are biomass chipping and transportation (from 19% to 50% of total fossil energy requirements). GHG emissions range from 57gCO2eq to 115gCO2eq per MJ of electricity produced. The present analysis demonstrates that biomass-to electricity can be a sustainable option regarding fossil energy use (primary energy savings: 21–28MJ/MJelectrical) and GHG emissions avoided (121–228gCO2eq/MJelectrical) but advanced energy conversion technologies namely gasification must be employed."

Indicators for sustainable water management in retail parks

Ramon Farreny, Jordi Oliver-Solà, Joan Rieradevall, Ademir P. Barbassa, Bernardo Teixeira, Xavier Gabarrell

"The use of planning and management tools in urban environments and in particular for the service sector is a promising area. Water indicators are particularly important as the proper management of this resource is considered a cornerstone of urban sustainable development. This research focuses on the description of two indicators to be applied in the expanding economic sector of retail parks. Firstly Water Intensity of a Purchase (WIP) which measures the water consumption related to a purchase measured in litres. Secondly Water Self-Sufficiency Indicator (WSSI) which considers the ratio between water harvesting potential and water consumption (a value over 1 means self-sufficiency).

These tools have been checked in two case studies in different contextual situations: Spain and Brazil. The results show a WIP of 8.3 and 22.9 litres per purchase respectively which is a measure of the (in)efficiency in the water use. This water demand mainly of low quality is met with pipe water while high amounts of water runoff is lost to sewage. The WSSI results 2.85 for Spain and 1.39 for Brazil show that these urban systems tend to have a potential surplus of water from rainwater harvesting. Both indicators can be helpful in urban planning and policies for sustainable water management. From the point of view of industrial ecology this leads us to think about the potential role of retail parks as water suppliers to the neighbouring areas once the appropriate infrastructures have been properly assessed and implemented."

Dynamic CGE model for sustainable resource management: a case of biofuels

Satoshi Kojima

"This paper aims to develop sustainable resource management policy assessment tool employing dynamic computable general equilibrium (CGE) modelling approach that is suitable to capture inter-sectoral repercussion and implications to economic growth of such policies. The model follows a tradition of Ramsey-Cass-Koopmans model but disaggregates production sectors and substitutes underlying perfect foresight assumption with continuous monitoring-feedback type expectation formation process. The present prototype model is designed to deal with sustainable biofuel production and water scarcity issues that have drawn worldwide attention in the context of global warming energy security food security and environmental sustainability. For demonstrative purpose a preliminary assessment of biofuel policies using the developed model is conducted."

Climate change implications of bioethanol production considering additional nitrogen fertilizer application and soil organic carbon

Kyo Suh, Ryan Barker, Sangwon Suh

“Current U.S. annual corn production is not sufficient to reach the 15 billion gallons of ethanol mandated under the Energy Independence and Security Act (EISA) considering existing and projected domestic food and feed demands estimated by the USDA. Higher yield breeds and different rotations of corn are possible scenarios for providing additional corn supply. However a suggested continuous corn rotation needs additional nitrogen (N) fertilizer (anhydrous ammonia) and generates N2O which has 310 times more powerful Greenhouse Gas (GHG) than CO2 in global warming potential (GWP)[1]. Continuous corn has been shown to produce less GHG in CO2 equivalence than corn-soybean (CS) rotation considering soil organic carbon (SOC) because corn residue can effectively sequester atmospheric carbon2. Assuming 50% of US corn fields adopt the corn-corn-soybean (CCS) rotation from 2009 to 2015with a 10% annual increase we compared three different scenarios for corn harvest: (1) without stover removal (2) with 50% corn stover and (3) with corn cobs. Additional N fertilizer is estimated to annually produce 8.0 7.0 and 6.5 million Mg CO2 equivalent GWP but CCS rotation can remove more carbon (6.2 3.1 and 5.2 million Mg CO2 equivalent GWP) than CS with SOC for scenarios (1) (2) and (3) respectively. Net CO2 equivalent GWPs of CCS rotation considering additional N fertilizer and SOC effects are 1.8 3.9 and 1.3 million Mg for scenarios (1) (2) and (3) but CCS will increase corn production which can reach 3.5 million Mg CO2 reduction through corn ethanol production. Further sections of this study will show more detailed strategies to meet the rest of the 15 billion gallons of corn ethanol via CCS and the life-cycle GHG emission per gallon of ethanol.”

