POSTER PRESENTATIONS

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Exploration of Technological Change of Japanese Waste Management Industry (Theme F 34)

In Japanese waste treatment and management area, the public sector, mainly referring to the central and local governments here, has adopted various policy and institutional measures to improve their performances. However, it looks like there are less studies on how the actual performance or technology level of the waste treatment and management industry has been evolved over time at the national scale, which inevitably requires the investigation of the private sector's contribution to the waste treatment and management. In Japan, incineration has been dominant treatment and tremendous amount of financial resources input by the public sector has further reinforced that measure over time, which is sometime criticized for its possible overinvestment and contribution to relatively expensive treatment cost. In order to clarify these questions, it is necessary to figure out how we should measure the technological performance of the Japanese waste treatment sector and whether or not the technological level of the sector has been improved. This study aims to shed right on the historical development of the Japanese waste industry by Total Factor Productivity (TFP) approach, which is a part of the economic growth accounting theory. We use a data-set (Japan Industrial Productivity Database 2006) which is developed by the Research Institute of Economy, Trade and Industry (RIETI), Japan and other supplemental data to measure the performance of the waste industry. We also intend to explore whether or not TFP approach could be appropriate to evaluate the technological change of waste treatment and management industry, recognizing that waste treatment and management may not be the same as other services sectors such as telecommunications and transportation; waste treatment and management sector provides the services of handling "bads" rather than "goods" and we are not fully equipped with the evaluation method for this unique service industry.

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Technological Innovations in North American Panel Industry (Theme F 34)

Ongoing market changes and innovative technological developments exert profound sustainability influences on the wood-based panel industry in North America. Technological changes taking place in the sector have led to: (i) increased wood recovery rates; (ii) increased exploitation of traditionally underutilized wood species; (iii) improved mill productivity resulting from increased automation and mechanization; (iv) fewer jobs per unit roundwood log processed in mills (v) fewer forest dependent communities; (vi) reduced energy and labour cost; and (vii) increased resin cost. Over the last 20 years the development of oriented strand board (OSB) markets at the expense of plywood has substantially altered the pressures on forest ecosystems used for panel production. It has also resulted in the closure of several plywood mills in the United States. Development of OSB may be considered to be a transformative technological innovation. The innovation was mainly driven by the pressure of circumstances, defined as a state of overwhelming urgency usually stimulated by policy, legislation or market developments. This paper examines technological innovations in OSB mills that have resulted in more efficient resource utilization and the influence that the market dominance of OSB has had on the sustainability of plywood mills. Mass Flow Analysis (MFA) methodology was used to evaluate wood utilization efficiency along the value chain in North America's panel mills over the last decade, using input-output (I-O) modeling. The results obtained showed 27% reduction in demand for high quality large diameter peeler logs and trebled demand for low quality small diameter 'OSB logs'. Technological changes within the industry have also resulted in a 15% increased yield of panel panels per cubic meter of wood harvested, enabling an increased demand for panel products to be satisfied by the same harvest volume.

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Technology Change and Environmental Management for Cement Manufacturing in the United States (Theme D 27)

Historically, the cement industry has been challenged by strict regulations to reduce its environmental footprint, and by global competition to improving the bottom line of business. Research and development of pollution abatement technology for cement manufacturing is key for effectively operating in this new environment. These new technological advancements compete against established technologies when cement manufacturers evaluate different pollution prevention strategies. This research presents a framework of analysis that benchmarks various emissions control technologies available to produce portland cement in the United States under a full cost approach. The sensitivity of the results was significant considering the variation of the level of available pollution abatement technology (APAT), the substitution level of fly ash with clinker and the potential variations of the environmental regulatory requirements. The results indicate that under the current U.S. technology mix for cement making and if only considering the private costs of a new dry-preheater/precalciner plant ($/ton clinker), existing less efficient plant configurations still present approximately in average 13% lower costs. When integrating a full cost approach, efficient cement production technologies outperform established production processes. Recent public policy changes as a result of tight market conditions for cement in the United States confirm the opportunity for integrating a full cost approach into the decision making process for technology change. Among these are the phase-out the U.S. tariffs on Mexican portland cement imports into the United States (from $26 dollars per ton to $3 per ton), with a national cap of 3 million metric tons until 2008. Limited number of plant retrofits (i.e., 2 cement plant retrofits were reported by the Portland Cement Association in 2005 with a similar number taking place in 2006), existing loopholes in environmental regulatory requirements are a sample of the different factors influencing the technology mix of the cement industry in the U.S.

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Opportunities of Food Waste Management in New York City (Theme B 18)

With approximately eight million residents plus over twelve million commuters and tourists, New York City (NYC) generates over 3,000 tons of food waste every day (DOS 2000; WE ACT, 2006). After the City shut down its last landfill in 2001, almost all the waste generated in the City has been exported outside its boundary. When mixed in the municipal solid waste stream, food waste not only causes decay and odor, but also complicates the collection and transportation of other types of wastes. To manage the food waste problems, the City has implemented several short-term composting programs but did not receive satisfactory participation rate as implemented in some other cities, such as Seattle. This suggests that food waste management in NYC needs to address the City's characteristics and the solution will be sustainable only if it is cost effective. This paper aims to raise public's awareness of food waste problems and seek policy implications to enhance the effectiveness of food waste management in NYC, as well as in other cities that share similar characteristics. I first provide a brief review of the NYC's pilot programs on food waste management and discuss the barriers for a large scale implementation. Based on the findings from recent technical research on food production, consumption, and disposal, I conduct a quantitative study of life cycle analysis of food products. In the case of NYC, I quantify the environmental impacts currently caused by food consumption and demonstrate the potential benefits of converting food waste to energy. I conclude with a discussion of the opportunities for NYC to convert food waste to energy and some suggestions to facilitate the implementation.

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Bayesian Material Flow Model (Theme F 34)

In this poster, we demonstrate the results of a mathematical model useful for the analysis of material separation processes characterized specifically by four qualifications: a target material A and a non-target material A'; a probability r of correctly identifying the target material (value-retention); a probability q of correctly identifying the non-target material (waste-rejection); and constant r and q over the concentration ratio of the mixture A / (A + A'). Given these propositions, we have used Bayes' Theorem and mass balance equations to achieve a number of valuable results. We demonstrate that with a proper index, the model is easily capable of handling complex systems, such as multiple separation steps and keeping track of multiple outflow streams, some of which become concentrated and some dilute. Relationships between each possible stage in a separation tree are defined and quantified. We also establish numerical conditions based on a cost-benefit analysis for determining whether one or more re-entrance flow can be successfully instituted in a given system and whether a waste stream should be enriched and re-entered for additional value. These conditions have the potential to save a substantial amount of target material from the waste stream, increasing the feasibility and profitability of the process as a whole. These results constitute a rigorous treatment of the rudimentary structure and uses of the model [Albino 2006] based on previous groundwork [Gutowski 2006]. Finally, we compare this model with results available in the literature for recycling systems.

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Applying Social Network Theory to Concrete Industry Standards: Identifying Levers for Sustainability in Concrete Infrastructure (Theme D 26)

Introducing new products and processes into the concrete and concrete products market is extraordinarily challenging. The concrete industry is highly fragmented by geography and agency. The diversity of materials and interests involved in placing concrete impedes widespread technology uptake. To accommodate divergent materials and interests, the industry relies heavily upon consensus guidance and standards to disperse knowledge and govern material specifications for new products. Additionally, multiple organizations within the industry author unique standards that govern various aspects of concrete and construction. Therefore, industry standards present significant opportunities and barriers for innovation. This research evaluates ways in which specific concrete industry standards govern sustainable concrete practice and products innovation diffusion. Networking the landscape of concrete standards is vital to understanding their relationships to each other and identifying the central/prominent standards, which have the greatest impact on the industry. This study employs a two-phase process by which Social Network Theory was applied to the American Society for Testing and Materials, American Concrete Institute, and the American Association of State Highway Transportation Officials specifications related to concrete bridge decks in order to identify the most prominent standards and case-studies identified leverage points for sustainable concrete practice. Social Network results demonstrate that the most prominent specifications are those related to the fundamental constituents of concrete and practice. Specifications related to cement, aggregates, and chemical admixtures and practices including the building code and guidance for mix proportioning are the most prominent. Case studies of these standards address opportunities and barriers for sustainable concrete product and practice diffusion. Additional case studies of Coal Fly Ash, Ground Granulated Blast Furnace Slag, Cold Weather Admixture System, and Shotcrete provide additional

insight into techniques for using industry standards to introduce new products.

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Waste Disposal and Waste Pollution Management in Urban and Rural Areas (Theme B 18)

Both wastes and the crude disposal techniques have created subtle and yet serious environmental pollution havoc in many developing countries. This has lead to the degradation of abiotic and biotic components of these nations' ecological systems. Poor industrial waste disposal systems as well as the indiscriminate and inappropriate domestic litter disposal habit have been identified and proved to be basic features in rural settlements, semi-urban areas and urban centers of the developing world. These have seriously contributed to environmental pollution and ecological deterioration. The major reasons for these were identified to be inadequate information and insufficient modern waste disposal facilities. This paper highlights the use of simple, yet efficient waste disposal techniques and recommends the adequate supply and optimal utilization of trashcan and rubbish drums in private and public places; the consistent and wide use of recyclable materials and recycling equipment; information flow and training of all on the use of new techniques and methods; and the need for the production and/or introduction of other appropriate technology and policy to enhance the implementation and execution of proper waste management schemes that will contribute to a cleaner and safer environment in developing countries.

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Analysis on the Modern Situation, Production Intensification and its Overall Growing and Promotion **(Theme A 11)**

Price increasing on oil and petroleum products goes up today and will be raising in future as well, therefore it is difficult count on oil influx as natural raw material. At the same time there is a great growing demand on engine fuel, lubricants and other petroleum products such as rubber and etc. There is a need of shifting the oil refinery process into much more intensive development way by increasing of fair oil products selection, by using of secondary proceeding of oil raw materials retreatment. Previous price index requires more consumption of raw products and energy: the more petroleum is refined, the more will be manufacture of commodity production, and therefore, as a result that will couse increase of labour productivity and salary funds. In petroleum refinery proceeding commodity production price consists in more than two third of raw petroleum cost, gas condensate, fuel and energy. The outcoming conclusion from such situation, is that in what degree enterprises are interested to consume more raw materials and how much “profitable” is that for economy. There is absent of stimulus in deepening the petroleum refinery, production increasing of fair petroleum products and economy in raw materials. The main indexes and achievements can be reached at minimum consumption increase of raw materials, financial and fuel-energetical resources. These tasks can be resolved on the basis of improvement of petroleum products quality, complex utilization of raw petroleum materials, mastering of modern technological processes “know-how” and high productive equipments. In this connection particular significance and important should be given to working out of scientific grounded economic methods of management for all administration levels. Economical methods stimulate financial and social interest and the responsibility of working collectives, as well. In improving of economical methods of administration the key role should be played by economical standards.

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Global Industrial Ecology – the North-South Link: Lessons from Research and Education
(Theme A 1)

This contribution argues for a global holistic view of efforts of realizing sustainable development from the perspective of North-South relationship that manifests in different forms, from diplomatic exchange to trade relationships. The creation of better knowledge base about the global impact of this relationship is vital in making informed decisions and developing national and regional policies. Research and education is discussed as a vehicle of such knowledge using examples. The first example is from a research project on environmental impact of Swedish import from countries outside EU. As a second example, lessons from two lectures of a graduate programme in Sustainable Technology at the Department of Industrial Ecology of RIT are discussed. Preliminary assessment from the research project that focuses on greenhouse gases shows that an improvement in the production system in one country (e.g. Sweden) will be far from solving the problem, in this case the climate change problem, unless an equivalent effort is exerted in other parts external to this core system. The experience from the courses reveals that there is a lack of knowledge on the students' side regarding the global implications of the over consumption of the North and the severe poverty in most of the South. The lectures have been serving a catalyzing function in mitigating this lack through discussions around the ecological, economic and social implications of over consumption in the North. The quest for a global industrial ecology should be an established part of research and education activities of higher education institutions. As today's students will be the next generation of policy makers, once equipped with the necessary knowledge they will not afford to ignore the global implications of local productions and consumptions.

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Recycling Information of Parts and Materials in End-of-Life Vehicles (ELVs) Recycling Industries in the United States **(Theme A 1)**

As the EU ELV Directive (2000/53/CE) modifies the current framework for dealing with end-of-life vehicles (ELVs) at the European level, automotive manufacturers are facing to reduce the environmental impacts and improve recyclability through the entire life cycle of their vehicles. The ELVs are a major source of scrap metal since the automotive industries are among major consumers of metal resources. The usual treatment of these ELVs in recycling system includes depollutioning hazardous materials, selective dismantling high-value parts, and size-reduction through shredding process for materials recovery. The automotive recycling industry generates approximately $8 billion in sales per year in the United States. Therefore, there is need for national database to provide economic and environmental information of parts and materials in these industries. It is the objective of this study to construct national database and its system by quantifying and estimating the secondary production of scrapped resources in ELV recycling industries in the United States. The database consists of general and recycling information: the statistics of ELVs, average vehicle unit per person, and economic (purchase cost, disassembly cost, maintenance cost, and selling cost etc.) and environmental information (energy use and waste quantity) about parts and materials production of ELVs industries in each state. This research also estimates the quantity of illegally abandoned retired vehicles and the vehicles imported or exported among states. Furthermore, the database will provide an idea for main vehicle manufacturers and policy makers such as how they meet their targets for waste and manufacturing cost minimization with minimized virgin material use as well as maximized recycled materials.

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Life-Cycle Resource Mileages for Material Flows: Metals Used in Automotive Manufacturing in the United States (Theme A 1)

Transportation and its environmental implications have received wide attention in connection to the globalization of transportation distances. Transportation produces relatively low value added but high environmental impacts. The concept of life-cycle resource mileage is presented and applied to copper, aluminum and steel used for motor vehicles produced in the United States in 1980s and the early 2000s. The working hypothesis is that transportation distance for basic metals will increase in the course of globalization counted here between 1980s and the early 2000s. It is the objective of our study to gain insights on the implication of the globalization to the resources flows by quantifying the distance that resources travel during their life-cycles. Geographical locations of the major ore producers, ports of export and import, intermediate processes and final assembly lines throughout the supply-chain of motor vehicles and the distances between them are identified. The use and post consumer activities are modeled and the overall life-cycle resource mileages are calculated. As multiple supply routes are involved for each metal varying quantity of shipment, a simple matrix approach is used to calculate the weighted average distance of travel. Contribution analysis is performed to highlight the major nodes that demand further attention. The results show that the life cycle mileages for steel and aluminum have increased in the early 2000s. In contrast, the life cycle mileages for copper have decreased in the early 2000s. The average resource mileages for steel, aluminum, copper are calculated as 8,189, 6,515, 7,224 miles respectively in the early 2000s. Although the quantity of imports for the three materials dramatically increased since 1980s, the average distance are changed +8% ~ -14%. Thus, the decreased portion of international transportation for the imports for copper causes the difference in the life cycle resource mileages.

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Teaching IE at Executive Level : Reasons, Objectives, Curricula and Target Audience for the Setting of a New International Continuing Education Programme in IE in Lausanne, Switzerland **(Theme G 36)**

During the last decade, industrial ecology (IE) curricula have started to be offered at the Bachelor and Master levels by an increasing number of universities worldwide, particularly in the US and in Europa. However, no course (or very few) on IE appear to exist at the postgraduate level, targeted to executives and professionals. In this context, the Federal Institute of Technology in Lausanne (EPFL) and the University of Lausanne (UNIL), Switzerland, are jointly organizing a new continuing education program in IE. The target audience is senior managers, decision-makers, as well as policy makers - coming from both public and private sectors. Among its main objectives, this executive training course promotes awareness in IE, encourages public-private partnerships, shows that implementation of sustainable development is compatible with high added value, and helps to formulate find concrete and workable solutions. This international professional development programme provides business and public sectors the state-of-the arts concepts of IE towards implementation, and thus requires the elaboration of a tailored and specific curriculum, distinct from undergraduate curricula. The reasons for setting and implementing a continuing education curricula in IE in Switzerland are discussed. Key identified issues are investigated, including the project objectives, as well as the detailed themes and syllabi. The challenges of prospecting for the targeted multi-stakeholder participants are demonstrated. The feedback from the first Executive Course, to take place in early 2007, are presented.

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Refillable Systems as an Approach to Change Household Consumption of Packaging (Theme A 14)

The wide spread use of refillable packaging is recognised as having the potential to reduce the amount of packaging going to landfill. However in the past, attempts to extend the use of refillables beyond a few traditional areas have met with little success and as of mid 2003 no major retailers in the UK operated any schemes in the reuse of primary packaging. It is believed that recent advances in technology, particularly new forms of retailing such as internet shopping and the development of product service systems may provide the opportunity to re-evaluate the role of refillable packaging systems. The innovative project, reported on in this paper, aims to address these issues and consider different ways of delivering refills in a product service systems context, to encourage the purchasing of refills whilst enhancing customer convenience and reducing packaging waste. The overall aim of this two year research project is to develop refillable packaging systems using a product service system approach and investigate their feasibility within the personal care market. This paper outlines the benefits of adopting refills in certain markets and presents the results of the design phase were a number of innovative concepts were developed. These concepts were tested with consumers to consider which would be suitable for further development, prototyping and testing within the market.

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Sustaining Fresh Water Resources within Urban Area- A Case of Bhopal City: A City of Lakes in Central India (Theme B 16)

Finding enough water is becoming a difficult task day by day due to increasing water demands due to urbanization which leads to the growth and development of city, but in turn brings adverse impact on the available precious water recourses. The Bhopal city- a city of lakes in the heart of India is no exception to this and over a period of time, grave situation has cropped in. Urbanization has brought a change not only in the demographic structure of the city but has also disturbed the physiographic features including the water resources. As a result all these lakes have become subjected to various environmental problems. A geological, geomorphologic and hydrological study of the Bhopal Urban Area has been conducted and related with the urban water demands both, present and future. We have tried to analyze how development has proved to be fatal for natural drainage system of water and has polluted the existing water reservoirs, both ground and surface. Our study comes up with a solution for sustainability for the precious water resources of the city. This is done by a Ground water potential zoning plan based on various thematic maps generated from remote sensing data which has been integrated and the potential areas have been identified on the basis of qualitative assessment. Secondly, we have given a planning proposal for the sewage system of the city so as to prevent the surface resources being polluted.