Potentiality of soil to reclaim Hg contaminated aquatic environment

Jatindra Nath Bhakta, Yukihiro Munekage

”This study investigates the efficiency of the six types of soils collected from various layer of three different geographical places Kagoshima Shimane and Tochigi Japan in removing Hg from contaminated water. After morphological and chemical characterization by SEM-EDS analysis 1 g of each soil was employed in 100 mL Hg (100 µgL-1) contaminated water and Hg concentration in water sample was examined at regular intervals for the period of 178 h. SEM-EDS data revealed the surface structure of each particles of soils predominantly constituted of Si (50 – 78.58%) and Al (12.37 - 38%) and followed by Fe (0.835 – 7.7%) and exhibiting highest percent abundance of Si in upper layer of Shirasu soil and minimum in Knuma and Akadama soil. Total removal of Hg by the different soils remarkably high enough and varied from 36.4 to 48.15 µgL-1. A critical appraisal of the data clearly revealed that maximum Hg removal efficiencies 0.27 and 0.26 µgL-1g-1h-1 were found in soil type Knuma and Akadama soil respectively. Obtained results of the present study clearly demonstrated that Knuma and Akadama soils containing low level of Si and higher level of Al have potential capacity to remove Hg from polluted water. Furthermore therefore and it may be concluded that soils have a potential impact and can be used as efficient tool to remove the Hg from the water which plays a significant role for the sustainable management of the water resource in the environment from metal pollution.”

Bio-fertilizer recipe:
Eco-growing towards sustainability in the palm oil industry

Wanida Wanichpongpan, Shabbir H. Gheewala, Masayuki Sagisaka

"Palm oil is the main vegetable oil consumed in the world today accounting for 33% of all oils consumed globally closely followed by soya oil with 31%. In the previous decade world palm oil consumption has more than doubled from around 16.7Mt in 1997/98 to over 40Mt in 2007/08. This figure is estimated to surpass 70Mt by 2020. Of the total 154Mt oils and fats production in 2007 palm oil accounted for around 25% soya oil 24% and rape oil 16%.

Considering food and energy security growth of oil palm has a consequent effect on land use as well as other environmental impacts related to agricultural activities such as global warming potential (GWP) groundwater contamination acidification and also carbon sequestration in soil. When existing plantations are considered oil palm growing phase is one of the largest contributors to the greenhouse gas (GHG) emissions. The GHG emissions in oil palm growing phase are from direct emissions of N2O from chemical fertilizer use and indirect emissions during production of fertilizers.

An investigation has been conducted based on chemical composition of natural gas based fertilizer as compared with bio-fertilizer from internally recycled materials from the palm oil based biodiesel production process. A mixed formulation consisting of empty fresh fruit bunch (EFB) decanter cake from purification process ash from the furnace sludge from wastewater treatment plant and nutrient enriched wastewater with high nitrogen is being studied. This utilization of by-products from the supply chain will reduce energy intensive fertilizer production and consequent GHG emissions the substituted natural gas could be used for other value-added products.

This new mixed recipe could retain the nitrogen and carbon in the soil and reduce investment cost to the farm owner. Furthermore this activity could encourage entrepreneurs towards corporate social responsibility (CSR) by providing bio-fertilizer arrangement to the contract farmers."

Community management of resources - A case study from Meghalaya India

Anamika Barua, Kitrphar Tongper

“Situated in the north eastern corner of India Meghalaya (Sanskrit)—literally \Abode (alaya) of the Clouds (megh)\”--occupies a hilly plateau of great scenic beauty with an average elevation of 2000 m (6500 ft). The state has a large forest cover accounting for the existence of an exotic variety of flora and fauna rich biodiversity terraced slopes and cascading waterfalls. Unlike other states of India Meghalaya falls under the provisions of the ‘sixth schedule’ of the constitution of India. This provides the state with a unique land tenure system. Land is owned by either communities or clans or is privately owned. Of the state\’s estimated total forest land area of 8514 sq km only 993 sq km is directly under the control of the forest department. The indigenous people have strong traditional systems for land use and forest management. Since the ownership of the land rest with the community or individual they have the discretion to use it in their own way. This is leading to degradation of landscape due to various activities namely shifting cultivation clear felling of forests for timber and mining etc. This is not only a threat to the landscape but also for the livelihood of the people. Involvement of the community is considered one of the first steps towards sustainable management of natural resource. In the case of Meghalaya the unique institutional set up provides the community full access to the state’s natural resources and a strong tradition of community-management already exists in the state. Inspite of this the natural resource of the state be it water forest biodiversity is under threat due to over exploitation by the community. The main cause behind this is lack of a long-term vision of the community. The community itself does not work as a cohesive unit and its action is rather based on collective individual actions which are not focused on an approach aimed at sustainable exploitation of resources but on maximization of individual benefits. This paper seeks to bring about an understanding of the various problems faced by such management of resources in the state and provide a framework for an institutional setup that will enable an effective management of resources by the community.”

Resource Management Implications of a Large-scale Organic Dairy in the U.S.: A Life-Cycle Perspective

Greg Keoleian, Martin Heller, Sarah Cashman, Keri Dick, Derek Przybylo, William Walter

“Aurora Organic Dairy (AOD) is the largest provider of private-label organic milk and butter in the U.S. managing over 12000 milking cows and processing over 84 million liters (22 million gallons) of milk annually. Milk from six AOD farms (three in Colorado and three in Texas) is processed in a state-of-the-art processing facility in Colorado and then distributed to retail outlets across the country. Recent growth and a commitment to sustainability and the organic industry have led AOD to evaluate its life cycle GHG emissions and explore reduction strategies. In this study we benchmark the life-cycle carbon footprint of AOD operations and explore the implications of a vertically integrated large-scale organic dairy on resource management logistics such as transportation. Data collected at AOD farms and processing facilities were used to build a LCA model for benchmarking the greenhouse gas (GHG) emissions and energy consumption across the entire milk production system from organic feed production to transport of packaged milk. Overall GHG emissions were 1.7 kg CO2 eq. per liter of packaged liquid milk. While the major GHG contributors include enteric fermentation (28% of total) and feed production (23% of total) transport (of feed raw milk and final product) over large distances account for 20% of the GHG emissions.“

Minnesota biogas potential: An environmental and regulatory assessment

Brian Walseth, Yiwen Chiu, Junghan Bae, Sangwon Suh

"Within its borders the United States has a great deal of coal oil and natural gas reserves however their distribution exhibits great regional variability. For example the state of Minnesota does not have any proven or potential fossil resources—annually importing 1.46 quadrillion BTUs of fossil energy including 350 trillion BTUs of natural gas. To improve its energy consumption patterns in 2007 Minnesota implemented a state-level Renewable Energy Portfolio Standard (RPS) targeting a 10% CO2 reduction and requiring 25% of electricity production to come from renewable sources by 2025. As Minnesota currently produces 106 trillion RPS BTUs (predominantly wind and hydro electricity) the importance of stable RPS sources is becoming increasingly important.

One of the largest underutilized potential stable fuel supplies in Minnesota is methane biogas. However there are lifecycle costs associated with the direct combustion for electricity of this bacterially-derived less-chemically pure gas. Our study assesses the associated regulatory and environmental tradeoffs of biogas consumption a GHG and SOX comparison of on-site combustion for electricity versus pipeline-quality biogas cleanup and scale & transportation costs. Our system boundary starts with feedstock byproduct generation in compartments (such as manure poultry litter etc.) and extends through scrubbed (or untreated) combustion. The functional unit of our study is 1 BTU and encompasses the various inputs and outputs of each byproduct compartment. Preliminary results show Minnesota has more than 3000 potential sites capable of generating more than 60 trillion BTUs of biogas. Biogas displacement has the potential to offset more than 18% of total natural gas CO2 production however SOX emissions can be up to 36 times higher if the gas is unscrubbed before combustion. Study results show that extending renewable credits from electricity to pipeline-quality biogas insertion would diversify the state's energy portfolio yielding significantly more environmental and economic utility to Minnesota's RPS."

Consequential Life Cycle Assessment of cellulosic ethanol production in the US Midwest state of Minnesota

Junghan Bae, Ryan Barker, Kyo Suh

"Under the US Energy Independence and Security Act (EISA) of 2007 the Renewable Fuels Standard (RFS) requires that 16 billion gallons of renewable fuels be obtained from cellulosic feedstocks such as corn stover. The RFS mandate also requires cellulose-derived fuels to have 60% less greenhouse gas emissions than their fossil equivalent. The aim of the present study is to assess the potential life cycle impacts stemming from the production of cellulosic ethanol derived from corn stover residues within the Le Sueur watershed in Minnesota. This potential feedstock consisting of the stalks leaves husks and cobs remaining after grain harvest presents significant potential for increasing domestic cellulosic ethanol supplies. Using a "cradle-to-gate" approach we examine the environmental impacts of stover cultivation transportation and storage and conversion to ethanol using dilute acid pretreatment and enzymatic hydrolysis technology at the assumed conversion rate of 340 L ethanol/dt. To gauge the life-cycle consequence of producing corn stover-derived ethanol we develop six scenarios identifying the environmental effects of 10% 30% and 60% stover residue removal under the current corn-soybean rotation practice as well as in the potential corn-corn-soybean cultivation cycle. Life cycle emissions during the various stages of feedstock and ethanol production allow for comparisons between these different scenarios: an eight-fold increase in CO2 emissions from diesel combustion during bale transport utilizing high-speed tractors instead of trailer trucks linear increases in global warming potential (34% higher for continuous corn) due to increased nitrogen fertilizer use for nutrient replacement and decreased eutrophication potential (9% reduction for 60% residue removal compared to no removal) caused by increased nitrate removal within stover residues. Through sensitivity analysis and life cycle modeling optimal conditions for the design and implementation of a biofuel economy will emerge revealing opportunities and constraints that can be additionally applied to other emerging cellulosic ethanol production areas."