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Hybrid Life Cycle Assessment: Modeling On-Site Construction **(Theme A 4)**

One tool available to assess and manage the environmental impacts is life cycle assessment (LCA). Existing research considering the life cycle impacts has generally utilized one of two LCA techniques, process-based and economic input-output (EIO); however, both techniques have distinct advantages and disadvantages. A hybrid approach combining both methods' advantages has been proposed and this research explores and develops hybrid modeling by specifically examining the construction industry. Although construction is responsible for many environmental impacts, including air emissions, land usage, waste generation, water use, and energy/electricity use and demand, it is an important step in the life cycle of a building that has a limited amount of research. This research attempts to fill a gap in the existing knowledge of the building life cycle and hybrid modeling. Because of wide variability in the construction industry, completing an LCA requires utilizing both LCA approaches. The process-based method will complement the more task-specific construction processes. The EIO-LCA method will be used to determine an appropriate boundary and to help develop a life cycle inventory for equipment manufacturing, construction support systems, and temporary construction materials. Model results will be presented, along with a discussion on equipment combustion emissions and their relative impacts.

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Sustainable Technology a New Extended Masters Program at KTH in Stockholm (Theme G 36)

Sustainable development is by definition a multi disciplinary area involving social and economic development in the limits of ecological carrying capacity. Technology has to play a vital role in the development of sustainable societies. It is not possible to discuss solutions and new technologies on waste handling, pollution prevention and greenhouse gases without also looking at industrial production of goods, consumer choices, legislation, and ecosystem restrictions. These understandings formed the masters programme Sustainable Technology at Industrial Ecology at KTH in Stockholm. The program started in September 2004 as a 1,5 year programme and are now from 2007 extended to a 2 year masters program. Until today more than 70 students from all over the world have started the program. Experiences from these 3 years are several and includes e.g discussion about relation between broader and deeper knowledge; social differences between different cultures and frameworks from a global world etc. These experiences have formed the new the Masters programme in Sustainable Technology, the idea with the program is to give students with different background specialties a possibility to learn management and methods for implementing technology from an Industrial Ecology and sustainability perspective. The new programme is built up around some important mandatory courses the first year. Second year the program will be deeper and dived into to branches; environmental technology and environmental management and the thesis project work will also focus more research methods and preparations. In this paper we will discuss our experiences from the three first year of the program and discuss how these experiences have effected the formation of the new program, and which issues have been the most important.

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Practical Use of LCA-Based Tools for the Built Environment –A Comparative Study Using Two Swedish Tools **(Theme A 4)**

The construction sector has a major responsibility for society's impact on the environment, and growing interest from legislators – along with the prospect of tighter regulation – means that the need for environmental information is increasing. Environmental assessment tools serve to improve the construction sector's environmental performance, as they help illustrate the consequences of different choices. In Sweden two Life Cycle Assessment (LCA) based tools for the built environment have been developed during the last years: the 'Environmental Load Profile' (ELP) and 'EcoEffect' (EE). Both are now standing in front of an implementation phase and in this paper we investigate how the tools work today. The purpose is to survey differences and difficulties, when practically using the tools. Because of the different approaches used in the ELP and EE it is difficult to make a complete comparative assessment and the tools give only few individual results that are comparable. Despite of an application of the comparative parts on equal basis (i.e. the object specific data) differences in results were found for the areas of environmental impact studied: global warming, photochemical ozone, acidification and eutrophication. The data presented in this paper indicate that the following factors give rise to statistical differences: (i) differences in material grouping and life expectancy for the construction materials used, (ii) diverse Life Cycle Inventory (LCI) data for material, electricity and district heating, consumed during the life cycle of the studied object and (iii) different impact analysis (i.e. classification and characterization). If the same LCI-data and impact analysis are used the assessment results become equal for the impact studied: global warming. The required level of knowledge to compare, analyse and evaluate assessments made with the ELP and EE is relatively high, which creates a barrier towards increased tool use.

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Systems Engineering Modeling: a New Tool to Achieve Industrial Ecology Project (Theme D 27)

Industrial Ecology (IE) concept first appeared in scientific literature in 1970 but has not really been seriously considered before being introduced by R. Frosch and N. Gallopoulos in 1989. Today, many IE applications are developing all over the world. Nevertheless, most projects are still only considered as pilot project: they are neither self-organized nor self-financed and are sometimes interrupted, waiting for further funds. Literature review shows that behaviors and decisional processes at territorial scale need to be modified to develop IE concept in long-term perspective. Unfortunately, this change did not seem to happen. That is why we can wonder if IE project is indeed able to achieve sustainable development targets, using methods and recommendations available in scientific literature. Our review of these methodological propositions used in IE projects shows they do not take the particular context of the region into account. Furthermore, they are dispersed in literature and refer to specific aspects. It seems that no global procedure does exist. Considering this, our methodological proposition aims at giving a hierarchical representation of the main tools and methods thanks to systems engineering modeling. The first original feature of our proposition is twofold: suggest an inventory of relevant methodological tools and recommendations already available; when gaps are identified, develop new methods based on experiences reviews. For example, industrial symbiosis is often presented as offering both environmental and economical benefits to the participants in the network, but few tools are today available to document and quantify these benefits. The second feature of the model is to more consider the particular context of the region. Our model indicates what the best procedure is to achieve an IE project according to the territorial economic, political and social context. One of the expected future outcomes of this model will be to test it on French experiences.

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Region-Scale Eco-Industrial Master Planning & Strategy: Planning for Long Term Economic and Ecological Prosperity **(Theme B 15)**

In communities where economic vitality depends on light and heavy industry, eco-industrial networking (EIN) is one of the key approaches used to help businesses and communities meet their sustainability objectives. EIN supports collaborative partnerships, or networks, between businesses, local governments, and wider communities resulting in more sustainable resource use. More and more communities are working together to adopt a regional approach to implementing EIN in their industrial areas. Kwinana industrial area (WA), Saxony-Anhalt, Germany, and Styria, Austria are three examples of region-scale EIN. The Alberta Industrial Heartland (AIH), and Greater Sudbury, ON are also establishing themselves as North American leaders in region-scale EIN. Building on initiatives such as Complementary Area Structure Plans, the AIH Association (AIHA) now aims to scope and implement a regional Eco-Industrial Master Plan (EIMP). The AIHA sees the EIMP as a means of leveraging its current activities, and implementing them in a more strategic way, to ensure the region remains vibrant and prosperous. The EIMP will help to provide an overall framework that integrates other eco-industrial projects and existing AIH initiatives, increases regional knowledge sharing, and maximizes the triple bottom line return on investments. The Greater Sudbury region, home to the largest integrated mining complex in the world, has also embarked on a region-scale EIN strategy. This strategy will concentrate on waste materials, by-products, and under-utilized energy sources and services. In addition to the strategy, information gathered in a region-wide resource inventory of >9,000 businesses and utilities, will be used to populate an online synergy finder tool. This presentation highlights key components of the AIH eco-industrial master plan and the Greater Sudbury Regional EIN Strategy, highlighting the importance of a systems-based approach to planning, as well as the critical need for accurate and available data.

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Eco-Industrial Networking: Greening Infrastructure to Create Sustainable Communities **(Theme B 19)**

Eco-Industrial Networking (EIN) creates collaborative networks between businesses, governments, and communities to more efficiently and effectively use resources, such as materials and energy, but also including land, infrastructure, and people. EIN is a tool for implementing the theoretical principles of industrial ecology. Historically, the industrial ecology field has focused on 'greening' business practices, particularly in the private sector. However, municipalities are realizing the multiple benefits of applying EIN to public infrastructure systems. Local drivers for green and integrated approaches in Canada include: an unprecedented infrastructure deficit in Canadian communities; and a national commitment to the reduction of greenhouse gases. EIN supports green and integrated infrastructure, which includes systems that are distributed, service-oriented, interconnected, ecological, low impact or renewable, context-appropriate, and adaptable. Systems are also multi-objective, achieving goals and targets set in a variety of areas. For example, by reducing paved surfaces, one can reduce the capital, operating, and maintenance costs of roads, as well as stormwater runoff. Moreover, by using the EIN approach, infrastructure systems can be viewed as 'anchor tenants', linkages from which emerge and support entire communities. Applying a systems perspective to infrastructure design and operation allows one to embrace a variety of important opportunities not the least of which is community economic development. This presentation includes two major examples of applying EIN to community infrastructure systems. The first is an Albertan community, designing a cold climate ecological wastewater treatment system (Solar Aquatics^{TM}) and discovering important economic development opportunities in addition to wastewater treatment. Second, is Innovista Industrial Park, where infrastructure will be strategically shared where feasible and will be both ecologically and efficiently designed and operated.

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Sustainability in the Largest Oil and Gas Region in Canada: Green Industrial Development in Fort McMurray, Alberta **(Theme E 29)**

Eco-industrial parks (EIPs) represent the application of eco-industrial networking within an industrial park. EIN supports collaborative partnerships, or networks, between businesses, local governments, and communities resulting in more sustainable resource use. EIPs support strategic economic development; by-product synergies; ecological design; green infrastructure; and shared business services. The Regional Municipality of Wood Buffalo (RMWB) ranks, by area, among the largest municipalities in North America. This rapidly growing community is also home to the world's largest oil sands industry, with near term projected investment in this region estimated at an astounding $56 billion. This description does not necessarily paint the picture of a 'green' community; however RMWB is rapidly taking the lead in eco-industrial development in Canada. The newest industrial park in RMWB will be an environmentally efficient and sustainable industrial park unique to this region and others. It will feature 'green infrastructure', sustainable design approaches, and will demonstrate the municipality's commitment to sustainability and innovation. This presentation will highlight what makes this eco-industrial park internationally unique. There are several major factors that pose significant barriers as well as provide important impetus for success in this eco-industrial development. These include: rapid economic growth and activity in the region; sparse availability of industrial land and therefore significant demand from both large and small (local) businesses; very tight timelines; interest from the largest oil and gas companies in the world, including investment potential and collection of greenhouse gas emission credits; and an existing stigma that this location constitutes the "polar opposite of sustainability". All of these factors will be examined, including how challenges have been addressed to date. Currently in the master planning phase, construction on this industrial park is slated to be completed by Spring 2007.

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You Mean That Isn't Legal? Policy Frameworks That Support Eco-Industrial Parks: Innovista Industrial Park and Other Case Studies (Theme E 29)

Eco-industrial parks (EIPs) represent the application of eco-industrial networking within an industrial park. EIN supports collaborative partnerships, or networks, between businesses, local governments, and wider communities resulting in more sustainable resource use. EIPs support strategic economic development; by-product synergies; ecological design; green infrastructure; and shared business services. In Canada, the majority of new EIPs remain in conceptual design and planning stages, with the transition from concept to implementation remaining impeded by significant economic, social, and policy barriers. One of the most important barriers (AND drivers) to the successful design and operation of EIPs is the local policy framework, including community plans, economic development strategies, and land use bylaws. This presentation will introduce three case studies where strategic policy and planning tools have been created, adapted, or re-designed to support eco-industrial networking, particularly the development of EIPs. The case studies include two EIP developments in the province of Alberta, and one municipal policy review for the City of Richmond, B.C. In Hinton, Alberta, the newly named Innovista Industrial Park (Canada's first greenfield EIP development) pioneered an eco-industrial policy and regulatory framework, including a new "eco-industrial district" zone in the local land use bylaw; and complimentary development guidelines, which were tied to the zoning. In Fort McMurray, AB, a similar approach is being taken for their new EIP, but with more mixed uses (light/med industrial and highway commercial) permitted on the site. In Richmond, the entire policy framework was reviewed and recommendations were made for enhancing eco-industrial language as well as modifying current processes (e.g. business data collection and management) that would facilitate eco-industrial networking, and EIPs, in the future (e.g. tying business data to GIS system).

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MESVAL, Valuation Initiatives in the Frame of Industrial Ecology (Theme E 29)

MESVAL is an Industrial Ecology project that has created a Network of Technological Centres and other organizations in order to cooperate in IE projects in the Mediterranean area. The MESVAL network is composed by different technological centres, universities and other industrial organizations in Catalonia (Spain), Tuscany (Italy) and Peloponnesus (Greece). Different steps have been followed to achieve the MESVAL objectives: 1. Creation and update of a MESVAL web page and strengthening the interregional network 2. Development of flow diagrams: first, qualitative and quantitative flow diagram for the different industrial sectors have been worked out; afterwards the flow diagram has been analysed to match the outputs and inputs of different industries. 3. Laboratory valuation assays 4. Design a set of sustainable development indicators and implementation of indicators to the valuation assays results in order to chose the most sustainable valuation 5. Contacts with firms in order to develop a pilot plant of a chosen valuation 6. Writing the valuation strategies document and contributing to the strategic plans for regional waste management. Concerning activity 3, MESVAL partners have developed the following valuation: A. Valuation of heavy metals from galvanic exhausted floats to be used as a tanning agent in the leather tanning processes. B. Cr(III) salt for the tanning processes obtained from the tanning exhausted baths. C. Valuation of protein wastes from leather tanning processes. Application: cosmetic uses; D. Valuation of fatty wastes from leather tanning processes. Application: machinery lubrication; E. Fertilisers made with fleshings (tannery wastes) F. Insulating panels made with tanned wastes and gelatine or plaster. G. Textile and tanning wastes as main components of acoustic and thermal insulating panels H. Collagen from the tanning industry as a sensor to test flavonoids in food or natural products I. Wastewater from olive oil production as a source of tannins and oils for the tanning industry A sustainable indicator set has been designed and applied to different valuation

initiatives in order to decide the most sustainable valuation. The network has been strengthen with meetings, a web page, a European conference, etc.

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Application of Industrial Energy Integration Method for Sustainable Development in Korea
(Theme C 22)

Industrial Ecology (IE) to make industrial systems emulate more efficient and sustainable natural systems is getting more and more attention in Asia. In the case of Korea, a main issue is to retrofit existing industrial complexes. The Yeosu industrial complex is the largest petrochemical complex in Korea. Due to the characteristics of the petrochemical industry itself, the Yeosu complex consumes a large amount of energy which is about 20 million TOE/yr. More than hundred companies are operating their plants in the complex. The individual companies have been trying to reduce energy uses during the last 40 years. Therefore, individual companies are operating their plants close to optimum energy efficiencies. However, high oil price and environmental regulation on CO_2 reduction are forcing us to further improve the energy efficiency of the whole complex. In this study, we optimized the steam network in the whole petrochemical complex. The major finding is that the utilization of the medium pressure steam from the two incinerators can significantly contribute to reducing energy uses and environmental impacts. The energy saving is expected to be about $7 million/yr in the complex.

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Life Cycle Cost Analysis in Road Infrastructure Management: Evaluating the Application by Michigan DOT (Theme A 4)

The 6.4-million-kilometers road infrastructure in the United States has become a massive financial burden to the federal, states and local governments. Every year, all levels of governments spend over $130 billion in highway-related activities. The situation is expected to become worse when most of the interstate highways built in the 1960s under the Federal-aid Highway Act of 1956 approach the end of service life and need reconstruction. As a means to explore the possibility for more efficient investment, life cycle cost analysis (LCCA) has become a common practice in road construction during the past decade. It enables pavement engineers to conduct a comprehensive assessment of long-term costs, and ideally highway funding can be spent more optimally. Michigan Department of Transportation (MDOT) has adopted LCCA in the pavement selection process since mid-1980s, and more than 120 multi-million road projects has been carried out by MDOT. However, the literature is limited in examining how LCCA is actually applied by states DOT and how effective their respective LCCA procedures are projecting the pavement type with the lowest life-cycle cost. Therefore, using case studies, this paper seeks to analyze MDOT's accuracy in projecting the actual costs over pavement service life and choosing the lowest-cost pavement alternative. Ten highway sections in Michigan were chosen. Their estimated and actual accumulated costs and maintenance schedules were compared. While results indicate that MDOT LCCA procedure correctly predicts the pavement type with lower initial construction cost, actual costs are usually lower than estimated by at least 10%. It is also uncertain whether practicing LCCA will generate the expected level of cost savings for MDOT on the studied pavements, partly because MDOT's model is not site-specific enough and there are differences between estimated and actual costs of maintenance activities.

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An Agent Based Model to Study the Impact of CO_2 Emission-Trading on Electric Power Generation (Theme D 26)

To achieve CO_2 emission reductions as agreed in Kyoto, CO_2 emission-trading (CET) has been setup in the EU as of January 1st, 2005. The major argument is that “the invisible hand” would lead to emission reduction at the lowest cost. We have developed a prototype Agent Based Model to simulate the impact of CET on real emissions of the Dutch power generation sector that is subject to CET. Around the world, electric power generation creates the major share of CO_2 emissions. The Dutch power generation sector is a suitable case, because it is physically shielded from other EU countries by way of the limited interconnector capacity. A preliminary specification of the long-term aggregate impact of CET on CO_2 emission via disaggregate investment decisions by individual electric power producers is presented. An agent-based approach quantifies the processes in this complex system to show the evolving portfolio composition in Dutch electricity generation subject to investment, mothballing and divestment decisions by companies in an oligopolistic market setting. The model definition includes the definitions of agents’ behavior and technological installations and exogenous data trends modeled in scenarios. Agents autonomously decide whether to undertake specific actions. To limit the scope of the simulated power world we assume an absence of incremental innovation, no change in regulatory regime and a fixed number of electricity producers. The results show that CET has significant impact on the actual CO_2 emissions, but probably does not lead to the preferred level of reduction. CET has significant impacts on the evolving portfolio distribution, lowering its CO_2-intensity. However, significant effects on CO_2 emission only emerge after three to five decades (!), because of the long technical and economic lifespan of power generation facilities. Therefore, it is concluded CET alone will not result in timely emission reduction in the power sector.

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Resource Recovery form Waste to Wealth: An Indigenous Sustainable Agrarian Practices Using Wastewater at East Calcutta Wetlands, a Ramsar Site in India **(Theme C 20)**

At the eastern fringe of Calcutta city is the locale of the biggest urban wetland ecosystem, the East Calcutta Wetlands (22°27'N 088°27'E), a Ramsar Site in India. For the past century industrial effluents mixed with municipal sewage (around 50,000 m^3 d^{-1}) and solid wastes (around 2500 MT d^{-1}) of the city are being deposited in the wetland areas without any pre-treatment. The wastewater is productively utilized for pisciculture and agriculture indigenously developed and maintained by the local people of the area. Around 10,915 metric tonnes of fish is produced annually from 286 large wastewater-fed fishponds, spread over 3,832.27 ha (over 30% of the total wetland area). The hydraulic regime of these shallow ponds (locally called, Bheris) as maintained by the farmers, is unique, having fairly high photosynthetic activities, involving natural biological purification against the regular loading of the wastewater at day time. Water hyacinth (Eichhornia crassipes) culture is also retained around the periphery of the ponds for preventing bank erosion by the surface waves, providing shades to the fish during summer and purifies pond water. Garbage filled cultivations is a common practice developed by farmers yielding nearly 370,650 $kg.ha^{-1}Y^{-1}$ of vegetables. The planning includes alternate bands of garbage filled lands and elongated trench-like ponds, locally known as ‘jheels’ for detaining of raw effluent before used for irrigation. The unique resource recovery by shifting of open loop system to a closed loop one for production of new processes utilizing wastes is evident in our study site. Making use of the wetland ecosystem and the tropical climate, the technicality of application of the composite effluents into edible productions, developed through the years of practices providing livelihood of around 50,000 agro workers in the area. The work thus envisages the three dimensions of sustainability: eco-centric, techno-centric and socio-centric aspects.