Life Cycle Analysis as a tool to assess agriculture sustainability

Tatiana Valada, Tiago Domingos

“In this paper we discuss the environmental social and economic impact of the irrigated agriculture that takes place in Lezíria do Tejo Ribatejo. We study the main crops grown in the region namely corn wheat rice sunflower peas broccoli winter tomatoes zucchini peppers and vines for wine. We used real data concerning production pesticides and fertilizers use water and machinery. Our goal was to evaluate the environmental social and economic impact of each culture.

In order to analyse the indirect and direct environmental impacts of each culture we use a Life Cycle Assessment approach using software SimaPro 6.0 and Eco-Indicator 95. With this approach we are able to measure the impacts associated with all the inputs considered namely the production of fertilizers pesticides as well as the use of machinery. To complement the study we analysed the characteristics of the region regarding the biodiversity soil and water resources.

The results obtained from the SimaPro depend on the functional unit considered and on the impact category analysed. It is also possible to integrate the social and economic analysis if we consider the impact per unit of labour or per unit of added value. We may conclude that the Life Cycle Assessment represents a suitable approach to analyse all direct and indirect impacts. According to our study the production of fertilizers and the use of machinery are the main responsible for the impact so their account is extremely important in sustainability assessment.

We need now to understand where the impact takes place and in order to interpret the results obtained from the Life Cycle Assessment. It is crucial to understand the environmental social and economic characteristics of the region and its sensitivity to which impact category.”

Life Cycle Analysis of bioethanol production and use

Tatiana Valada, Ricardo Teixeira, Tiago Domingos

“In this paper we discuss the environmental and energy viability of the production and use of bioethanol as a substitute for gasoline. In Portugal the most likely crop to be used as raw material is maize.

Our main innovation is the fact that our study does not just compare the production and emissions of the two fuels by themselves but also the consequences regarding land use. We consider two plausible land occupations for the same area: maize which is used for bioethanol production and sown irrigated pastures (SIP). SIP are direct competitors of maize crops in which there is direct grazing by cattle. When maize is used for feeds cattle are produced intensively in stables. However if SIP are installed instead of maize there is no ethanol production and no gasoline is replaced.

We analyzed both scenarios in a Life Cycle Assessment approach using software SimaPro 6.0.

Our results show that overall the most favourable scenario is SIP installation with the continuation of the use of gasoline. The difference between the two scenarios is especially high considering SIP carbon sequestration. However the use of bioethanol always reduces total energy expenditure in relation to gasoline. Therefore we concluded that the production and use of ethanol is not in the context of our study a favourable choice in terms of greenhouse gases but it is as an energy policy.

Regarding all the other categories it must be noted that the only category for which the maize scenario is favourable is the ozone layer depletion.

As results verification we studied the most common case in the literature a simple analysis of bioethanol production and use disregarding the alternative land use. Comparing the results we conclude that the consideration of alternative land uses is critical to the conclusions obtained.”

Life cycle assessment of an integrated biofuels production system in Brazil

Simone Pereira de Souza, Sergio Almeida Pacca, Claudinei Andreoli, Márcio Turra de Ávila

“Sugarcane and palm oil plantations produce the highest biofuel yields per area 6 to 7.5 thousand liters of ethanol per ha and 3.5 to 7 thousand liters of vegetable oil per ha respectively (UNICA 2005 LIMA et al 2000). About 30% of the life cycle energy input in ethanol production in Brazil comes from diesel consumption during the agricultural and transportation phases. It is expected that the future expansion of mechanical harvesting which is supported by the law phasing out pre harvesting burning will increase diesel consumption for ethanol production. Therefore we propose an alternative system of sugarcane production in which part of fossil fuel inputs are displaced by palm oil. The proposed combined cropping scheme aims to reduce fossil fuels consumption and their corresponding greenhouse gas (GHG) emissions thus increasing the sustainability of sugarcane’s ethanol production. We assessed the effects of substituting B30 for diesel in tractors and trucks used in ethanol production. Based on 7000 liters of ethanol per ha and 4000 liters of palm oil per ha yields we calculated the net energy ratio and GHG emissions of the biofuel systems. The energy intensities and greenhouse gas emission factors were obtained from EBAMM and GREET models. The net energy ratio for biodiesel and ethanol separately produced was 10 and 6 respectively. The GHG emissions of the coupled system using the B30 use was 26% lower than emissions due to ethanol production using diesel. This reduction corresponds to 18% when the full ethanol life cycle is considered. In order to run such a system we estimated that for every 28 hectares of sugarcane it is necessary to cultivate 1 hectare with palm trees so that the B30 demand for ethanol production is met.”