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Urban-Rural Relationship in Land Management : Economic Waste Management System for Sustainable Environment in India **(Theme B 18)**

The Maharashtra state in India has 325 Towns and 33 cities. There are 232 municipal councils including A ,B, and C class , and 12 municipal corporations .These local authorities are looking after the civic administration at town or city level .These towns are now facing the acute land problem for disposal of solid waste (Domestic waste, market waste and industrial waste) causing the environmental Pollution. The combined effect of this pollution is degradation in the soil , water and air quality , which ultimately affect the civic health in these areas. The farmers from the peri-urban areas are bringing their agricultural products including vegetables in the city market. This creates large amount of the solid waste from vegetables as well as animal excreta especially organic waste, which contain more percentage of moisture content. The economic instruments for reduction of solid waste cannot be successfully implemented with out pre-existing appropriate standards and effective monitoring and enforcement capacities. Although economic incentives have been viewed as alternative to the traditional approach, they can not be considered as short cuts to the solid waste management. The source reduction, source separation and producer responsibility, these three factors are critical in developing and designing ecological sanitation model for economic and optimum waste management model using composting system in towns of the Maharashtra . The municipal councils and local authorities are spending large amount of their budget on solid waste management system, which is major constraint in expanding other civic services to citizens. This research study deals with present scenario in environmental management using compost using the Organic waste such as night soil, animal excreta etc. and its application in agriculture and forestry from urban and rural region, past efforts to ensure the economic development of compost process from agriculture waste.

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Factual Obstacles of Executing Eco-Industrial Plan in Developing Region Rich in Mineral Resources: A Western-South China Case Study
(Theme C 20)

The areas in Western-South of China are rich in mineral resources like coal, phosphorus, etc. Their industrial growth has been depending on the expansion of raw minerals and primary products exportation to the developed regions for quite a long time. The situation is changing. The Development Strategy for West China launched at 1999 promotes the area's industries upgrade, with urgent needs to the ecological performance improvement and environmental protection at the same time. Industrial ecology as one of the development guiding approaches entered the local authorities' vision field in 2002 around. With the help from consulting institutions, innovative industrial development plans were announced, most of which mentioned to extend the product chains to take advantages of the rich mineral resources, and adopt measures such as comprehensive waste utilization, eco-industrial park construction to lessen negative environmental impacts. Some obstacles emerge while carrying out these plans. This paper presents a case study of the execution of the 2003 industrial development plan of Kaiyang, a county well-known for its high quality phosphorus mineral located in Guizhou Province, Western-South China. Based on stakeholder interviews and project tracking, factual obstacles like benefit conflicts among companies, flaws of the authorities system, mismatch of financial policies, lag of industrial technologies, etc are thoroughly discussed.

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A Multi-Media Stocks and Flows Model for Regional Water Budget Analysis (Theme D 27)

A dynamic Stocks and Flow (STAF) model is applied to regional water budget analysis, as a part of a state-wide scenario project. The project is yet in an early stage, and the current poster presentation highlights the methods and the model-framework part of the study. Over the last decade the accuracy of water budget projection has been significantly improved by using advanced computational capacity and better sensor systems. However, new types of challenges in water budget analysis emerged: global climate change is altering the patterns of precipitation in an accelerated rate; watershed hydrological regimes also have been disturbed due to the rapid land cover changes. Other human-driven changes that are of relevance to water budget analysis include population growth, urban sprawl, changes in vegetation and agricultural practices and changes in the patterns of water appropriation. The current study is aiming at better understanding the channels of water distribution via the interactions between the antroposphere and the ecosphere, leading to envisaging the future of regional water budget in Minnesota. First a regional hydrological map will be drawn, which will show the overall water inputs and outputs. The hydrological map will be refined throughout the project by identifying and distinguishing major media and relevant compartments. Key parameters that determine the input and output fluxes of the material under study will be identified and their changes over time will be projected considering the aforementioned major anthropogenic interventions. The parameters will be geared to a dynamic STAF model for a long-term simulation linked to the hydrological map, which is expected to help us to better understand the future water budget of Minnesota. The results are expected to help policy makers, local governments and the general public to make an informed decision on the future of water environment in Minnesota.

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An Agent Based Analysis for Optimisation of the Coal-Electricity Supply Network (Theme D 26)

In recent years Industrial Ecology (IE) literature has moved progressively from a focus on conceptual considerations in IE to the need for defensible modeling tools to support decision making and strategic planning., with a focus on industrial networks. One area which shows considerable promise in this regard is the application of an agent based modeling approach to simulating industrial networks. Here independently acting decision makers which impact on the network are captured in terms of functional considerations (such as access to resources), decision making routines, and perceptions of the network, and the impact of both overall network-wide properties and individual agent properties and behaviour on network performance is explored. The approach provides a powerful tool for understanding network performance and conducting scenario analyses in a dynamic environment. This paper demonstrates the application of an agent based analysis to optimizing the overall performance of the coal-electricity supply network in South Africa. Consideration is given to both individual economic and environmental objectives, and to separate use of an overall performance objective using an aggregated indicator approach. Environmental performance is determined using a life cycle model of the coal power station supply chain, which takes into account supply-side technologies for power generation, cooling and ash management, and the impacts of mining and waste disposal. Hence the optimization addresses the whole coal-electricity supply chain. After describing in detail model construction and realization, the paper presents selected results which demonstrate the application in guiding optimal sourcing of coal and scheduling of power stations towards overall network performance. This analysis considers the context of changing network dynamics, outside influences (such as global carbon markets), contractual arrangements and government interventions. Challenges associated with model development are discussed, including data availability, and obtaining information on the decision making routines used by the individual agents.

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New European Policies on Waste Management: Exploring the Concept of Secondary Raw Materials **(Theme A 13)**

The European Commission launched, in 2005, a process intended to revise the Waste Framework Directive. The objective is to establish a basis for a long-term strategy intended to promote Europe as a recycling society that seeks to avoid waste and to use it as a resource. One of the foreseen proposals includes the possibility to reclassify certain wastes as secondary product materials or substances, thus facilitating the reintroduction of discarded materials in the economical system. This paper explores the implications of this new approach, by discussing the multiple interpretations that could be given to the concepts of by-products and secondary materials, considering both environmental and quality criteria. This conceptual analysis is illustrated making use of several quantified scenarios for Portugal, pointing out the advantages and shortcomings of different strategies adopted and the potential benefits associated with them, namely in terms of improving the overall recovery and recycling of materials in the country. It is concluded that in order to foster waste recovery and recycling, the legal approach to be adopted is very relevant and could have significant results, depending on the criteria and methods to be defined. Anyway, it is clearly shown that more flexible and market oriented instruments need to be established in order to facilitate material recovery by industries and the market acceptability of products with recycled content.

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An EIP In My Back Yard: the Case of Chamusca's Eco Industrial Park, in Portugal (Theme E 29)

Industrial symbiosis evolved from pollution prevention plans, to closing cycles and product dematerialization in a defined area, forming the basis of eco industrial park development (EIP): an area where a number of companies are based, sharing resources, energy and services, in interaction with the surrounding community. Early literature referred to EIPs as the concretization of industrial ecology, but today, its development requires global market vision and understanding of local economies strengths and challenges. By understanding these characteristics, EIP planning can be oriented to provide the necessary conditions to attract and retain tenants. In the European context, and particularly in the Portuguese case, industrial waste handling is usually linked to a general stigma against the location of these activities being close to residential and business areas: the Not In My Back Yard effect (NIMBY). So, if EIP deals with waste treatment and reuse, in a community setting, how can EIP development occur within the Portuguese context? This paper presents the initial developments of the first EIP in Portugal, more precisely, in the Municipality of Chamusca, in the Ribatejo region. Despite being one of the largest regions in the country, with a central position relatively to large urban agglomerates, it battles an ageing population, with low education levels and poor economic development. It is concluded that, despite obvious weaknesses, Chamusca's strengths lies in turning these challenges into drivers, through broad political consensus, preparatory work together with the community, and vast experience in waste management issues. Hence, we observe the development of an opposite NIMBY effect, relatively to the EIP planning, and by framing concrete sustainable development challenges for public policy, and presenting them as challenges to be transposed, we can expect to provide answers through local policy development for Chamusca's EIP.

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Decomposition of the US Economy: has the Move to a Service Based Economy in the US Reduced Carbon Intensity? **(Theme A 11)**

On February 14th, 2002, President Bush announced the following: “My administration is committed to cutting our nation's greenhouse gas intensity -- how much we emit per unit of economic activity -- by 18 percent over the next 10 years. This will set America on a path to slow the growth of our greenhouse gas emissions and, as science justifies, to stop and then reverse the growth of emissions.” Incidentally, greenhouse gas intensity in the US has declined exactly by 18% over the last 10 years, and more of course if we look further back. The objective of this presentation is to illustrate the use of Laspeyres and Divisia decomposition methods to assess what component of change has led to this decline in carbon intensity – going back to 1960. The components assessed are: changes in technical energy intensity, fuel switching and structural change in the economy. The analysis is conducted (1) at the state level – examining the relative importance of those three factors and (2) sectoral level within a state assessing the relative importance of fuel switching and changes in efficiency. The analysis is based on a database compiled from various data sources such as the EIA’s state level energy database, economic activity data from the Bureau of Economic Analysis, vehicle miles from the Department of Transportation in addition to data from the US Census Bureau. The results reveal substantial state and sectoral differences, and what is revealing is that in many states changes in energy efficiency in the industrial sector seems to be the largest culprit of change, rather than a structural change in the economy – i.e. a switch to a service based economy. Furthermore, a comparative analysis between sectors and states vividly reveals the future capacity for change in the US economy.

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What is Sustainable Energy Development – and Can We Measure It? **(Theme A 11)**

Since the publication of the Brundtland Report, sustainable development (SD) has evolved from a vague concept into a coherent development framework. The foundation of this framework is embodied in Agenda 21, which was adopted by the United Nations Conference on Environment and Development (UNCED) at the 1992 Earth Summit. Agenda 21 categorized the primary themes and goals of SD into three key dimensions: economic, social and environmental - theorizing that the challenge for future development is balancing economic development with social and environmental objectives. Energy use is a vital component of economic and social development, but the use of energy also significantly contributes to environmental degradation. Consequently, the development of sustainable energy systems has emerged as one of the priority issues in the move towards global sustainability. This presentation introduces and applies a new multi-dimensional metric - the SEE index - to assess whether two selected countries have moved towards or away from Sustainable energy development by looking simultaneously, at sub-indicators within each dimension and by analyzing the movement within each dimension. The two countries chosen are very different in terms of their developmental patterns – and thus are used as cases to assess if the index really is able to capture such movements. The countries chosen are the United States and Iceland. The presentation also will suggest improvements to the current structure of the index.

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Research on Building Regional Eco-Industrial System in West China (Theme A 8)

In recent years, eco-industrial park (EIP) is expanding rapidly in China, and establishing regional eco-industrial system (REIS) is becoming a new trend. As main energy source and raw-material base of China, West China is developing with a extensive economy growth model which mainly depends on resource outputs at present. So it is important to put forward to sustainable development models for west China. In this paper a development pattern of REIS in the west of China is explored on the basis of a case study. Liupanshui is an important coal resource city in the southwest of China. Heavy chemical industry such as coal, coal chemicals, power and steel are main industries in this city, so potential conflict between economic growth and environmental protection is obviously. For that, q regional eco-industrial system planning is finished for sustainable development of Liupanshui's industries. The planning is based on 3R(Reduce, Reuse and Recycle) principle, and cleaner production, industrial coupling and symbiosis are carried out on both micro- and meso-scopes in related industries. Then six different kinds of EIPs in the system are designed according to the eco-restructuring theory and industry designing principles. On the basis of material flow exchange among these EIPs and evolution of each EIP, Liupanshui regional eco-industrial system will be finally formed on macro-scope. Bulk Material Flows Analysis(Bulk-MFA) is introduced in this case to evaluate resource utilization with Direct Material Input(DMI), Resource Productivity(RP), Solid Waste Recycle Ratio(SWRR). The result indicates that resource can be much better used by the planning. . Environmental Impact of the planning is also evaluated. In addition, a supporting system including information system, infrastructure construction, management system etc. is considereded in the planning.

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Innovating Agriculture in Metropolitan Areas – International Association for Sustainable Agroparks (Theme B 15)

The world is developing into an urbanised network society. Metropolitan Areas are becoming the nodes of globalisation. Intensive agriculture (i.e. horticulture, livestockfarming) has since long been developing around urban areas. ICT, network-organisation and advanced production technology are driving new inventions to the market. The consumer himself now is granting the licence to deliver, forcing retailers into competition on food availability and –safety, quality control and ethics. Reliance on the chains that provide the main fresh products is becoming of strategic importance. The Agropark concept, based on the notion of Industrial Ecology, meets these agricultural challenges of metropolitan areas. It is a system innovation integrating plant (greenhouses, mushrooms) and animal (chicken, pork, dairy, fish) production chains in (spatial) clusters with interconnected chains and cycles. Agroparks can achieve outstanding Triple P performance. Agroparks reduce economic costs and environmental effects but also improve product quality and reach for synergy effects in knowledge and site management. An Agropark is always a tailor made solution, adapted to the local physical, economical and socio-cultural conditions. TransForum and InnovatieNetwerk are setting up an International Association to share experiences with sustainable development through Agroparks. The Association will incorporate all relevant stakeholders involved with agropark development, from science to society and from entrepreneurs to ngo's. Transdisciplinary knowledge creation, further development of the concept based on practical experiences and realizing new opportunities for agropark development will be the main results of this International Association.

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Green Supply Chain Management Practices – Influence and Motivation for Adoption (Theme E 30)

In this paper, we analyze the factors that drive companies to adopt green supply chain practices beyond regulatory compliance. We are interested in understanding whether external stakeholders such as customers, suppliers, competitors, regulatory agencies and environmental NGOs play influence the adoption of these supply chain practices. The green supply chain practices that we study include: the adoption of a green purchasing policy, the request that suppliers adopt ISO14001 certification, and that they provide environmental performance information. Data for this study were derived from an original survey and publicly available databases. The survey gathered information about the relative influence of various external and internal stakeholders, and what management practices each facility has adopted. The survey was sent to 3255 U.S. facilities in 8 industrial sectors: pulp, paper and paperboard mills, chemical and allied products, refining, primary metals, machinery, electronics/electrical, automotive, and utilities. 562 responses were received and analyzed using regression statistical tools. Preliminary results indicate that customers, suppliers, and environmental organizations influence companies to adapt different green supply chain practices. The strongest motivation for adapting those practices is the interest to generate new products/services. The original survey results provide insight for actual practices that companies chose to adapt. Government, NGOs, and local communities can employ this information to learn the prevalence of different environmental management practices across various industries, and to better understand how firms are motivated – and influenced – to adopt green supply chain management practices.

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Environmental Standards and Certification – Case Study of the Wine Industry (Theme E 31)

There are currently several emerging environmental standards that firms can adopt to mitigate their environmental impacts. These include for example the international environmental management standard ISO 14001 or organic certification labels. Because these standards are relatively recent, there is still scant evidence on the comparative environmental and commercial benefits of these standards. Firms interested in adopting these standards need to make decisions with limited information. Using the context of the wine industry, we analyze the case of a California winery whose owner is wondering about the comparative advantage of two competing certification standards: the organic standard and the less known biodynamic standard. We analyze the existing evidence about the environmental and commercial potential benefits of these standards. In particular we assess the potential for environmental differentiation through these environmental standards. In order to assess the potential commercial benefits of the standards, we conducted a survey (that elicited 400 responses) of consumer knowledge about the organic and biodynamic standard and also of consumer preferences regarding the consumption of organic and biodynamic wines. In addition, the case provides information about the winery history, operation, and the different environmental strategies that are being contemplated. We pay particular attention to describe the decision process that guides the owner's decision to choose a particular environmental standard. Although the case is based on the wine industry, it brings together environmental, economic, and cultural (consumer based) aspects and uncertainties related to the implementation of environmental standards that are applicable to other industrial contexts.

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A Financial Analysis of Eco-Industrial Parks
(Theme E 29)

Movement towards closed loop systems is not only a benefit for the environment. It provides an opportunity for a financial benefit to a firm that redefine its inputs, outputs, and the way they are handled. The aim of this study was to evaluate the impact of the adoption of the eco-industrial park model on the overall health of the firm. Two types of eco-industrial park were examined: virtual and physical. Several measures of growth were used including financial ratios, increase in square footage, increase in headcount, and increased product lines.

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Implementing Industrial Symbiosis for Sustainable City Transports Based on Biogas Production (Theme B 15)

In 1996, a company was started with the aim of addressing two environmentally related problems in Linkoping, Sweden. First, it was the air pollution of the inner city and secondly it was problem of the handling of slaughterhouse waste. The founders of the company were a municipally owned regional energy and waste company, a cooperatively owned meat producer and a farmers' organization. The idea was to produce biogas to fuel buses in the inner city, to deliver a high-class certified fertilizer back to the agricultural sector and make something useful of the slaughterhouse waste. During 2005, about 4,7 million m^3 biogas was sold replacing the same number of liters of petrol and diesel. This amount covers more than five per cent of the total vehicle fuel market of the city. A new biogas production unit has been developed in the region making use of by-products from ethanol production and future plans focus on so called green gas from cereals that could be grown on agricultural land at present in fallow. Making use of only the fallow land for biogas production could replace up to 25 % of the fossil fuels used for transports in the region. The organization of the biogas production was changed in 2003 when the energy and waste company bought the biogas company and now have customer relations to the meat producing company and the farmers' organization. This success story is analyzed through interviews with central actors to see whether there are general conclusions that could be drawn from this ten year industrial symbiosis. The analysis is inspired by the literature of "large technical systems" and focuses on aspects such as initiative, actors' interests and power relations, barriers and enabling factors for development of industrial symbiosis.