Life cycle modelling addressing direct land use changes: the palm oil biodiesel chain

Érica Geraldes Castanheira, Fausto Freire

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“Biofuel systems have recently become a focus of controversy, first because of the energy balance issue, second due to the high environmental impacts associated with intensive land use practices and lately concerning impacts due to indirect land use changes, as increased demand for biofuels is expected to produce changes in the present land-use configuration. Land use changes refers to the conversion of one type of land to another and has only been addressed recently and with limitations, since accounting for land use in life cycle studies is inherently problematic. Therefore, in order to determine the environmental impacts of an increasing demand for biofuels, there is a need for a modelling of the overall consequences caused by the increased utilisation of biomass for biofuel production. The main goal of this paper is to address these issues in the particular case of the palm oil biodiesel chain. A life cycle model and inventory for palm oil produced in Latin America and industrial transesterification taking place in Europe has been implemented. The life cycle model includes land use conversion necessary to establish palm oil plantations, milling, extraction and oil refining, transportation of palm oil to Europe, where biodiesel production takes place. Alternative land use change scenarios have been investigated addressing direct implications in terms of the GHG balance due to soil carbon stock changes. Life Cycle Impact Assessment results are presented and, in particular, the scenario in which tropical rain forest is converted into palm oil plantations shows the worse environmental performance.”

Life cycle assessment of two alternative biomass-to-hydrogen pathways for transportation in Portugal

Ana Coelho, João Nunes, Fausto Freire

“Hydrogen is expected to play a significant role in the future energy system. However the majority of hydrogen production is currently accomplished by steam reforming of natural gas and other fossil resources with less than 3% based on renewable energy sources. A prospective Life Cycle Assessment has been carried out to investigate the energy requirements and environmental impacts of bio-hydrogen (bio-H2) to be used in transportation. A “well to wheels” model has been developed and implemented. The model includes two alternatives ways of producing bio-H2 from lignocellulosic biomass: i)hydrogen compressed (35MPa) to be used in fuel cell engines and ii)hydrogen liquefied (253ºC) to be used in internal combustion engines (ICE). A detailed life inventory has been performed. The model was developed for the center region of Portugal where data regarding biomass production and logistics has been collected. Data concerning the hydrogen production technologies has been obtained from the literature. Results have been calculated for the Energy Cumulative Demand and the CML2000 life cycle impact assessment methods which have been assessed considering a “well to tank” and a “well to wheels” perspective. The compressed bio-H2 route requires less “well to tank” primary energy per MJ of bio-H2 which is mainly due to a higher energy intensive liquefaction process (more 39%). Furthermore compressed bio-H2 performs better than liquefied bio-H2 for all the environmental impact categories. “Well to wheels” results for the 2 alternative bio-H2 vehicles have also been compared with a diesel ICE vehicle and it has been found out that the bio-H2 fuel cell vehicle is the one that requires less fossil energy and could reduce greenhouse gases emissions in about 34% compared to the diesel vehicle. However the potential for implementing a biomass-to-hydrogen system in Portugal has been investigated and a strong limitation has been found in terms of the cultivated area needed to supply the large hydrogen production scale expected for near-future plants.”

5th International Conference on Industrial Ecology

2009 ISIE Conference

Visions on new IE-based paradigms toward Sustainability

Prospects for bio-industrialism: the Brazilian sugarcane ethanol sector

Peter Wells, Thaisa Faro Wells

"Industrial ecology provides the inspirational base for the foundations of new paradigms of production at both the metaphorical and practical levels. In this paper the scope for a transition away from lithoculture and toward bio-culture is explored in the context of the Brazilian sugarcane / ethanol sector. In so doing the paper goes past the debate on food versus bio-fuel to expose the contradictions and scope for a transition towards a broad bio-materialism. This is an important topic as yet relatively under-developed in industrial ecology: how far will future materialism be dependent upon the extraction of (more or less finite) resources from the planet? Alternatively what are the practical limits of societies based on biomass and what barriers are there to this transition? These large theoretical questions are at least demonstrated if not fully answered by the case study of sugarcane ethanol.

Sugarcane distilled ethanol has been demonstrated to be vastly superior in net carbon emissions terms to other ethanol sources such as US corn but it could be argued that this apparent advantage obscures and hinders the development of the nascent cellulosic processing of sugarcane (which would be even more efficient than distillation) and also of the use of the resultant ethanol as a material feedstock (generating symbiotic benefits at the local level) rather than simply as a fuel. Similarly the globalisation of Brazilian ethanol via international (mainly US) investment houses and large-scale bi-lateral agreements for supply to countries such as Sweden and Japan may act to negate the scope for industrial symbiosis and bio-materialism at a local level within Brazil. The paper concludes that the valuable contribution and insight offered by industrial ecology needs to be grounded in economic context to fully understand the potential for change."

Modeling the Sustainability of Wood-Based Bio-refinery and its Supply Chains

Anthony Halog

“This research pursues a vision of sustainable production of wood-based bio-fuels in view of the triple dimensions of sustainability. Political leaders policy makers and the public demand detailed information about the environmental social and economic impacts of any emerging technology and how it compares with existing mature processes. Thus the need for assessing the environmental economic and social sustainability implications of promising technology and product systems over their life cycles are inevitable such as the production of forest-based bio-fuels in industrial symbiosis context.