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Using General Circulation Models to Better Understand Continental Material Cycles (Theme A 11)

Climate, life and society are beautifully intertwined through a variety of interacting cycles and feedback loops on scales ranging from molecular to planetary. These feedback loops are multidirectional - not only is the organization and distribution of life partially dictated by physical climatic conditions, and social structure, but life itself exerts an influence on the construction and regulation of atmospheric composition. As current and anticipated changes in the Earth's climate are better understood, it has become evident that potential solutions to what can be one of our greatest challenges will likely be a portfolio of technologies, and not a singe source solution. Further, this approach will require the input and cooperation of biological and physical scientists, policy and financial experts and behavioural scientists, so early adopters/developers in the field of synthetic biology should expect to have a visible presence in this portfolio. Despite the relative infancy of synthetic biology, I argue that synthetic biologists can and should start to make connections with Earth system modellers and industrial ecologists, in an effort to incorporate new biological components into the equations embedded within climate general circulation models (GCMs). GCMs are typically large scale (usually global) fluid dynamic models which attempt to quantify various parameters in the ocean-atmosphere-land system. While the resolution of such global models is usually coarse, there are several mid-latitude and tropical regions where the models do a particularly good job in simulating finer sub-basin scale processes.

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Considering Human Factors Perspectives on Sustainable Energy Systems (Theme D 24)

Engineers are skilled in discovering technological solutions to ecological problems. These solutions often require that the public consume less energy, schedule their use of renewable energy sources, or manage more complex devices. In addition to requiring more effort, such technologies often require changes in human behavior: individually and societally. Unfortunately, citizens often show a reluctance to change which can undermine the potential of these new technologies. Human Factors Engineering is concerned with adapting technology to better fit human nature. Theories developed through the integration of psychological and engineering concepts can be applied to the design of complex systems to more effectively support human behavior. In the past decades, the safety and productivity of domains such as aviation, nuclear power, and medicine have all been significantly improved through human factors contributions. These results have shown that human behaviour change can be greater achieved through molding technology to humans via intuitive and easy-to-use devices rather than conforming humans to technology through education, persuasion, or punishment. To become more efficient and less environmentally taxing, sociotechnical systems will grow more complex and demand greater problem solving and planning from the humans involved in their operation. Such increasing demands on human performance often result in reliability, efficiency, and safety concerns that system designers do not anticipate. Successful incorporation of Human Factors design principles can help alleviate these stresses, thereby making new technologies more manageable. Design approaches such as Ecological Interface Design have been shown to give humans a better understanding of the internal dynamics of complex systems, resulting in more effective control. This presentation will draw from both theory and practice to illustrate how Human Factors techniques can be applied to help realize the full potential of sustainable energy technologies in the home and the workplace.

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The Sustainability of Traditional Populations Exposed to Technological Changes (Theme C 21)

The development of new technologies has some controversial aspects. At the same time that it has been used to increase profits and improve standard of living in the population in general, it has negatively impacted traditional populations. This can be seen, for example, in the exploitation of water resources. Heavy industries, such as oil refineries and chemical and petrochemical plants have been placed in estuaries and bays and other vulnerable coastal ecosystems. In many of these ecosystems, traditional populations have been settled and taken their livelihood for centuries. As many other poor people, they are directly dependent on the natural resource, and therefore severely affected by its degradation. This paper seeks to illustrate the vulnerability of traditional populations by taking the case of artisanal fishermen in Guanabara Bay, in the state of Rio de Janeiro, Brazil. The intense industrial development and the chaotic urbanization of the last century have severely impacted the artisanal fishery. A situational analysis was carried out aiming at understanding the physical, historical and political contexts where the artisanal fishery developed. Data needed was gathered using primary data – interviews and on site observations. Secondary data was gathered from historical and contemporary research and from the media. The results of this study shown that the artisanal fishermen and their organizations experience a precarious social economic situation of growing poverty and lack of power to revert such situation. The paper concludes by pointing out the relevance of artisanal fishery in Brazil and especially in Guanabara Bay, and the importance of stimulating its development.

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Frame Analysis and Environmental Conflicts in Guanabara Bay, Brazil **(Theme D 24)**

One of the problems of multiple use of water resources is the creation of environmental conflicts. Numerous analyses have shown that such conflicts tend to be persistent. Analysts have suggested that the persistency of the conflicts results from the way the parties in a conflict select the facts for their attention and/or the way they interpret them. The selection, organization and interpretation of the facts depends on the underlying system of believe, perception and appreciation held by a person. This developed into the concepts of frame and reframing. Frame is the way a person “sees” a situation and reframing is the changing of ones’ frame. This paper seeks to illustrate that the concept of frame is useful in the analysis of environmental conflicts. In order to demonstrate this, the paper presents an analysis of the oil spill occurred in 2000 in the Gauanabara Bay, in the state of Rio de Janeiro, Brazil. The severity of the accident raised, aggravated or made visible several conflicts. Among them, the conflict between the oil refinery responsible for the accident and the representatives of the petroleum workers was selected to be frame analyzed in this paper. A situational analysis was carried out aiming at specific understanding of the situation of the conflict, the physical and organizational settings, the historical and political context, the parties involved and their position in relation to the conflict. Data needed for frame analysis was gathered using primary data – interviews, on site observations and organizational documents. Secondary data was gathered from historical and contemporary research on the topic and from the media. The paper concludes by suggesting that a reframing process was provoked by the oil spill, which resulted in the solving of the conflict.

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Case Study: Eco-Development Planning in Kaiyang County, Guizhou Province, China
(Theme A 3)

Kaiyang County in western-south China is located in the center of East Asian karst region, which is one of the three largest karst regions in the world. The ecological balance in this area is quite fragile, facing severe risks of vegetation damage and rock-desertification. Kaiyang County owns high quality phosphate mineral, widely-distributed selenium, climate and soil appropriate for agriculture and valuable tourism resources. However, for several decades, its economy development has been relying on export of raw phosphate rock and other primary products, while the excellent climate resources, selenium-rich soil and tourism resources remain in unexploited state. In recent years, the natural environment, the selenium-rich soil and the tourism resources have been threatened by mining-caused geological disasters, mineral rough processing and agricultural non-point source pollution. There is an urgent need of sustainable development for this underdeveloped resources-dependent region. The local government of Kaiyang made an eco-development plan in 2006 with help from consulting institution. Based on a thorough study on the planning, this paper summarizes the eco-development planning method for region rich in resources and mineral-dependent, obstacles such as lack of investment, defects in government system, choice between temporary and long-term interests, conflicts among different industries are discussed in details.

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Sustainable Development in Africa – Possibility or Myth? **(Theme C 21)**

As they say, time is the best healer. It is a matter of time before the suspicion and animosity which the Africans nursed (and some still do) for the Europeans in their hearts, will slowly vanish, and time will heal most of the wounds inflicted by Europe on Africa in years bygone. (Or will it?) Even as the EU actively seeks to help Africa on its path towards sustainable growth and industrial development, implementation has always been fraught with obstacles – some known and many unprecedented. Things are not the same in the Dark Continent now, as they were in the last century. Awareness is higher and the realisation of the need to step out of the dark and restore the glitter that the continent truly deserves is now stark and clear in the minds of Africans. A balance among the primary occupations – agriculture, lumbering, fishing and mining, - and the secondary sector - manufacturing and processing - is called for. The latter is still very much nascent in most parts of the continent, but with the ground slowly but surely becoming more conducive for foreign direct investment, industrial growth is also very much possible. Africa now has a chance to start off with sustainable development from scratch, by learning from the mistakes committed by the developed world in the past. That is a sure-shot advantage, and it should not come as a surprise, if a handful of model countries spring up on the continent before 2025. Entrepreneurs willing to start all over again can contribute to the economic development of this continent. Small ideas will go a long way…

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Predictive LCA/Predictive MFA: Framework and Application in a Case Study of Greenhouse Gas Policy in the Automotive Industry **(Theme A 4)**

Scientists, political figures, environmental organizations, and corporate leaders are just a few of the many stakeholders calling for international, national, state and local policies to reduce greenhouse gas emissions. Light duty vehicles are one prominent target for emissions improvement via fuel economy standards, fossil fuel and combustion engine alternatives, and other instruments and mechanisms. However, the very nature of the light duty vehicle—an “icon of liberty” in personal mobility for the developed and developing worlds—could make policy implementation costly and have unforeseen economic and environmental consequences as vehicle users adjust their purchasing, use and disposal behavior. Analysis tools which can quantitatively incorporate policy measures, technology options for meeting those measures, and models for the resulting vehicle market to predict emissions and material flows outcomes in the wake of new climate change policy are needed. This presentation outlines a framework for predictive lifecycle assessment (pLCA) and predictive material flows analysis (pMFA). The framework assimilates regulatory, design and demand scenarios in the structure of these assessment tools to analyze potential burdens. A test case accounting for light duty vehicle design strategies and sales forecasts in response to several regulatory instruments will be used to analyze the utility of the methodology for understanding emissions consequences. The model predictions will be interpreted in the context of past automotive market observations. The broader applications of the framework to predictive material flows analysis will be introduced.

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Build an Eco-Industrial Park in Old Industrial Base in Northeast China (Theme C 22)

China is a developing country, and the areas in the east and the west of it develop unequally. Southeast China got favourable policy about twenty years earlier than other areas and developed quickly. Oppositely the northeast China is not so developed as southeast for its behindhand technology, inconsequential industrial frame, and so on. And Chinese government has made a decision to develop northeast China. On this condition, the purpose of planning eco-industrial (EIP) is to instruct the area how to construct an EIP. Mudanjiang is a city in Heilongjiang province in northeast China. This paper contributes to a series of strategy to plan a EIP for this city. Mudanjiang has many advantages which were not exploited before, such as: scores of mineral resources, water resource, forest resource, soil resource, travelling resource and so on. Four industrial chains were designed to develop these resources: coal chemical industry chain, paper making chain, abio-silicon material chain, construction material of waste residues, and integration of agriculture and industry.

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Material Flow Analysis in Eco-Industrial Park Planning **(Theme C 23)**

Eco-industrial planning is an effective way to manage resource. As one of foundations of eco-industry planning, Material flow analysis (MFA) is a direction to plan an eco industry park. This article introduced how to use MFA in eco-industry park planning. A natural gas corporation in northeast China was taken as an example. The formations of material flow and connecting technology before planning and after planning were compared. Carbon and hydrogen elements were analyzed. The result indicated that MFA was helpful to survey the process of material flow and to estimate the efficency of resource usage.

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Including Sustainability in Bridge Management Systems **(Theme B 19)**

Several recent efforts to improve the environmental profile of civil engineering infrastructure, such as LEED and BEES, have raised awareness and likely improved design and construction practices throughout the United States. However, the application of indutrial ecology or green design tools is primarily limited to buildings. There is little research or design guidance related to bridges. Despite the development of sophisticated multi-objective optimization models for management of bridge structures, there remains scant consideration of the potential environmental or socio-politi8cal impacts of bridge design and construction. This research presents an approach to life cycle assessment of bridge structures. However, particular emphasis is placed upon socio-political aspects, where coventional LCA tools are insufficiently developed. Therefore, we present a case study in public paricipation for sustainability as exemplidied by the New Harmony birdge between southern Indiana and Illinois. The eventual result of this work will be development of a sustainability module for incorporation into existing bridge management systems.

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Corporate Responsibility in the German and Brazil Automotive Industry **(Theme E 31)**

The research team PROBRAL with scientists from Darmstadt University of Technology (Institute WAR), Federal University of Rio de Janeiro (COPPE/SAGE) and the Federal Center of Technological Education (CEFET/Rio de Janeiro) is dealing with the analysis and comparison of corporate responsibility behaviour of German Automotive Sector Companies producing in Germany and Brazil, who have signed the Global compact. One focus of the research is set on the methods of sustainable management in the supply chain of selected Automotive Sector Companies. A car is a complex multi-component product. Therefore the research is concentrated on only one component - the tyres. After a characterisation of the tyre supply chain in Germany and Brazil, the presentation will show the results upon questioning selected tyre producers in Germany and Brazil. First it will be pointed out whether tyre producers have implemented common sustainable management systems like ISO 14001 and OHSAS. Second it will be answered the question whether these companies have adopted elements of corporate responsibility of the automotive industry and if they are forced to do so by a supplier contract or supplier standard. A third question is how tyre producers behave selling to different automotive companies in different countries with an own corporate responsibility culture. It will also be under examination, what kind of organisation structure for sustainable management they have implemented. The final result will show different corporate responsibility behaviour of tyre producers who refer to different cultural and economical backgrounds like Germany/EU and Brazil/Mercosul. It will be pointed out what is the main influence on their corporate responsible behaviour, the automotive industry as their customer, the German / Brazil legislation and European / Mercosul legislation, regional aspects and the role of Non-Governmental Organizations.

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Stocks as Potential Wastes and Secondary Resources – Material Stock Accounts of Construction Minerals for Japan (Theme A 7)

Economy-Wide Material Flow Accounts (EW-MFA) studies have shown that the overall physical stock of our economy is growing steadily. Stocked materials within the economy are considered to be potential secondary resources as well as potential wastes in the future. Brunner (1999, 2004) pointed out that most materials that have been exploited in past centuries are still "hibernating" in the anthroposphere. But will those materials all come out of “hibernation”? For accurate estimation of future outflows, information related to stocked materials is indispensable. This study applies our proposed framework of Material Stock Accounts (MSA) to construction minerals, which are dominant stocked materials in the economy. An important feature of our proposed MSA is its classification of stocked materials. Accurate estimation of future outflows demands that stocked materials that will not become wastes or secondary resources in the future be distinguished from those that will become, because, realistically, not all input materials become wastes or secondary resources. Infrastructure provides a good example: construction minerals used for land development, road bases, tunnels, etc., will remain almost forever at the site where they are used. In our proposed MSA, materials that are counted as stock in EW-MFA are classified into three: materials that are considered to be within the economy (collectable), on the boundary between the economy and the environment (uncollectable in most cases), and in the environment (already dissipated). MSA of construction minerals for Japan revealed that: 1) Most construction minerals are stocked as infrastructure (on the boundary between the economy and environment). Only some are potential wastes or secondary resources, which means that most construction minerals don’t come out of “hibernation”; 2) Some construction minerals are considered to have been already dissipated into the environment. They are mainly demolition wastes left at demolition sites, which are not captured in waste statistics.

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Dynamic Substance Flow Analysis of Aluminum and Its Alloying Elements in Japan (Theme A 1)

Aluminum is now widely used as automobile, beverage can, and window frame. The increase of products using aluminum leads to the generation of large volumes of obsolete scraps. Recycling of obsolete aluminum scraps can reduce production energy because it only requires 5-10% of the energy consumed in producing virgin aluminum. Therefore the recycling of obsolete aluminum scraps should be promoted. However aluminum scraps are usually recycled to castings. For most uses, small amounts of other metals are added to aluminum to give several properties. Though more than one kind of aluminum alloy is usually used for a product, aluminum included in the end-of-life product is collected together. For this reason closed-loop recycling is scarcely achieved. An assessment of the aluminum recyclability considering both the amount of scrap generation and alloying elements in scraps is important to promote recycling. In this study, a dynamic substance flow analysis of aluminum and its alloying elements was conducted for assessing the recyclability of obsolete scraps. A population balance model was applied to estimate future aluminum scrap generation by end-use category until 2050. It was found that 2,800 kt of scraps would be discarded in 2050, 1.33 times as large as that in 2000. The multiple-contaminant material pinch technique was applied to estimate the recyclability of the aluminum scraps, considering main alloying elements: Si, Fe, Cu, and Mn. Results of the pinch analysis showed that constraint would not appear and all of discarded scraps in Japan could be recycled until 2050.

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No Pet Bottle Anymore **(Theme A 13)**

I want to change the tranditional vending machine into refilled one. Everyone brings his own cup or water bottle and get the drink. If like this, we don't need to use pet bottle anymore. We can save plastic and other resources. At the same time we also can reduce the garbage.

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Identifying the Relative Importance of Implementation Strategies in Green Supply Chain Management (GSCM) Practices via Fuzzy Analytic Hierarchy Process (FAHP) **(Theme E 30)**

The Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS) and Eco-design for Energy using Products (EuP) legislation passed by the European Union (EU) recently led to a prohibition on the use of hazardous substances and was responsible for the imposition of product requirements in electronics manufacturing. Both the WEEE and RoHS Directives, and particularly the RoHS, directly impacted Taiwanese electrical and electronic products and that more than 30,000 companies were affected. Consequently, green supply chain management (GSCM) has considered as a proactive approach to improving the environmental performance of processes and products by Taiwanese manufacturers. Although various studies have identified strategies for GSCM practices, the reliability and validity of those strategies have not been demonstrated. These strategies thus lack consistency as an effective means of assisting companies develop best GSCM practices. This study proposes a structure model for strategy selection for implementing GSCM using factor analysis (FA) and the fuzzy analytic hierarchy process (FAHP). The proposed model is developed using FA approach extracts strategies from literature review, consultation experience and interviews with three managers, which were categorized into four dimensions. Twenty strategies are conducted using appropriate tests to establish reliability and validity. Subsequently FAHP is utilized to determine the relative importance of implementation strategies. This study thus aims to demonstrate how the model can assist in solving decisions regarding GSCM practices. Furthermore, the critical and prior strategies of GSCM practices validated in this study can help decision-makers identify areas for improvement in GSCM, and in prioritizing GSCM efforts.

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Ecological Footprint Analysis of Liquid Crystal Display **(Theme A 9)**

The Ecological footprints (EFs) theory has been widely applied in assessing the sustainability of nations and regions. Through reversing the concept of carrying capacity, it can effectively analyze and quantify the impacts of human activities and consumption, and convert them into limited land areas. However, traditional ecological footprint analysis concentrates mainly on consumption activities, which fall into six major categories: food, housing, transportation, energy, consumer products and services. And very few studies focus on establishing the conversion factors of pollution, which is a very important consideration for analyzing sustainability using EPs concept. In order to extend the application and utilization of EF concept, this gap must be mended. In this study, an EF conversion database for various pollutants was established by adopting carrying capacity and vegetation purification theories, i.e., defined as the area of land to be abandoned due to pollution and the area of land planted with vegetation that needed to absorb air and water pollution, respectively. The carrying capacities of different lands were determined by governmental regulations, and the purification capacities of different vegetations were collected from the literatures. The concepts of Environmental Burden (EB) and Potency Factors (PF) were applied to assess and aggregate the footprints (land areas) of the different chemicals that have similar environmental impacts. Environmental impacts/pollutants converted in this study include greenhouse gases, acidic gases, photochemical smog, airborne carcinogens, eutrophication, heavy metals in water, soil organic pollutants, and heavy metals in soil. After the EF conversion factors of pollutants mentioned above were developed, a liquid crystal display (LCD) was used as a case study to calculate the life cycle pollution of EFs. The EFs of different pollutants are: greenhouse gases 0.03 ha/yr, acidic gases 0.033 ha/yr, photochemical smog 0.01 ha /yr, airborne carcinogens 0.029 ha/yr, eutrophication 1.3 E-05 ha/yr, heavy metals in water 1.3E-06 ha/yr, organic contaminants in soil 0.04 ha/yr, and heavy metals in soil 4.2E-05 ha/ yr. In terms of EFs, the total impact of the case LCD equates 0.207 hectares every year.

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Discussion on the Eco-Industrial System of Coal Gasification Polygeneration in China (Theme C 20)

Energy resource of China is characterized as “full of coal while lack of oil and natural gas”. Therefore coal will play an important role in China’s energy structure. But current coal industry in China still has many problems such as environmental pollution and lower utilization efficiency. For that, eco-industrial development should be introduced to retrofit the current industry for the demand of sustainable development, environment protection, and resource saving. For getting better use of coal in China, in recent years, it was recognized that coal gasification polygeneration will be an effective way to solve above-mentioned problems. Since a coal polygeneration system, which requires coupling and symbiosis of different industries, involves many materials, products, intermediates and wastes, it will be the best development model to construct eco-industrial systems based on coal gasification polygeneration. In this paper, some key technologies and problems of a coal gasification polygeneration eco-industrial system are discussed, which includes syngas generation, products synthesis, carbon dioxide reduction and system integration. A polygeneration case with co-feeds of natural gas and coal is studied. Two practical cases of eco-industrial parks based on coal gasification polygeneration are analyzed. The results are helpful for directing sustainable development of coal chemical industry in China. For implementing coal gasification polygeneration eco-industrial system, there are still many problems such as techniques, investment and policy support to be solved in China. But it is believed that this model will become the main trend of coal chemical utilization in the future.

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As Good as New - Reprocessing/Remanufacturing of Used Goods and their Trigger for Innovations within a Supply Chain **(Theme E 30)**

Reprocessing/remanufacturing strategies profit from the remaining form structure of used products for producing products which meet the qualities of new ones with the same guarantees and applications. The principle of ‘as good as new’ makes the important difference to second hand products and lead to some success in commercial markets (B2B). Although the contribution of these strategies to resource efficiency is well known, they are not acclaimed. One of the most common arguments against these strategies is that they hinder innovation and technological progress. Quite the reverse is true, as a research project has proved: Based on six case studies of successful remanufacturing companies (tires, oil, medical devices, textiles, diesel engines, toner cartridges) important findings on reprocessing/remanufacturing strategies have been worked out demonstrating to what extent reprocessing-activities contribute to innovation and a sustainable development:• Impacts on innovation activities (and R& D): reprocessing-activities offer a huge range of challenges for innovations including technological innovations (like wear research, non-destructive testing, application of RFIDs for reverse-logistics) as well as organizational innovations (like new forms of business models, partnerships, logistics) • Economic impacts: reprocessing-technologies save money and open up new service markets – the remanufacturing of goods can reduce costs by up to 50 per cent, • Environmental impacts: reprocessing-activities considerably extend the utilization period of goods, increasing the resource efficiency by up to 90 per cent! • Social impacts: reprocessing-activities are predominantly/mainly based on (local) services, creating to a large extent regional added value and jobs! The re-integration of used goods into the supply chain turned out to be the key for successful remanufacturing strategies. Subtle adaptions of supply chains and supply chain management are necessary as well as framework conditions which do not impair the competitiveness of these sustainable strategies.

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Best Use of Natural Gas: A Life Cycle Comparison of NG/LNG Consumption for Different End Uses **(Theme F 32)**

Natural gas (NG) is one of the most important sources of energy in the U.S., providing 24% of the energy consumed. During the 1990's there was a surge in demand of NG by power plants and now NG fuels 18% of the country's electricity generation. This increased demand has caused a steady growth in imports of LNG, and by 2030 more than 15% of the U.S. NG supply is expected to come in the form of LNG. This decision to increase reliance on imported LNG lacks important environmental and technical considerations. For example, although NG combustion air emissions are lower than for other fuels, no examination has been performed on the life cycle air emission impacts of increased LNG imports, or how these emissions compare to the life cycle emissions of other fuels. The demand for NG by the transportation sector is currently negligible, but worldwide interest on NG-derived transportation fuels is increasing. In response, the U.S. could either produce these fuels internally, requiring larger imports of LNG, or import them from NG-rich countries. Alternatively, the U.S. could produce transportation fuels from coal. Although non-existent in 2005, by 2030 coal-to-liquid-fuel producers are expected to consume as much coal as coke plants. Our analysis performs a life cycle comparison of air emissions from the use of NG and coal for electricity generation and for the production of transportation fuels. We also compare the infrastructure requirements and the economic implications of using coal and natural gas for these purposes. Our preliminary results suggest that for electricity generation, life cycle air emissions from coal and NG/LNG are closer than generally reported. Similar results are expected from the comparison of NG and coal for transportation fuels. These comparisons can help us answer important questions about how to better use our limited NG resources.

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Integrated Stability Analysis of Eco-Industrial Symbiosis Network (Theme C 22)

The concept of industrial symbiosis network (ISN) has progressed in recent years and has become a hot issue in the field of industrial ecology. There are lots of stability problems in the eco-industrial practices. A major challenge in stability analysis is to effectively deal with different kinds of exogenous and endogenous attributes, especially their quantification problems and their effect on the design and operation of the industrial ecosystem. To promote and manage stability of ISN, this work focuses on the methodology of integrated stability analysis based on information fusion technology. This paper provides a brief introduction of classification and characteristics for stability attributes. The exogenous and endogenous attributes are presented in detailed. An integrated analysis method based on information fusion is proposed to deal with the acquisition, transmission and processing of stability information. This method attempts to use the data from multi-sources under various spatial-temporal conditions. Two-level information fusion model is proposed to obtain the holistic result. In the first level (data level), the data filter and estimation based on modular neural network model is developed to obtain the characteristic value. The in the second one (decision level), the characteristic value processing and fusion is implemented based on the approximate reasoning algorithm. This proposed methodology will facilitate the representation, the inner relation and working mechanism of multi-sources information among the member entities in the ISN. To demonstrate the applicability of the proposed methodology, Dongxi hu Eco-industrial Park as a case study is presented.

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Process Design and Analysis Based on Regional Toxicological Impacts (Theme F 35)

In response to the staggering environmental problems associated with process industries, significant industrial and academic efforts have recently dedicated much attention to the development of holistic methodologies and their related tools that target environmental impacts minimization from a systems perspective. Base on our previous work (Jia, et al, 2004), this paper will focus on a methodology for process design and analysis in terms of contributions to potential toxicological impacts on human health and the environment on a regional scale. Firstly, relative impact potential (RIP), an environmental indicator based on the ecological toxicological model on a regional scale, was introduced. To obtain RIPs, the steady-state multimedia fate model of Mackay is used to estimate the change in exposure concentrations in a region. The physical–chemical properties for the Mackay model include Henry constant, octanol-water coefficient, solubility in water, half-life in air, soil, and water, etc. The estimating algorithm and module is developed in Microsoft Excel. Then the framework of process design and analysis based on RIP was established. The framework consists of four phases: (1) to generate process alternatives and relevant information in the process simulator; (2) to generate and extract relevant data for environmental impacts from process documentation; (3) to link estimating algorithm of RIPs with the process simulator; (4) to analysis and optimize the process according to RIPs. Based on minimum RIP, for each design alternative best solution is obtained. Finally, HDA production system is used to illustrate the proposed framework. Results show that it is possible to minimize the regional toxicological damage. To link the ecological system with industrial system by the multimedia model, the work could be further expanded to investigate industrial park to enhance its capability for supporting industrial systems decisions, which could be presented to support design,

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Circular Economy and Industrial Ecology Education in Chinese Energy College (Theme G 36)

The students from energy colleges will be policymaker, designer, engineer of energy industry in China. By Circular Economy and industrial ecology education, the students will be able to apply the industrial ecology approach, i.e. to conduct systematic analysis of energy industrial activities and to find optimal solutions for many problems related to sustainable industrial development and make sustainable energy policy. A programme in Circular Economy and Industrial Ecology has been developed in our college, which consists of graduate and post graduate, in the college. This paper presents the prerequisites for the establishment of the programme of industrial ecology and circular economy, its aims, goals and structure as well as the relation of different subjects of the programme to the concept of industrial ecology and circular economy.

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The Energy Benefits of Stainless Steel Recycling
(Theme A 11)

Material flow analyses for chromium, nickel, and iron created the foundation for this stainless steel energy flow analysis study. The energy used to produce austenitic stainless steel was quantified throughout its entire life cycle for three scenarios: (1) current global operations, (2) 100% recycling, and (3) use of only virgin materials. The primary energy requirements to produce one ton of austenitic stainless steel (with assumed metals concentrations of 18% Cr, 8% Ni, and 74% Fe) is (1) 53,000 MJ, (2) 26,000 MJ, and (3) 79,000 MJ for each scenario, with CO_2 releases totaling (1) 3.6 tons CO_2, (2) 1.6 tons CO_2, and (3) 5.3 tons CO_2. Thus, current recycling operations reduce energy use by 33% and CO_2 emissions by 32%. If austenitic stainless steel were to be produced solely from scrap, which is currently not possible on a global level due to limited availability, energy use would be 67% less than virgin-based production and CO_2 emissions would be cut by 70%. The production of 17 million metric tons of austenitic stainless steel in 2004 used approximately 9.0 x 10^17 J of primary energy and released 61 million tons of CO_2. Recycling efforts resulted in an energy savings of 4.4 x 10^17 J of primary energy and a reduction of CO_2 releases by 29 million tons in 2004.

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Metal Casting: Moving to Sustainability (Theme A 8)

The metal casting industry is a vital part of the US manufacturing base, with 90% of all manufactured goods containing cast parts. The industry uses a substantial majority of metallic scrap in the manufacture of new products and is a critical link in the metals cycle. Improvements in the materials and energy consumption of these foundries would improve their competitiveness with overseas facilities that are increasingly taking over market share. It is therefore imperative to analyze the industry for efficiency improvements and emissions reductions that will ensure the industry's continued success in the US. This NSF MUSES project is a joint venture between Penn State University and MIT with the close collaboration of Furness-Newburge and several foundries. An input-output materials flow model of a foundry has been developed in order to analyze the metal casting industry. This materials and energy flow model will allow for further study of proposed process improvements and their relative impacts on efficiency and emissions. Limited R&D resources can then be directed to the most promising technologies. Additionally, an exergy analysis performed on the different melting processes shows cupola melting to be twice as efficient as induction melting, with the Second Law efficiency of the cupola at 27.5% and the induction melter at 14%. This is important in light of new federal regulation stemming from the Clean Air Act that further reduced acceptable limits of air pollution from foundries. A review of the Clean Air Act and how its enforcement has influenced technology choice in the metal casting industry is being conducted and our working hypotheses are 1) there has been a move from efficient technologies that pollute at the source to less efficient technologies that move pollution to the electrical generator and 2) this will contribute to greater and not less air pollution, as intended.

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A Framework of Sustainability Network Theory (SNT) and Model for Industrial System (Theme D 24)

Sustainability networks concern properties that arise in systems of many objects linked together and displaying both static and dynamic complexity. From a static perspective, networks are characterized by a number of key concepts such as connectivity (nodes, links, and flows), criticality, loops and cycles, dynamics, modularity, trees and hierarchies. But it is the dynamics of industrial systems that are particularly challenging, and it is here that the need for SNT becomes apparent, because many of the behaviors of such systems arise not from the substantive factors that are the usual focus of analysis, but from their underlying network structure and dynamics. A conceptual SNT framework made up of a social, cultural and regulatory network (SCRN); an economic and financial network (EFN); and a material, energy and environmental network (MEEN). In general terms, a social, cultural and regulatory network is broadly defined as an arrangement of differentiated elements linked to each other by a multitude of ties of a specified type. This model includes communities, social structures made of nodes and ties at the individual and organizational level; additionally, it focuses on the interrelationships with broader social systems. The goal of the economic and financial network model is to develop theoretical tools for the analysis of specific processes and their interaction into an appropriate representation of an economic and financial network. In an industrial system, materials and energy movement extends from the extraction of resources for manufacturing, to consumption, to the discharge of wastes into the natural environment. The representation and interpretation of material and energy flows in an industrial system has become one of the most important tasks of industrial ecology and an important part of environmental management in organizations.

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Economy Metabolism:Concepts and Analysis Framework **(Theme A 3)**

It is important to carry out physical flow analysis not only for understanding the micro-level of circular economy, but to examine management polices of circular economy. This research focused on the economy metabolism. In this research, we try to put forward the concept of economy metabolism and basic analysis framework, to understand the complex of economic processes of physical flow occurring within the economy that are necessary, which not only can in some extent insight into metabolic mechanism in economy, but present some important management policies to make physical flow in economy be harmonious with human.

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Impact Assessment of Resort Development on Lakes Basins : Application to Orford-Magog Area, Southern Quebec (Theme A 11)

The increase of anthropic pressure on recreational lakes area may have an important impact on the aquatic media. The development of resorts is more often linked to deforestation and soils waterproofing. When located in rural areas, water supply and wastewater constraints must be carefully considered. Tap water is often supplied through lake or groundwater catchments. Wastewaters are still often treated by individual systems, as for example septic tanks, the impact of which being non neglegible on the quality of ground and surface waters, more particularly with phosphorus and nitrogen contaminants. Thus, it is necessary to develop a methodology which allows identifying and quantifying water demand and dissolved pollutants flows (in particular organic matter, nitrogen, phosphorus) linked to existing or future resort developments. The methodology presented is based on the approach of industrial ecology. It includes several steps, and more particularly the data collection from various sources (municipal, provincial, governmental, associative) and interviews of municipal departments and water users. The exploitation of these data is achieved by an Excel calculator giving the possibility of evaluating flows corresponding to different scenarii as well as individual or collective means of mitigation. This methodology has been tested on the Orford-Magog area, Southern Quebec. These region owns many beautiful lakes which support the development of recreative, touristic and holiday activities. That leads to a growth of holiday residences very close to these remarkable but very fragile ecosystems.

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Improvement of Dredging Operations Management with Industrial Ecology and Competitive Intelligence (Theme C 20)

Harbour activities generate major commercial flows. These flows not only result from traffic of goods of various natures (hydrocarbons, industrial bulks, agroalimentary products, manufactured goods, containers...), but also from the development of activities on the harbour platforms (logistics, iron and steel industry, agroalimentary, refining,...). The majority of harbour sites are located in sheltered zones such as estuaries. In these areas, sedimentary phenomena are often significant. This sedimentation of suspended matters from continental or marine origin can limit the access of ships to the harbour infrastructures, leading to dredging operations necessary to ensure accessibility. For example, 185 millions of tons per year should be extracted in european harbours. This study presents a new methodology for the management of dredging operations. Partly derived from existing methodologies (OECD, UNEP, AIPCN), its aim is to be more complete, by integrating the qualities and complementarities of former methodologies. Moreover, according to the industrial ecology approach, the methodology supports the development and the implementation of solutions of waste management of dredged materials, minimizing the environmental impact of dredging operations. In complement, competitive intelligence is used for research management (partnership with universities, industries, Harbour's authorities and local communities) and knowledge linked to the development of innovative solutions. The methodology also uses a tool called DRAGSED, based on MultiCriteria Decision-Making, involving all stakeholders of a dredging project (harbour's authorities, industrialists, municipalities, administrations, populations, associations,...). The implementation of this methodology enables to reach a consensus for the dredging solution retained, as it will be shown with some applications.

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Competitive Intelligence and Industrial Ecology for the Sustainable Development of the Industrial and Harbour Area of Fos sur Mer (France)
(Theme E 29)

This study presents the issue and the methodology based on a competitive and territorial intelligence approach of the industrial and harbour area of Fos-sur-Mer (South East of France). This region was facing to several economical, social and environmental issues in order to preserve its leadership as one of the first world harbours. Harbour's authorities plan and promote harbour services to increase maritime traffic as well as the development of the close industrial area. In a severe competitive context, Harbour's authorities must propose advantageous offers and news services in order to maintain existing industrial activities (petrochemistry, iron and steel industries, …) and attract news and effective activities. Therefore, a project based on industrial ecology and competitive intelligence in the frame of a partnership with several research centers has been proposed, for a new vision of the territory and to improve its economical, environmental and social performances. The originality of the methodology used is based on the industrial ecology approach as a tool for the competitive intelligence. Industrial ecology has been used to identify and characterise material and energy flows linked to industrial and maritime activities, but also to identify intersectorial and industrial synergies between existing industries, as well as news ways of industrial diversification. The competitive intelligence approach links this knowledge with technological or complementary data in order to have an environmental, social and economical evaluation of the synergies and industrial prospectings. This project has led to identify news activities, more particularly in waste management, civil engineering and agribusiness, improving synergies with existing activities in the industrial and harbour area, and in the environment.

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Supporting Framework for Biomass Energy System Planning (Theme A 10)

Biomass resources are expected as alternative and renewable energy sources. Since they are distributed widely and their energy density is low, biomass energy system (BES), which consists of processes such as sourcing, transportation, energy conversion, and waste treatment, should be appropriately planned considering the environmental impact associated with the life cycle of biomass. For example, the location of power plant effects on the route of transportation and on CO_2 emission as well. We investigated existing reports on BES planed by local governments and found that evaluation considering the environmental impacts due to upstream and downstream of the energy conversion process has not been performed. Because the procedure of life cycle evaluation of BES is not known or difficult for the planners even though they want to perform it, and many types of information are required to assess BES; information about the characteristics of biomass, the topography of region, technological candidates and so on. Furthermore, it is not obvious to include the results of the environmental evaluation into design procedure. In this study, a supporting framework for BES planning is presented as a function model describing the activities for life cycle design and for evaluation of BES. In this framework, information required for the activities is structured as a data model. In order to develop the framework, a case study was carried out. Assuming planning in a region where a sufficient amount of thinned woods are available, several alternatives of BES were generated and LC-CO_2 was evaluated. As energy conversion processes, centralized steam-turbine cogeneration system and distributed stove in individual house using chipped wood were considered. The activities and information flows extracted from this case study were structured and proposed as a function model and a data model.