Sustainability involves recognizing interconnections among ecological social and economic systems and competing views of acceptable tradeoffs among them. Criteria and indicators are used to operationalize the overarching principle of sustainable development. Majority of the existing systems models for analyzing the impacts of biofuels have not considered the triple dimensions of sustainability and failed to integrate the different tiers of biofuel supply chains. The current research focuses on the development of a prototype systems model for life cycle sustainability assessment of biofuel technologies. The primary use of this model is to analyze the life cycle and long term environmental emissions energy and other resource consumptions of the wood-based bio-refinery system. Nonetheless social and economic aspects such as population increase growth in economy and employment are taken into consideration.

Sustainability of biofuel supply chain is modeled using a holistic approach such as dynamic system modeling. The interrelationships of critical variables are modeled over a finite time horizon. A suite of interlinking models for technology assessment in biofuel industry is being developed to integrate the entire biomass-to-hydrocarbons process. When a valid working prototype is created scenario analysis is carried out to assess whether the development and use of novel biofuel technologies can really contribute towards meeting the sustainable development of biofuel supply chains.”

Urban Carbon Carrying Capacity - Quantification Reconciliation and Enhancement

Eugene Mohareb, Christopher A. Kennedy

"Cities are the primary drivers of our economies but bear responsibility for resultant ecological impacts. In 2005 direct greenhouse gas (GHG) emissions from the Greater Toronto Area (GTA) totalled 67.5 Mt CO2e or 12.1 t/capita (Kennedy & Mohareb 2008). Looking globally CO2 emissions from fossil fuel combustion cement manufacture and gas flaring in the same year was 7985 Mt (Marland et al 2008). This underscores that civilization and its economic structures depend on processes resulting in the release of carbon emissions. Any effort to transition from the current carbon-intensive energy system to a more sustainable one will require renewal of urban infrastructure.

In determining what will be entailed in a sustainable system a long-term goal towards sustainable carbon consumption must be selected. The IPCC (2007) has proposed Annex I countries achieve an 80 – 95% GHG emissions reduction by 2050. The implied goal (on a per capita basis) as it relates to the GTA has been quantified suggesting one measure of urban carbon carrying capacity.

A summary of current energy end uses and their GHG emissions for the GTA are presented. Transitional energy technologies for potential pathways to meeting carbon carrying capacity are proposed and assessed. These include solar thermal photovoltaics wind biomass & geothermal. The role of nuclear technologies is also examined being a technology of "last resort" due to perceived environmental and economic burdens. As well infrastructural shifts are analysed using technology S-curves for transportation and buildings the two largest contributors to GHG emissions.

Wackernagel and Rees (1996) proposed in their Ecological Footprint concept that a sustainable settlement (one that is at or below carrying capacity) requires that energy-related GHG emissions are (at most) equivalent to sequestration opportunities. Potential sinks within the GTA as well as its hinterland are also quantified to determine effects on carbon carrying capacity."

Images of Sustainable Development in the Dutch Agriculture System

PJ Beers, Frans Hermans, Hanna Schösler, Joost Vervoort, Dirk van Apeldoorn

“Agriculture in metropolitan regions is confronted with rising demands in food quantity and quality while at the same time being challenged by increasing land prices and urban demands on green space. In answer to these challenges TransForum a Dutch innovation institute is carrying out a series of projects that implement promising agricultural innovations based on a triple bottom-line for sustainable development. However in the public arena many such projects are met with stereotypical _images_ which can stifle their innovative potential. For instance agricultural innovations through industrial farming are often met by the image of the _pig city_ and connotations of disease-outbreaks (e.g. bird flu mad cow disease). One and the same innovation can be a clear-cut image of progress to entrepreneurs and a nightmare for environmentalists. What is the role of multiple images in complex sustainability issues and what are promising approaches to deal with their associated problems?

We report on the insights and results of a research programme on images of sustainable agriculture. Earlier research suggests that 1) images are only loosely related to the issues they represent 2) strong images have high innovation potential and 3) highly conflicting images cause stalemates in the policy arena. We hypothesised that insights from complex adaptive systems and social adaptive capacity could offer guidelines for dealing with images.

Selected results are:

1) Crucial dynamics of complex systems are the first to disappear when images dominate public debate.

2) Visualisation techniques have the potential to preserve those dynamics for the debate.

3) Images are grounded in society which decisively impacts how innovations will be received.”