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Impacts of New Bridge Construction Technologies on US Cement Industry Material Flows **(Theme A 1)**

The cement industry in the United States plays a critical role in the economy through contributions to both buildings and civil infrastructure. Yet the significant environmental implications associated with cement manufacturing challenge planners and policy makers who are promoting and developing sustainable infrastructure systems. Recently, a number of new construction materials have attempted to reduce the need for concrete and cement in bridge construction. Material technologies evaluated within this study include fiber reinforced polymers (FRP) and engineered cementitious composites (ECC) for durable bridge decks which require less cement over a seventy year service life. A new comprehensive model was developed to evaluate cement flows for bridge deck construction, incorporating mechanical and phenomenological bridge deterioration models which provide maintenance and reconstruction timelines for the seventy year service life of an average US National Bridge Inventory (USNBI) structure. Combining these timelines with construction plans for the five bridge technologies considered (one control concrete bridge, two FRP bridges, and two ECC bridges), cement flow for US bridge deck construction is modeled. Also considered is the rate of innovation diffusion throughout the construction industry, which varies according to the radicalness of a particular construction innovation. The application of the five bridge innovations considered can reduce cement consumption for bridge decks from 10% to 95% over the seventy year service life. Nationally (US), such reductions could result in between 110,000 and 1.4 million metric tons of cement saved over the service life of the new generation of bridge infrastructures. Such consumption shifts can have significant impacts on economics of the cement manufacturing sector along with global greenhouse gas emissions. Complicating the comparison of new technologies are additional impacts associated with FRP bridge designs which use little cement, but remain highly energy intensive due to embodied feedstock and production energy, which are also considered.

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Vapor Grown Carbon Nanofibers- A Life Cycle Energy Analysis and Environmental Impact Assessment (Theme F 33)

Any technology can be a double-edged sword, and the fast emerging field of nanotechnology is no exception. Life Cycle Assessment (LCA) of nanomanufacturing and nanoproducts has been identified as crucial for guiding their sustainable development. However, conducting the LCA of nanotechnology poses several formidable challenges, due to the severe lack of inventory data about the nanomanufacturing life cycle and about the fate, transport and impact of new nanomaterials and products. This paper presents one of the first LCAs and Life Cycle Energy Analysis of Vapor Grown Carbon Nanofibers (VGCNFs). These nanomaterials are selected because the combination of their properties and expected lower manufacturing cost make their adoption for commercial use more likely than other nanoproducts like carbon nanotubes. Our study is based on data about various stages in the life cycle of VGCNFs collected from the open literature and industrial collaborators. It considers the cradle-to-gate synthesis of these nanofibers from hydrocarbons and evaluates several different feedstocks and production scenarios to quantify the life cycle energy intensities and their variability. Comparison of VGCNFs with traditional materials like aluminum, steel and polypropylene indicates that the life cycle energy consumption of VGCNFs is 7-17 times higher than that of the conventional materials per kilogram. A Process LCA of these materials has also been completed, and mid-point and end-point impact assessment methods suggests that VGCNFs may impose a higher environmental burden than traditional materials per kilogram of product. The implications of these results for decision makers and directions for future work will also be presented. Future work is expected to use these results for the LCA of specific nanoproducts. These studies ignore the possible emissions and impact of nanoparticles, and thermodynamic LCA methods are also being explored as proxy indicators in the absence of emissions and impact information.

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Eco-Industrial Urban Development: Kansas City Regional By-Product Synergy Initiative (Theme E 29)

The growth of By-Product Synergy (BPS) projects is exceptional in its evolutionary path taken. At first, as in case of the Chaparral Steel Company and its parent company Texas Industries, BPS started as a green-twining project between two firms. Then, a series of BPS projects followed. Practices and know-hows from them enabled to distill a ground framework of eco-industrial park. As the scale of the project has grown, participants of the project also have increased and diversified, from firms and champions to governmental agencies and local non-governmental organizations. Kansas City Regional By-Product Initiative is a recent outcome in BPS's evolutionary path to build an eco-industrial network at the scale of metropolis. Kansas City is a mature metropolis located in an economically challenging region suffering from the deindustrialization of America. As an eco-industrial urban development project, Kansas City initiative has made continuing progress since 2004 and now is entering its 3rd year and expanding, which is in sheer contrast to the current status of other planned eco-industrial parks in the U.S. The venturous but doable connection between eco-industrial framework evolved and drilled along with experiences from other BPS projects and given social, economic and institutional networks of the established metropolis is a key to understand the current progress of the initiative. Kansas City case is expected to arouse a neglected area of economic base and industrial mix in sustainable city debate. Furthermore, the active role of local institutions, including Environmental Excellence Business Network (EEBN) and Bridging the Gap, in the initiative provided an insight how 'institutional anchors' can help to realize structurally unrealized opportunities to harmonize economic and environmental performance of material anchor industries and their auxiliaries in mature city. Finally, the case sheds a light on the role of connector or consultant in innovation diffusion and adaptation in different settings.

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Development of Industrial Complex Energy Optimization Method For Eco-Industrial Park (EIP) (Theme E 29)

Eco-Industrial Park (EIP) is an industrial community which efficiently shares resources such as materials, energy, and infrastructure, and produces sustainable development to increase economic gains and high environmental quality. Sharing energy is one of the most important problems because it is highly related to economy and environmental contaminations. These days reducing energy consumption is getting more important due to the high oil price and increasing of environmental concern. Energy optimization in each industrial plant has been steadily progressed during the last decades, and consequently each factory exhibits high energy efficiency. However, many plants still discharge low or medium pressure steam. Therefore, energy optimization method for the entire industrial complex should be developed. In this work, a steam network optimization method has been developed using Steam Networking Matrices (SNMs). Results show that significant energy saving is possible using the developed method.

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Re-engineering Construction Waste Streams
(Theme A 2)

40%+ of global waste comes from construction. More than half of this waste is within the commercial and industrial (C+I) sector. The C+I construction industry is undergoing many changes in its business model. Reducing the C+I construction waste footprint is an important part of improving our global industrial ecology practices. This paper and presentation will focus on how C+I construction designers, contract managers, and on-site project managers can leverage existing methodologies and practices in reducing project wastes. Designers need to become more aware and rethink their design culture. From renovating rather than demolishing; from dematerialization to leveraging local markets; from specifying salvageable and 'greener' materials, to using JIT (just-in-time) on-site design practices; to enable higher utilization of existing and locally available materials and minimizing waste. Contract and on-site construction managers need manage on-site waste reduction programs. Contracts need to include waste estimation and management practices by bidders. Contract award criteria needs to include points for lowest material impact. On-site practices need to include provisions for more waste containers allowing for separation of waste streams; to enforcing designer's waste reduction specification. This paper will present these and other methods currently being used and tested on construction projects. Initial results of reduction and global extrapolations will be presented along with financial analyses.

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Development and Implementation of a Nationwide Landfill Rating Systems in Switzerland – a Contribution to Sustainable Development (Theme D 27)

As final sinks of the anthropogenic metabolism landfills will most likely continue to play a crucial role in our society. There are several studies and approaches that analyze and assess specific aspects of landfills, such as their leachate behavior (e.g. hydrological models) or their ecological impacts (e.g. life cycle analysis). Yet, only few methods exist to comprehensively assess the short and long-term risks landfills pose with respect to the guiding concept of sustainable development. The Sustainability Potential Analysis (SPA) aims at overcoming this deficit by assessing the potential of a landfill to hinder or support sustainable development form a systemic perspective. For so doing, the assessment criteria used are derived from general system theoretical considerations (including aspects such as well-structuredness, change rates etc.). Besides being based on sound scientific theories and concepts, such an assessment approach should be developed in strong cooperation with experts and practitioners. This cooperation is important because of two reasons: first, sustainable development is a normative construct whose concrete operationalization should be the result of a societal negotiation process among all affected stakeholder groups; and second, a broad acceptance of an assessment approach is crucial for its lasting and effective implementation. In this paper, we present how a pragmatic legislative landfill assessment based on the system theoretic considerations of SPA was developed in a transdisciplinary process including different stakeholder groups (e.g. representatives form administration and landfill operators). The overarching goal of this method development was the nationwide implementation of a standardized landfill rating in Switzerland. The method development included two field studies and an intensive expert validation. Despite several simplifications necessary to make the rating feasible and transparent, most of the crucial ideas of SPA are still visible in the final rating methodology. Currently the implementation of the rating in its final phase.

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The Establishment of Eco-Industrial Park and Circular Economy on the County-Region Depending on Coal-Resources: a Chinese Case Study **(Theme B 15)**

The environment problems caused by industrial pollution present a serious challenge to the sustainability. Great efforts have been focused on the theoretical study and practices of circular economy and industrial ecology in China. The problems of high energy consumption, heavy pollution and low efficiency of resource utilization exist in the industrial fields of coal, metallurgy and energy, which is the frame of industry in mid-china. The case study presented in this paper provides an attempt of county-region EIP construction in Yima City in Henan province, P. R. China. Yima City is one of those typical mid-china counties depending on coal resources with coal-chemical industries, fuel-power plants and a chromate plant. The industrial solid wastes in Yima are mainly coal-gangue, fly ash, cinder, chromium slag, desulfurized gypsum of power plant and so on. In 2004, the local economy is strictly restricted by the safety of resources and environment, so the local government set Circular Economy Program with the help of Institute of Process Engineering, Chinese Academy of Sciences in order to fulfill the goal of sustainability. By now, an eco-industrial network with coal-chemical industries, fuel-power plants and a chromate plant has been preliminary established in the principle of the circular economy. Resource productivity has increased from 310 Yuan per ton in 2003 to 518 Yuan per ton now. The resource recycle utilization ratio has increased from 9 percent to 11.3 percent. For the value of industrial output per ten thousand Yuan, the standard coal consumption has decreased from 3.1 ton to 2.42 ton, water consumption has decreased from 49 m^3 to 44 m^3, and solid waste disposed has decreased from 1.84 ton to 0.93 ton. The experience of this case could be used for reference in other related study in china.

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Emergy-Based Sustainability Assessment of Industrial Systems **(Theme D 27)**

Emergy analysis offers a new methodology for an integrated assessment of natural system, industrial system and economic society. The concept of emergy measures physical flows, such as resources, products and services, and their monetary values on a uniform basis. In the present research, a series of new indices of sustainability were defined based on emergy and applied to an industrial system composed by a sulfuric acid firm and a titanium dioxide plant. These indices were introduced to assess the environmental and economic performances as well as the sustainability of the industrial system and its components on a uniform structure based on the conventional emergy-based indices developed by H.T.Odum. Comparing to the existing emergy sustainability indices that mainly applied in studies of agricultural or natural ecosystems, the newly defined emergy-based indices addressed the characteristics of industrial systems, i.e. the impact of treatment and emission of wastes from industrial systems, and provided new theoretical guidance to the industries on how to improve their performances on multiple objectives.

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Comparison of Environmental Multipliers of Physical and Monetary Leontief Inverse (Theme A 6)

The question to be analysed in this study is whether Leontief inverse of a physical i/o table will give more reliable estimates especially for total environmental impacts of products – or for environmental multipliers - than that of a monetary i/o table. The analysis is based on the physical and monetary i/o tables of Finland 2002 comprising 150 industries. The physical i/o table consists only of mass flows. The first problem in applying a physical i/o table to multiplier estimation is the lack of immaterial input links. Thus the purely physical mass flow i/o table has first to be extended to include these. Some important immaterial input links can be measured in physical terms too. The first one is the use of electricity and district heat, which may be measured in energy units, in kWh or in Joule. Secondly, goods transports can be measured in terms of ton kilometres. For other services monetary values have to be used. This kind of extended hybrid physical i/o table is a reasonable alternative to compare with the pure monetary i/o table. In the multiplier comparison, three different environmental basic inputs are used: total material requirement (kg/€), primary energy use (J/€) and greenhouse gas emissions (kg CO_2 eqv/€). A closer analysis is performed on the causes of the largest differences in industry by industry multipliers between the hybrid physical and the monetary Leontief inverse. In the detailed analysis conclusions may be drawn on the question of whether the physical i/o allocates the environmental impacts in the product processing chains better than the monetary i/o does. This study belongs to the methodological part of the ongoing research project Environmental impacts of material flows caused by the Finnish economy (ENVIMAT). For more information on the project, see: http://www.ymparisto.fi/default.asp?contentid=195528&lan=fi&clan=en

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Porto Marghera Case Study and Industrial Ecology: from Risk to Opportunities **(Theme E 29)**

Porto Marghera is one of the main industrial areas in Italy. After a prosperous development during more than half of the last century, today it faces a crisis that started in the 1980s. In order to guarantee the survival of the area, managing pollution-related risks from past and current activities is one of the most pressing issues. The analysis of the area using principles, language and tools from Industrial Ecology highlights that Porto Marghera presents some important elements to achieve sustainable development, such as cooperative approach among the different actors, introduction of environmental management systems and cleaner production initiatives. Some of these elements are related to the nature of this industrial area, but many others developed through the common need to manage risk. Continuing on this path and with the help of Industrial Ecology further opportunities could be explored.

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Development of Material Flow Cost Accounting for the Recycling Chain Management (Theme E 30)

Material flow cost accounting (MFCA) is presently used as a method of environmental management accounting. Until now, the use of MFCA has been limited to factory production lines. It is theoretically possible, however, to extend the use of MFCA. Furthermore, we propose that the scope of MFCA can be extended to include the entire supply chain. We previously studied the development of a new evaluation method that made use of MFCA, because we considered MFCA potentially useful for the evaluation of meso-scale resource circulation. Here, we rearrange MFCA concepts from our previous study and discuss a theory of meso-scale MFCA. Specifically, we implemented a theoretical study on our proposal and developed a general framework of meso-scale MFCA. Furthermore, we implemented a case study for the Kitakyushu eco-town project in order to demonstrate the effectiveness of the proposed method. As a result, it became possible on a unitary framework to grasp the current status of the regional recources circulation structurally, clarify problems, and evaluate the prepared measures by expressing the structural changes in resource circulation. We also verified that our proposed method would be an effective management tool for actual policy processes. We plan on improving meso-scale MFCA by adding a monetary unit in addition to a physical unit. We will also evaluate the effectiveness of the eco-town projects in terms of the criteria of business management, economics, and the environment. We would also like to accumulate evaluations of the effectiveness of meso-scale MFCA in the wide-area resource and energy circulation system that includes the eco-town area.

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A Systematic Uncertainty Analysis of Life Cycle Assessment (Theme A 5)

Uncertainty has been one of issues of life cycle assessment (LCA) in the literature, but most studies focus on individual stages of LCA, such as life cycle inventory (LCI) and normalization and weighting of life cycle impact assessment (LCIA). In addition, many studies evaluate the results of different LCIA methods applied to the same LCI data, and they demonstrate that the assessment results would be different with different LICA methods used. An important question has not been answered from those studies: which part of the LCA processes will lead to the main uncertainty? The understanding of the uncertainty contributions of each of the LCA components will facilitate the planning of improving the credibility of LCA. To address this question, a novel methodology is proposed to systematically analyze the uncertainties involved in the whole procedure of LCA. The Monte Carlo simulation is used to analyze the uncertainties associated with LCI, LCIA, and the normalization and weighting processes. Four different LCIA methods are considered in this study, i.e., Eco-indicator 99, EDIP, EPS, and IMPACT 2002+. The LCA of municipal waste management strategies in Taiwan is used as a case study to illustrate the proposed methodology. This study not only confirms that the different LCIA generate different assessment results, but identify the significant sources of uncertainty. The primary uncertainty sources are used are the weighting process and the normalization process when Eco-indicator 99 and EDIP are used, respectively. When EPS and IMPACT 2002+ are used, the major uncertainty derives from the LCI process. It is also found that EPS has the greatest uncertainty from the LCI process than the other LCIA methods.

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Novel Polymer Recycling Processes on a Local Scale **(Theme F 34)**

Technological barriers prevent the economic recycling of certain types of industrial polymer waste by traditional methods. For example, different polymers tend not to mix well when mechanically recycled, and produce a low strength material. Features that add value to products may inhibit recyclability; for example, some chlorine containing polymers, decompose when heated, giving off HCl(g). Other components also give off dangerous compounds when heated, for example Isocyanate (used as glue in some multi-layer products) gives off Cyanide gas during heating. In order to facilitate the recycling of these difficult-to-handle products, the current recycling paradigms, which include elevated temperatures and high forces, must be challenged. By reducing the energy input required to recycle the material it may be possible to improve the economic conditions as well as the quality of the recyclate. We refer to this approach as the “minimum intervention” approach. Conducting the process on a local scale i.e. close to, or on the site of, the production of scrap, may also improve the economic balance by reducing transport costs. A source of multi-layer scrap containing many of the features described above has been identified as being difficult-to-recycle by traditional methods. By applying the concept of minimum intervention, two potential approaches have been developed: Separation, where the thermo-mechanical differences between the layers are exploited to separate the material into purer waste streams, and Mixed processing, where the material is pressed at a low temperature to form a useable material, whilst avoiding decomposition of the unstable chlorinated polymer.

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Strategic Resource Mapping – A Modelling Approach for Resource flows in Textile Industries Supply Chain **(Theme E 30)**

In their public statements textile companies often argue that their striving for sustainability is based on a triple-win situation characterised by complementary economical, ecological and social goals. However, a closer look at companies' global supply chains reveals a different and more complex picture. Process innovations that were targeted to foster sustainability, such as sourcing of organic cotton, recycling of synthetic fibres or environmentally friendly textile finishing, are stuck in an ecological niche market. Our research results suggest that the reason for these findings originates from the fact that textile industry's sustainability efforts do not fit into the dominant business logic. Businesses are geared to increase their efficiency, whereas - in most cases - a more sustainable supply chain is involved with higher costs, lower flexibility and slower processes. As a consequence, companies' sustainability efforts frequently fail. An innovative research stream in strategic management theory interprets sustainability as economic rationality. Companies striving to maintain their long-term survival have to secure their sources of supply. Therefore, the resource exchange relationships between company and environment need to be managed sustainably. In this perspective, sustainability is conceived as an equilibrium between corporate resource consumption and resource supply. By modelling resource flows, businesses can gather information about their vital resources, their strategic sources of supply, potential threats to supply security and possibilities to invest in resource reproduction. Thus, strategic resource mapping provides the basis for a more balanced management of resources on a company, supply-chain or industry level. As most textile businesses directly or indirectly rely on the same sources of supply they might decide to invest in supply security in a collaborative manner.