The Environmental Loans and Debts of Taiwan

Chia-Wei Chao, Ming-Lung Hung, Hwong-Wen MA

“With the prevailing trend of globalization the intensive exchange of material and goods leads to the domestic environmental flows are deeply affected by the foreign demands. As an export-derived economy and island with limited nature resource the environmental burden embedded behind Taiwan\’s vigorous international trade activities should be explored. This study aims to apply Input-Output Life Cycle Assessment (IO-LCA) to identify the domestic impact generated by the industrial production to fulfill the foreign needs(The Loans) and the foreign impact impute to the domestic consumption in Taiwan (The Debts). The primary result reveals that for the energy and resource consumption the debts on water is larger than the loans while energy shows different trends. It is worth noting that although the Degree of Dependence on Imported Energy are up to 97.65% in 2003 the loans on petroleum are almost equals to the debts even more the loans on electricity are 40% higher than the debts. The main source of the loans on electricity is electronic component export to United State and China. Moreover since the electricity structure is highly carbon intensity the huge GHGs loans were lend to those countries. Beside the loan on carbon budget the other urgent issue is the public healths are paid as tribute to China United State and Japan because of the loans on NOx SOx Arsenic and Lead are almost higher than the debts caused by domestic consumption activities. The main driver of this circumstance is the exportation of electronic components and steel. To summarize the full picture of environmental flows the main environmental debtor nations of Taiwan is Japan China and ASEAN countries while those countries are also serve as environmental creditors. To conclude this study identifies the duality of Taiwan and the environmental flows across the Strait. Based on above evaluation we recommend the government should re-exam the relevance of existing environmental diplomacy projects and the source of environmental debtors and strongly suggest the industrial development policy should be reshape to mitigate the damage on domestic environmental quality.”

The Social Embeddedness of Industrial Ecology

Jennifer Howard-Grenville, Frank Boons

“From its inception the field of industrial ecology has taken a distinctly technological approach to understanding and improving ecological consequences of industrial activities. Increasingly however scholars and practitioners are developing perspectives on the social embeddedness of industrial ecology: the ways in which material and energy flows in regions and product chains are shaped by the social context in which they occur. In this session we plan to offer a summary and dialogue based on contributions to an edited book entitled “The Social Embeddedness of Industrial Ecology” (Boons & Howard-Grenville editors forthcoming from Edward Elgar publishers in 2009). The book presents empirical work addressing how cognitive cultural political and structural mechanisms condition the emergence and operation of industrial ecology. Contributing authors draw from their own studies of either regionally-focused or product-chain focused industrial ecology and explore how these social mechanisms help us understand both the barriers to and opportunities for altering the ecological impacts of industrial practice. The book is also designed to encourage a dialogue between members of the industrial ecology community from different disciplinary backgrounds. Accordingly the conference session will also engage authors who contributed reflective chapters to the book that integrate the insights of the empirical chapters and comment on the challenges and opportunities for interdisciplinary work. Through the conference presentation we aim to catalyze work that combines social science methods and theories with those from science and engineering to expand interdisciplinary approaches to industrial ecology.”

Chemical Industry as Complex Networks

Junming Zhu

"The chemical industry is a large highly-interwoven complex and constantly changing industrial system representing the highest level of material utilization in anthropogenic sphere. While chemical processes are now designed and manipulated well the structure and dynamics of material utilization of chemical industry as a whole are seldom studied. Like the molecular interactions within a cell chemical industry could be viewed as a large network with chemicals as nodes and processes as links between pairs of nodes. With help provided by complex network theory two networks a smaller one representing a case in 1970s and a larger and later one are constructed analyzed quantitatively and compared with cell's networks and food webs.

The results have shown that similar to biological systems material production patterns are hierarchically organized units named Feed-forward loop Bi-fan and Bi-parallel in chemical industry which reflect the inner feature of chemical production and keep unchanged through development. Important chemicals tend to interact with a large number of chemicals and function as hubs connecting those units rendering the network robustness against error. The cumulative distribution of nodes' in-degree is exponential while that of their out-degree follows power-law suggesting fierce competitions within processes producing same products rather than those using same feedstock and consequently homogeneous production and heterogeneous utilization of chemicals. Chemical industry has fitted small world model better through time indicating better synchronizability. There is also better structural efficiency of material utilization in the later network since fewer processes are needed from basic feedstock to final products.

The small world and error-tolerance characters of chemical industry enable that it could be adjusted by economic and policy stimuli which should follow the structural and evolutionary principles in chemical industry. For better management of chemicals and higher efficiency in chemical industry further effort is needed to construct larger network database and to study the building mechanism of structural units."

Economics of Industrial Symbiosis

Gabriel Grant

“Numerous examples of successful spontaneous industrial symbiosis exist yet their ability to disseminate is unknown. Unlike recycled metals which can be traded through conventional markets waste materials are typically non-standard off-spec or highly variable in composition. Furthermore attempts to plan or design for industrial symbiosis such as eco-industrial parks have generally failed. Neither classical markets nor hierarchical coordination provide sufficient explanation or support for the inter-firm collaboration fundamental to industrial symbiosis. This presentation reviews established and emerging economic theories and contrasts their ability to provide descriptive and prescriptive explanation for industrial symbiosis.”