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Adopting a Business Perspective on Waste Management (Theme E 28)

Adopting a Business Perspective on Waste Management A perspective on Business waste management is an overview which explores emerging concepts of business design and practice which reflect principles of sustainability. From a business perspective, the concept of waste is often tied to the idea of success. That is, more successful companies can maximize all of their resources, and thus waste little. As waste decreases, profits generally increase, this perception creates a cycle that focuses on waste reduction. Although in the past environmental concerns were considered to be separate from business and economic issues and also from development and social conditions. Things have changed today, waste recycling has become a stardand component of waste management policies worldwide and requirements for producers to take responsibility for their products at the end of their useful life are common. International organisations such as UNEP and OECD are increasingly involved in issues relating to waste management. International Conventions have also indicated concern over the matter. For instance the Basel Convention has had a major influence on waste management practices through its implementation in national Laws. A wide range of environmental regulations are in place in Uganda yet only a few specifically address hazardous wastes but many have important implications for its management. Thus the purpose of this presentation is to show how the business enterprise can adopt more business perspectives on waste management. The presentation will show some of the projects that have been implemented in an effort to achieve a more business approach to waste management in Uganda.

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How Should be Waste Management and Recycling Policies with Extended Producer Responsibility:EPR Concept? (Theme E 28)

OECD has advocated the concept of “Extended producer responsibility (Extended Producer Responsibility: EPR)” since 1994. The concept is a new policy principle to reduce waste and decrease burden to environment through placing the responsibility for the end of life products to their producers. This concept is being reflected in waste and the recycling policies in each developed country now. In Asian region, not only Japan and South Korea, but also Taiwan that is not the OECD signatory, execute waste management and recycling policies introducing the EPR concept. But, each country recognizes each different problem concerning about waste, each country has difference of industrial structure. Therefore, waste management and recycling policies in each country are not necessarily consistent. In this study, we use electronic as an example and show the background of the introduction of waste management and recycling policies with EPR concept in each country. We focus on comparing waste management and recycling policies before introducing EPR concept with that of introducing the concept. We analyze details of the waste management and recycling policies with EPR concept in each country, and consider if present system is effective or not for the problems which they concern. If that is less effective, we find out the shortages and barriers. With this study, keeping it in mind that how producers’ role should be, we generalize various conditions, and make some models that are appropriate under the conditions.

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Evaluation of Integrated Policy Scenarios for Building Material Circulation System (Theme B 18)

A large amount of carbon is accumulated in wooden house. To prevent the carbon dioxide discharge from urban buildings, the integrated building material circulation system to co-ordinate environmentally efficient recycle technologies and appropriate social circulation policy programs are needed. In this paper, the effects of environmental improvement by applying the integrated circulation system for the wooden construction material are evaluated. High-value added engineered wood is manufactured from waste wood through the process of crushing, drying, orientation, adhesive coating, pressing, and casting. It has high strength that can also be used for the main structure material of wooden houses. Since it can be recycled multiple times, it is expected as one of the technologies to play an important role for achieving the wooden circulation system. After the wood fiber is deteriorated up to the extent that cannot be used as engineered wood, energy is recovered by bio-ethanol technology instead of incineration. The technology that manufactures the bio-ethanol from sugarcane and corn is spreading all over the world widely. However, there is few case intended for the waste wood. First, the recycling technologies of high-value added engineered wood and energy recovery as bio-ethanol were investigated. Second, to attempt an appropriate integrated circulation system in the wooden houses, integrated policy scenarios were designed to combine recycling technologies in the life cycle of the wooden houses. Scenarios incorporate the technological characteristics and the regional balance of demand and supply for different waste wood recycling systems. Third, about each integrated policy scenario the amount of material input, generated waste wood, and recycled wood were calculated. The effect of eco-efficiency by considering alternative scenarios from lumbering stage, transportation stage, operation stage, dismantlement stage, recycling stage, and landfill stage was evaluated.

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Options for Aquaculture and Drying Processes in the Mongstad EIP (Theme E 29)

Substantial quantities of low-temperature heat are available at Mongstad refinery and at the planned combined heat and power plant (CHP). Finding interesting uses for this energy is a substantial challenge, because the demand for low-temperature heat is dispersed in society. This heat quality is commonly connected to the heating of buildings, but is rarely a costly input to industrial processes, compared to other production factors. It is therefore not likely that existing facilities will relocate to a site where cheap low-temperature heat is available. However, new production processes connected to emerging industries may be attracted to an EIP based on the availability of low-temperature heat. For Western Norway, aquaculture activities are of significant interest. We investigate the farming of regionally new aquaculture species with operational heat demand such as lobster, turbot and cod. Also the potential for several species in symbiosis systems, the location of other production processes in the value chain, such as feed production, and the drying of the product and the processing of by-products. We present a review and screening of different activities to identify industries and processes with potential interest for Mongstad. In addition, we present life-cycle assessment results for turbot farmed using the heat from the refinery and an indication of the eco-efficiency of farmed turbot when comparing energy scenarios for heating.

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Sensitivity Analysis of the Reduction of Environmental Impacts due to the Home Appliance Recycling Law in Japan **(Theme A 5)**

In Japan, the Home Appliance Recycling Law for used TVs, air conditioners, refrigerators and washing machines was enacted in 2001. Consumers are required to pay recycling fees when they dispose of them. Owing to this “pay-later” system, some of them would be recycled illegally to avoid the payment. However, the refrigerant and foaming agent have been replaced by hydrocarbon, because manufactures do not have to recover them unlike fluorocarbon. In this way, the materials have been being changed due to the law. Therefore, governmental regulation influences on many activities in the recycling system. In order to operate the recycling system efficiently, the sensitivity of each activity in the system with time-series data should be grasped. This study analyzed the material flow of used home appliances from 2001 to 2015 to quantify the environmental impact reduction due to recycling activities. The Life-cycle Impact assessment Method based on Endpoint Modeling (LIME) was employed for impact assessment. The sensitivity of each activity was analyzed by Monte Carlo simulation, and its time-dependent change was clarified. Regarding the recycling system of used refrigerators, for example, we analyzed the sensitivity of four activities: the recovery of fluorocarbon, the recovery of resources, the prevention of illegal processing and the reduction of environmental impacts in recycling processes. As a result, the sensitivity of the recovery of fluorocarbon was largest followed by the prevention of illegal processing in 2001; however, thanks to the alternation of fluorocarbons, the recovery of resources became the largest followed by the reduction of environmental impact in processes in 2015. Though we did not consider the measures for feasibility and economics, such analysis can be employed using the same manner and it helps us to consider what measures should be developed and incorporated in the future.

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Gherkins, Ipods, and Nalgenes **(Theme F 33)**

Defining design education in the 21st century involves engaging sustainability as the force that will determine the trajectories of future designers and their products. Unlike other ideologically clear movements, sustainability lacks a clear aesthetic. I am a professor of liberal studies and design at the Ontario College of Art & Design. I teach courses at OCAD in vernacular design, design methodologies, and sustainability to students in environmental design, industrial design, material arts, and the fine arts. My students express themselves through time-based media as well as traditional forms of design. This semester my sustainability and design course has been focused on understanding sustainability and its impact on the design process by asking the question, what is the emerging aesthetic of sustainability as it crosses into the mainstream? We have analyzed product designs ranging from eco-friendly repackaging of hotel soaps to alternative means of milk delivery in German grocery stores. Our studies have also included alternative housing models including ecovillages, kibbutzes, and an analysis of Davis, California, as a model sustainable village. The question remains, what is the emerging aesthetic of sustainability? Science fiction author, Bruce Sterling, in a recent lecture at OCAD, remarked that sustainability is not sexy, and the only truly sustainable in Sterling's words are "the dead." Sustainability has an image crisis. Sustainability is inevitably the next overused advertising gimmick and is being marketed shamelessly to sell everything from pesticide-free condominiums to organic cotton socks. However, sustainability has many faces. The Segways, Smart Cars, and Nalgenes that hit the market will define sustainability through consumer use and reaction.

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Reducing the Environmental Impact of an Aluminium Pressure Die Casting Plant (Theme A 8)

Many models exist to analyse the environmental impact of industrial activities and the possibilities to reduce this impact. However, most of these models do not take a company perspective in defining and evaluating pollution reduction strategies. Therefore, we developed a model (MIKADO) that can be used to evaluate the environmental performance of a plant. Our model includes a number of emission reduction options, and can be used to calculate their technical potentials to reduce the environmental impact as well as associated costs. MIKADO assesses the potential environmental impact resulting from emissions of pollutants from an existing plant supplying the automotive industry. In this study we use MIKADO to analyse a number of scenarios reflecting different strategies to reduce the environmental impact of the plant. The model may assist the management of the company in answering “what …if” type of questions (‘what would happen, if we do….´?). MIKADO calculates the potential to reduce emissions, the potential environmental impact and the costs associated with implementation of pollution reduction options. We perform three different types of analyses. First, we present results that reflect the current practice in the plant. Second, individual pollution reduction options are analysed systematically. Third, we analyse, in terms of their environmental impact and costs associated, seven types of reduction strategies, assuming the simultaneous implementation of different reduction options. We calculate that the 25 reduction strategies differ largely in their potential to reduce the environmental impact of the plant (10 – 87% relative to the unabated situation), as well as in the costs associated with the implementation of options (-268 to +277 kEuro/year). We are able to define 12 strategies, reducing the overall environmental impact by more than 50%. Among these, three have net negative costs, indicating that the company may in fact earn money by implementing these.

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Decomposition Analysis of Factors in the Generation of Waste Durables (Theme A 1)

In contrast with the steady progress in the recycling of waste products, the waste prevention has been less achieved. For the promotion of waste prevention, material flows of products from production through to discard have to be estimated, and then factors in the generation of waste products have to be identified quantitatively. In this context, two studies reported the decomposition analyses of factors in the generation of packaging wastes, which are the representative consumables. This study focused on durables and analyzed factors in the generation of waste electrical equipment using the decomposition analysis method. First, a method for analyzing factors in the generation of waste durables was developed. The factors were decomposed into changes in: “present lifespan distribution”, “past shipment for replacement”, and “past shipment for newly purchasing”. These factors respectively represent changes in “present behaviors of discarding”, “past behaviors of discarding and replacement”, and “possession level” of durables. Moreover, the third factor was decomposed into changes in “number of households” and “number of possessed durables per household”. Second, we applied the method to the analysis of typical consumer durables. For example, waste CRT TV sets in Japan decreased by 6.1 million and 0.7 million from 1995 to 2004 due to the changes in the present lifespan distribution and the past shipment for newly purchasing, respectively. Meanwhile, waste CRT TV sets increased by 1.7 million for this period due to the change in the past shipment for replacement. Therefore, the net number of waste CRT TV sets decreased by 5.1 million, and the main factor of this decreasing was the change in the present discarding behavior. Additionally, the number of waste CRT TV sets is still somewhat influenced by the past behavior of discarding and replacement, although CRT TV sets have been replaced by LCD TV sets in recent years.

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Cities, Services and their Metabolism. Case Study in the Urban Park of Montjuic (Barcelona, Catalonia, Spain) **(Theme B 15)**

In industrial economies the services sector represents between 60% and 70% of GDP, and most of them are located in urban areas. As a result the research about the metabolic flows and resources consumption in this sector plays a key role for generating the knowledge that will help to design sustainable cities, not only locally but globally. It's from this context that the metabolism of a services park, Park of Montjuic, in Barcelona (Catalonia, Spain) has been studied. By using the Flow Analysis and Life Cycle Assessment (LCA), the system's global environmental impact has been estimated. The water and energy consumption of around two hundred service facilities including many sectors (sport, education, culture and leisure among others) have been analyzed, including also the waste generation in the whole services system. This project has allowed to quantify the services sector consumption of resources and its associated environmental impact, which was a forgotten sector for the environmental research. In the Park of Montjuic the average technical energy consumed per visitor is 0.35 Koe (4 kWh), which represents an emission of 2 kilos of CO_2 equivalent per visit. The water consumption per visitor is about 75 liters, and the waste generation is 1.4 kilos. Each type of service has a different energy and water consumption and also a different waste generation and it must be taken into account that inside each type of service there are also huge differences on the amount of consumed resources in terms of absolute and relative consumption per user or surface unit. This project has shown the relevance of the environmental impacts of the service sector, which up to the moment was forgotten from the environmental perspective.

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Pollution Flows in International Trade: Accounting for Intermediate Imports (Theme A 6)

There is increasing interest in the use of multi-regional input-output models (MRIO) to determine the pollution embodied in traded products for areas such as household consumption and national economic activity. Depending on the treatment of imports to intermediate production, there may be an inconsistency between studies constructed for sub-national activities such as household consumption and national totals. For a given demand, such as an individual household, MRIO endogenously determines intermediate imports required to produce the household demand. By aggregating the results for households, government, and capital, a measure of a countries footprint can be obtained. If starting from national totals for consumption, the import data includes imports to both final demand and intermediate demand. The intermediate imports also include imports required in the production of exports. Consequently, the calculated national footprint will differ markedly if one considers consumption at a national level compared to if one aggregates individual consumption from households, governments, and gross capital formation. In this paper I show the difference between the choices of consumption accounting scheme for key countries in the global economy. I use the results to provide motivation for consistent treatment of environment impact assessments at different levels, such as, individual products, households, and national accounting. I discuss the implications of the results for constructing emission inventories at a national level. An important consideration is the trade-off between constructing more complex but consistent inventories compared to less complex but inconsistent inventories.

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Is Free Trade an Encumbrance for the Environment? The Case of Primary Aluminium
(Theme A 11)

Objective of the presentation is to analyse the development of selected greenhouse gas emissions by the process chain of primary aluminium in a “globalizing” world. The analysis bases on a partial equilibrium model (PEM), using scenario technique. Contrasting other commonly used approaches, PEM allows modelling not only economic relations between economic agents, like MFA and SFA, but also driving forces underlying economic decisions, like profit maximizing. LCA focuses on environmental consequences of a product as they are determined by used technology. Actually, GHG emissions are heavily influenced by economic decisions. The used PEM permits an integrated analysis of the technical, geographical, ecological and economic dimension of material flow of primary aluminium. inclusive its auxiliary chains. To simulate the impacts of increasing globalization of GHG emissions a scenario with any trade barriers is compared with a scenario with slight trade liberalization. In a “globalizing” world emissions of CO_2 will fall, as emissions of CF_4 and C_2F_6 will not be affected. CO_2 emissions induced by the increasing trade are outmatched by the slow down of emissions induced by smelters. A world with no trade barriers promotes the instalment of smelters in regions using mainly energy carriers with low or no CO_2 emissions.

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How Production Theory can Support the Analysis, Planning and Understanding of Waste Reduction and Recycling Systems (Theme E 28)

Modeling approaches are in general developed for production systems. To identify the best possible alternative in waste management, models of reduction systems are required, that offer the same flexibility like the modeling approaches for production systems. With complex issues at stake within a production system, it becomes more difficult to measure the trade-offs between environmental benefit and economics. A modern approach in production theory of business and management economics enables this complex calculation by valuing everything in the system. This approach proposes that objects (e.g. materials) are defined as good, bad, or neutral. In transformation processes in production or recycling systems this makes it possible to distinguish stringently between the economic revenue of a process and the economic and ecological expenditures for it. Materials and energy classified as good are considered as an expense if they are used by the system and a product or revenue, if they are created by the system. This approach can be transferred to entire systems of processes in order to determine the system revenue and the system expenditure. The process can be more easily understood using material flow networks or graphs. In complex material flow systems, it becomes possible to calculate not only the costs, but also the direct and indirect environmental impacts of an individual process or system revenue (for example a product or the elimination of waste) consistently. The approach permits a stringent analysis as well as different analysis perspectives of a material and energy flow system. It is particularly suitable for closed-loop economic systems in which material backflows occur. This presentation outlines how this approach can be employed in the field of waste management using examples from European industry, such as the green dot system.

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Visualization of Value Chains – Why Sankey Diagrams are so Popular! (Theme F 35)

In Engineering there is a long history of using sankey diagrams to visualize energy flows, e.g. the original sankey diagram displays the energy flows of a steam engine. But the visualization of energy flows of one process, a region or an equipment today is only one field of application of sankey diagrams. We can observe a wide range of applications displaying mass flows, costs and environmental impacts of value chains. The poster presentation will deal with the evolution of sankey diagrams taking into account examples from policy, research and industries. The focus will be on the use of sankey diagrams to support communication and decision making processes along value chains. Especially the combination of mass and energy flow sankey diagrams with cost sankey diagrams gives a special support to decision making processes as it allows persons with very few knowledge on the mass and energy flow perspective of production systems to easily understand the links and interdependencies with costs and environmental impacts caused by this production system. Several of the examples of sankey diagrams featured on the poster will have their origin in German Small and Medium Sized Companies which recently started to work with sankey diagrams to improve material efficiency of their production system. Since February 2006 the German Government is offering funding to SMEs which want to obtain consultancy with the aim of the improvement of their material efficiency.

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Policies for Integrated Planning of Land Use and Transport Network in Developing Countries: A Case of India **(Theme A 9)**

The land use and transport relation is age old, since the man exists. The ancient civilizations have grown along the navigable rivers as the life line. The roman cities sprang up on the cross roads. With the invention of faster means of transport the cities grew in size. The coordination between the land use and transport network became weak. They were now treated as separate entities. The solution for one became a problem for the other. This is presently the case in most of the developing countries. Considering the two aspects separately has developed the present scenario and need for sustainable development is felt. Today many developing countries face the problem of fast rate of urbanisation leading to urban sprawl. The unplanned growth and changing land use in urban areas is causing the environmental and infrastructure problems. The increasing automobile traffic causes many ill effects on environment. To curtail them the management of transport is essential in conjunction with land use. This is essential for any city to sustain. The paper will discuss the policies for integrated planning of land use and transport network in developing countries. These policies will be more applicable to growing cities which are in the process of fast urbanisation. The policies shall be discussed with the help of case studies from developing countries.

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Bottom-up Accounting of In-Use Copper and Iron Stocks at Different Spatial Scales **(Theme A 7)**

During the summer of 2006, the standing in-use stocks of copper and iron in the State of Connecticut were quantified in a bottom-up analysis, centered about the year 2000. This work continues the development of the bottom-up methodology first created and applied to the city of New Haven, CT. Future work is planned to apply the bottom-up methodology to the national scale. Using results from other top-down MFAs, we can now establish estimates for the in-use stocks of copper and iron for the city, state, and national scales of the USA. With the ability to estimate in-use material stocks at different spatial scales, the effects of scale and system boundaries on the distribution of in-use stocks can be examined. Among the most important and interesting results are as follows: (1) The present study yields an overall result of approximately 540 Gg (thousand metric tons) of copper (157 kg/capita) and 31,700 Gg of iron (9300 kg/capita). Buildings make up the largest category for both iron and copper, containing over 50% of the total in-use stocks. This result compares to an in-use stock of 136 kg/capita of copper and 8400 kg/capita for New Haven, CT. (2) Relative to the top-down analyses performed at larger spatial scales, the per capita in-use stock of metal is less in Connecticut and New Haven than for the entire USA. It is unclear how much of this difference is due to methodology and how much is due to spatial heterogeneity. Future work on a bottom-up analysis of the USA is planned to answer this question.