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455 Peter Lowitt, Neil Angus

456 Yong Geng, Fujita Tsuyoshi, Mr.Chen Xudong

457 Weijun Bao, Huiquan Li, Yi Zhang

458 Gemma Cervantes Torre-Marín, Jenni Arce López, Penelope González Zenteno, Fabián Robles Martínez

459 Sabrina Brullot

460 Hung-Suck Park, Jung-Hoon Kim, Sang-Yoon Lee, Shishir Kumar Behera

461 Ban Yong Un, Jeong Hurnkun, Hwang Gyu Hwan

462 Albena Bossilkov

463 Ling Xu, Hongbo Zheng, Chong Chen

464 Albena Bossilkov, Karin Schianetz
465 Minoru FUJII, Tsuyoshi FUJITA, Shizuka HASHIMOTO

466 Benoit Charriere, Suren Erkman
467 Toru Matsumoto, Tadashi Tsuruta, Atsushi Fujiyama
468 Han Shi

469 Matthew J Eckelman, Marian R Chertow

473 Monika Olsson, Sviatlana Mefodieva
474 Carla L. Simões, Susana M. Xará, Carlos A. Bernardo

475 Panate Manomaivibool

476 BAHERS Jean-Baptiste

477 Qiong-hua Zhang, Xiao-chang Wang

479 Elsa Olivetti, Jeffrey Dahmus, Susan Fredholm, Jeremy Gregory, Randolph Kirchain
480 Petri Peltonen
481 Paula C. Oliveira, Filipa Charters Taborda, Marta Cabral, Fernanda Margarido, Carlos Nogueira

482 Mark Dempsey, Dr Lauren Basson, Dr Kirstie McIntyre
483 Vered Doctori Blass

484 Vered Doctori Blass, Roland Geyer

485 Magnus Bengtsson, Chika Aoki, Shiko Hayashi, Yasuhiko Hotta, Yoshiaki Totoki

486 Atsushi Terazono, Aya Yoshida

489 Catarina Bjelkengren, Jeffrey B. Dahmus, Theresa M. Lee, Richard Roth, Randolph E. Kirchain
490 Arnim Scheidel

491	Renate Huebner
492	Jan Urban, Iva Zverinova, Milan Scasny
493	Jayadi Kamrasyid, Apendi Arsyad
494	Mario Sedlak, Dan Jakubowicz, Petra Bußwald
495	Yasuhiro Hotta, Shiko Hayashi, Chika Aoki, Magnus Bengtsson
496	André Reichel
497	Arnim von Gleich, Christian Pade, Michael Steinfeldt
498	YAGITA Hiroshi, SAKAIRI Satoshi, SATA Tatsuya, SAKAI Yasutomo
499	Anne Sibbel
503	Imtiaz khan, Gul Hassan, Muhammad Ishfaq Khan
504	Monika Olsson
505	Nani Pajunen, Helena Mälkki
506	Ricardo Teixeira, Ana Simões, Oriana Rodrigues, Tiago Domingos
507	Ricardo Teixeira, Tiago Domingos
508	Jon McKechnie, Yimin Zhang, Steve Colombo, Heather MacLean
509	Gudrun Lettmayer
510	Bhandari Govinda
511	Hariharan PV
512	João Miguel Nunes, Fausto Freire
513	Ramon Farreny, Jordi Oliver-Solà, Joan Rieradevall, Ademir P. Barbassa, Bernardo Teixeira, Xavier Gabarrell
514	Satoshi Kojima
515	Kyo Suh, Ryan Barker, Sangwon Suh
516	Jatindra Nath Bhakta, Yukihiro Munekage
517	Wanida Wanichpongpan, Shabbir H. Gheewala, Masayuki Sagisaka
518	Anamika Barua, Kitrphar Tongper
519	Greg Keoleian, Martin Heller, Sarah Cashman, Keri Dick, Derek Przybylo, William Walter

520 Brian Walseth, Yiwen Chiu, Junghan Bae, Sangwon Suh

521 Junghan Bae, Ryan Barker, Kyo Suh

522 Tatiana Valada, Tiago Domingos

523 Tatiana Valada, Ricardo Teixeira, Tiago Domingos

524 Simone Pereira de Souza, Sergio Almeida Pacca, Claudinei Andreoli, Márcio Turra de Ávila

525 Érica Geraldes Castanheira, Fausto Freire

526 Ana Coelho, João Nunes, Fausto Freire

529 Peter Wells, Thaisa Faro Wells

530 Anthony Halog

531 Eugene Mohareb, Christopher A. Kennedy

532 PJ Beers, Frans Hermans, Hanna Schösler, Joost Vervoort, Dirk van Apeldoorn

533 Chia-Wei Chao, Ming-Lung Hung, Hwong-Wen MA

534 Jennifer Howard-Grenville, Frank Boons

535 Junming Zhu

536 Gabriel Grant