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Life Cycle Assessment of Firewood Based Heating (Theme A 9)

Household heating by wood stoves is significant in Norway, providing an important supplement to electricity and oil furnaces. In light of the growing concerns about global warming, emissions of CO_2 from energy production is getting increased attention. Biomass based energy can be one of many ways to mitigate global climate change. As marginal electricity in Norway is shifting towards more fossil fuel based electricity production, biomass can play an important role in reducing the electricity demand for heating in households. A comparative life cycle assessment of a wood based heating system with old and modern stove technology is conducted. A novel hybrid approach is applied, limiting the data intensity usually associated with the method. Preliminary results show that despite the assumption of climate neutral carbon dioxide from biomass combustion, the combustion process is still the most significant contributor to global warming in the system, due to methane emissions. There is also a significant difference between old and modern, clean burning, stoves.

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Global Warming versus Eutrophication: Assessing the Environmental Affects of Bio-Based Production (Theme A 10)

Although substitution of bio- for petroleum-based fuels may reduce life cycle carbon dioxide emissions, intense fuel crop agriculture may increase the dispersion of fertilizers and by-products throughout the agricultural environment. Consequently, a shift to biofuels may result in carbon cycle improvements at the risk of increased perturbation in the nitrogen cycle with attendant risk of eutrophication or groundwater contamination. To properly weigh decision, design and policy alternatives, it is necessary to assess trade-offs between incommensurate environmental endpoints, such as global warming and eutrophication. One approach to comparison of disparate effects of chemical pollution is called pollution potential, which has been applied to assess the comparative importance of global warming versus stratospheric ozone depletion effects of CFC substitutes. In a pollution potential approach, the total change in chemical composition of the environment is measured in terms of entropy of mixing (i.e., configurational entropy). Hypothetically, cross-comparison of pollutants in different media and with different ecotoxicological endpoints can be assessed on a pollution potential basis. This presentation will demonstrate the utility of the pollution potential approach in life-cycle impact assessment, based upon probabilistic life-cycle inventories for both petroleum and biofuel production systems. The results show that under some conditions biofuels may be environmentally favorable while under others biofuels represent a poor environmental choice.

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Development of a LCA-MFA Based Methodology for Assessing Water Exploitation Strategies and Designing Regulation Patterns for Sustainable Water Use: the Case of Olive Oil Production in a Syrian Dry Area **(Theme C 23)**

This work aims to assess socio-economical potential and environmental risks related to a new water exploitation strategy in a Syrian dry area. In the 1990's, farmers began to grow olives in our study area. There are historical traces of such culture in the region during the Byzantine era, but since the XIII century the area was mainly occupied by Bedouins. For farmers and local engineers, olive cultivation, which results from private initiatives, is considered as an interesting strategy for regional economic development. For the Syrian administration, olive trees cultivation is forbidden, because of the supposed groundwater overexploitation. However, previous studies observed that, locally, water is not obviously overexploited. The current policy does not seem to match with the real water availability. But groundwater remains a fragile resource. Olive growing is a mid-term investment and farmers have interest to preserve ground capacity to provide water in the future. The challenge of the methodology being developed is to give a global image of the regional environmental risks, related to the use of natural resources for olive oil production, considering the local particularities and the large range of individual practices and interests. LCA seems suitable for assessing environmental impacts through a complete life cycle of olive oil production, because groundwater resources have to be protected as a whole and impacts can occur at different stages of the production process. Also, detailed flows have to be known, linked with local variability and vulnerability. For thus, MFA can provide essential elements. The ultimate goal of the project is to provide a tool that could be used as a basis for further discussion between the various stakeholders on groundwater policy.

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Concept of Do-It-Yourself: Sustainable Soluction for Low Income Families in the Third World
(Theme A 14)

Most low income people in the Third World either buy second hand furniture or cheap furniture, and usually it implies inadequacy to space availability, functional requisites, aesthetical aspirations and so on. Current furniture design for this market rarely considers possibilities aspects that affect the life cycle expansion such as the need for frequent disassembly of the furniture within low income families since they have a greater mobility in comparison to richer people. In this context, do-it-yourself products offer an alternative strategy to provide them with a better quality of life and, at the same time, it allows lower cost for production since it involves the user him/herself on the assembling process.The do-it-yourself market already exist and it is quite consolidated in various developed countries, mostly because of cultural and economical reasons such as the cost of manpower. In countries like Brazil the low income consumer is already used to get involved on adapting, changing, cutting, etc, the products in order to fit to his/her needs. However, most products in the country are not designed for this purpose and usually are designed assuming that a professional will assemble the product. The current research project has investigated the current state of the furniture market in Brazil in relation to do-it-yourself requirements for low income families. The study consisted of a survey that characterized the products of the five largest companies in the country and presents a diagnosis on the main possibilities for design intervention in order to enable this new pattern of consumption in the country.

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Agro-Industrial Symbiosis and Population's Living Condition Improvement in North Nigeria
(Theme C 20)

Background: This project takes place in the West African context, more precisely in the north of Nigeria. The population is essentially rural and particularly poor. The production of cement is the only industrial activity in the region. The cement factory, belonging to the Lafarge group, presently requires around 200t of fossil fuels per day (petrol and coal). Goal and Scope definition: In an industrial ecology perspective, this project explores the potential of substitution of up to 10% of the fossil energy (petrol and coal) required for the cement factory by using biomass as a fuel. Simultaneously, the projects aims at improving the living standard and food security of the population around the factory. With respect to agronomic and social particularities of the region, different types of crops are evaluated to reach these goals: jatroffa, sunflower, cotton, etc. A feasibility study evaluates the economical viability of new agro-industrial activities to be implemented, the identification of potential investors and operators. One additional objective of this project is to develop a model of operation for the Lafarge group (one of the largest building materials company in the world) for possible replication in other developing countries. Methods: The basis of the evaluation is a material flow analysis of the cement factory and of the surrounding region, and evaluation of the energetical potential of various crops. Conclusion and Perspectives: This work shows the potential gains and limitations of creating agro-industrial symbiosis in developing countries, in terms of environmental impact reduction, securing and optimizing energy supply for the company, diversification of revenue and improvement of the level of living for rural population.

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Life Cycle Aspects of Nanoscale Manufacturing Technologies (Theme A 8)

Manufacturing involving the nanoscale has rapidly become important for the production of value-added devices and components. In this context, it is important to uncouple nanoproducts from nanomanufacturing methods, i.e. nanoproducts can be made using “macro” fabrication methods (so-called “top-down” approaches that use processes such as grinding, etching, lithography), or “nano” fabrication methods (bottom up approaches) that rely on manipulations at the atomic level (such as self-assembling reactions, chemical synthesis, positional assembly). Likewise, “macro” products can be made using new nanomanufacturing methods as replacements for existing technologies. “Top-down” manufacturing is the more common approach used today to produce nanoproducts; limited data suggest that waste-to-product ratios (W/P) for such processes can be exceedingly high. In contrast, it is often suggested that “bottom-up” nanotechnologies should be the ultimate tools for sustainable manufacturing since they allow for the customized design of reactions and processes, at the molecular level, that can minimize the generation of wastes. While these attributes may well ultimately prove be the case, available evidence where such nanomanufacturing methods have been brought on line at large scale have been inconclusive. Both top-down and bottom-up nanomanufacturing methods may have what might be termed “entropy-penalty” and toxicity problems. Past experience with manufacturing methods has shown that inclusion of environmental considerations early in investigation, design, and scale-up stages results in far more efficient, cost-effective, and environmentally responsible solutions, and generates a compatible regulatory climate for further development. This paper focuses on the application of life cycle assessment tools and metrics to assess nanomanufacturing technologies. It contains two parts: 1. A framework for conducting material and energy flow analyses for generic classes and types of nanomanufacturing processes, and 2. Results from two case studies drawn from existing, but new, nanomanufacturing technologies, one each from the xerographic

and microelectronic industries, which are compared with existing manufacturing methods.

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Potentials for Eco Industrial Park Developments in Turkey (Theme B 15)

Regardless of the fact that industrialization takes a very important place within the efforts for development of Turkey and it is indispensable, on the other hand, industrialization is the cause for significant environmental problems, such as the loss of natural resources like forests, water basin, water-air-soil pollution originated from the industry, hazardous wastes as well as immigration to cities and the growth of urban areas without control and plan. As the existing industrial and environmental policies cannot protect the natural areas and resources against the above-mentioned thread, it is obvious that new approaches in planning are necessary. Although there exist many examples in many countries all over the world, it is a fact that the eco-industrial parks are not known well enough in Turkey and such applications are very rare. The purpose of this study is to investigate potential for eco-industrial parks in Turkey and to evaluate the current situation. With this purpose, the structure of eco-industrial parks existing in many countries will be examined and their structures will be compared with the organized industrial zones of Turkey, that present a quite similar industrial area approach. Most of the time the Governor or the Mayor of the province are among the founders of the organized industrial zones and this fact helps in increasing the effectiveness of the area. As the area administrations are authorized for planning, waste management, substructure services, and property ownership, this authorization provides additional opportunities for the applications targeting the protection of the environment. The increased consciousness of the public on environment, also motivate the administrations of the industrial areas in taking responsibility for solving the environmental problems. The leader role of the industrial area administrations within the business world should also be taken into consideration.

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Interdisciplinary Planning Practices for Sustainable Development of Water Resources in the Wake of Global Changes **(Theme A 1)**

Climate Change and Urbanization are the two most driving forces of change in the 21st century. These two forces are bringing a shift in the normal cycle of working of the human and environmental systems; Water system being one of them. Water resources all over the world are getting scarcer because of the huge rise in population and also due to population pressure in the urban areas. Climate change is another threat to the sustainability of the water resources especially because of the uncertainty involved with the climate system and problems of predictions of climatic upheavals. Data unavailability and the credibility of the data available make drawing proper plans and strategies all the more difficult. The planning issues are deeply intermingled because of the interdisciplinary character of the issues involved; both as related to climate change and as related to process of urbanization. The conventional planning practices somehow have lacked an overall perspective and interdisciplinary characterization of the planning process which has led to many discrepancies. The paper explores and stresses on the importance of use of interdisciplinary knowledge and integration of the same in the planning practices to ensure sustainable development of water resources.

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Network Complexity of Industrial Symbiosis System: Gongyi case in China (Theme D 26)

Complex networks, including the Internet and ecosystem networks, have attracted many research interests since 1990s. In industrial ecology field, it is acknowledged that industrial symbiosis system can also be complex networks. Through preliminary research, however, we find that with common initialization of factors and measures, some classical industrial symbiosis cases including Kalundborg Industrial Symbiosis Network do NOT perform network complexity, whereas some industrial systems at county level in China DO. The facts above naturally raise two puzzles. One is that if material/energy factor is considered only, whether an industrial system performs simplicity or complexity. The other one is that if other factors, such as economic or information exchange, are introduced, what will happen to the network complexity. To answer the two questions, it is necessary to distinguish the differences between industrial and other networks. We believe that heterogeneous node, multiple relationship and strong impact of measures are the main characteristics of industrial networks. Thus, clearly defined nodes, relationship and measures are preconditions for analysis. We select Gongyi, a county in China, as case and compute relevant characteristic indicators, such as clustering coefficient, network length, betweenness and degree distribution of nodes, to evaluate network characters of its industrial symbiosis networks. It should be noted that the evaluation results strongly depend on initialization of factors and measures. For example, “Enterprise-Competition-Static” and “Material-Material Flow-Dynamics” imply different initialization modes which induce different evaluation results. Thus, we have to clearly illustrate the impact of different factors and measures on network complexity. By changing factors and measures, we believe a conclusion framework for the two puzzles above will be formed.

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Metabolism Speed of Material Stock for De-Materialization with City-Scale 4D-GIS (Theme B 15)

With regard to the urban infrastructure (i.e. the stock of buildings and road networks), Metabolism speed of material stock directly reflects level of dematerialization. Lifetime of building and infrastructure is a part of Metabolism speed of Material Stock. Even if society keeps high level of recycle rate of construction material with high metabolism speed, such social system cannot establish de-materialized sustainable society. However, quality and quantity of material balance in construction sector need to consider in the course of transformation toward sustainable city. With existing “down-recycling” system, which construction material emerged from demolished building is used for roadway construction, successive newly roadway construction is required for keeping on recycling demolished buildings. In many cities in Japan, same as European cities, construction materials are stocked as structures in some years, but overage and unnecessary structures can cause new material flow to be wasted. In the near future, a huge amount of overage stock built during a period of rapid growth in Japan will cause the new material flow to become waste. In order to avoid becoming a society dependent on recycling, we should focus on "upstream" countermeasures, which are more important for the long-term, rather than "downstream" countermeasures, which are effective only in the short-term. In order to assess urban metabolism speed regards to construction sector, we need to know change of Material Stock “spatially” and “successively”. Material Stock of urban infrastructure were estimated using 4-D GIS (fourth dimensions geographical information systems), which includes spatial 3-D GIS with time scale. Manchester City in UK, Wakayama City in Japan, are selected to estimate change of material stock. From case studies, quantities of demolition from building and roadways in the near future, which should be recycled, are estimated using this system, and metabolism speed in each city are estimated with local identities.

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Life Span of Commodities (Theme A 7)

How long do commodities and products stay (use and hibernation) in our society? This is key information for stock accounting as well as estimation of wastes from stocks. This study explored a variety of definitions of life spans of various commodities, from consumables to durables, and reviewed values of life spans surveyed in literature. This study also examined the methodology of obtaining the life span of commodities. First, this study revealed that there are many types of definitions of life span of commodities and life-span-related periods. The authors propose several important types of definitions. Total life span of products differs from domestic residential span of products. Domestic residential span of a product excludes the period that the product is used in other countries, and is useful for designing a recycling-and-disposal system in a nation. Product age means the period from the manufacturing to the time of interest. Second, this study reviewed values of life spans in literature and the definitions from existing literatures are organized into the proposed definitions. More than 200 data of Japan and more than 50 data of the other countries were compiled. Finally, methodology of estimating parameters of the distribution function of life spans of commodities is discussed. For instance, advantages and disadvantages of several approaches to estimate average domestic life-span of consumer durables were examined. Then, an approach based on remaining rate of shipped products was applied and the average domestic residential spans were calculated for 6 items used in Japan. Average domestic residential spans calculated were 11.1 year for TV set, 11.6 year for refrigerator, 9.2 year for washing machine, 14.1 year for air conditioner, 6.2 year for personal computer (household-use only), and 16.3 year for microwave oven with the coefficients of determination of 0.77 to 0.99.

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Radio Tracking of Products in Recycling Chains
(Theme F 34)

We demonstrate use of battery-powered radio transmitters and hand-held antenna systems to track the path of recycled items through a recycling chain. Technique is demonstrated through tracking of a telephone book from curbside, through a materials recovery facility and to the Port of New Jersey, and throught tracking of a plastic bottle from curbside through a Georiga materials recovery facility to a plastics recycling plant. General application to verification of recycling pathways is discussed.

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The Relevance of Clusters for "Green" Innovation: Cased by the Diffusion of Lead-Free Soldering in Electronics Industry in China
(Theme A 8)

The EU Directives on e-waste management (WEEE and RoHS) draw attentions of the electronics producers around the world to the environmental benign technologies in recent years. One of the technological challenges to the electronics manufacturers is the adoption of lead-free soldering system. Based on fieldwork in Southern China, this research studies the diffusion of lead-free soldering technology within electronics producers, to find out the relevance of clusters for the diffusion of environmental benign technological innovation among firms. Four agents as key promoters were identified within the production network – leading global brand name companies, the OEM companies who provide integrated manufacturing service, the suppliers of lead-free components, and the specialized consultant companies. The dynamics and topological relations among these agents are presented, and the incentives for firms within the cluster to collaborate for learning are addressed.

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North American Potential for Production of Diesel Fuel from Bio-Based Feedstocks (Theme F 32)

Concerns over energy security, dependence on nonrenewable resources and global efforts to curb greenhouse gas emissions demonstrate the need to evaluate fossil fuel alternatives for long term transportation energy supply. Diesel fuel produced from bio-based feedstock is an emerging renewable alternative that can potentially displace use of fossil based diesel. Critical to determining the potential for biodiesel is a comprehensive inventory of the biomass supply that could be available for conversion. This research evaluates the production potential of biodiesel from both first generation (Oil seed) and second generation (cellulosic) feedstock sources in the United States and Canada. Feedstock sources, availability and competing uses are assessed for the domestic North American Market. Domestic feedstock and fuel production is the focus of this work; however the import of key biodiesel feedstock from other geographical regions such as palm oil will also be evaluated. The engineering and environmental aspects of the relevant conversion technologies will be assessed for a set of existing and proposed biodiesel production technologies. An inventory of biodiesel production pathways currently in use at the commercial scale and those expected to be feasible in the midterm will be collected and the associated current and expected technical and environmental characteristics will be quantified. The metrics developed for the biodiesel pathways will be incorporated into existing well-to-wheel life cycle models developed by this research group. The results of this research are expected to contribute to the further understanding of the feasibility and technical progress of biodiesel production in Canada and the United States.

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Untangling the Web of Heavy Metals in the U.S. Economy: Estimation of Supply Chain Cadmium, Lead, Nickel, and Zinc Intensity with the MUIO-LCA Model **(Theme A 6)**

The risks associated with releases of heavy metals are of great concern for companies, regulators, and society at large. Understanding how and why we use these toxic chemicals can help us use them more efficiently. Here LCA and MFA are combined in the formulation of a mixed-unit, input-output life-cycle assessment (MUIO-LCA) model to improve environmental decision-making with respect to heavy metals. National economic IO tables including roughly 500 sectors of the US economy were augmented with additional sectors for explicitly handling physical flows of Cd, Pb, Ni and Zn described by the US Geological Survey. The model allows for material usage, environmental releases, and other flows of interest to be estimated for the complete supply chains of goods and services. Benefits of using the MUIO-LCA model for evaluating the life-cycle impacts and material flows associated with products include greater detail, explicit tracking of material flows, and the ability to model production of select commodities based on mass units rather than dollars. The inclusion of process sectors based on physical quantity reduces the burden on the model user to calculate the cost associated with these commodities and allows for better estimation of the impacts associated with imported goods by removing the dependence of physical flows on price. We use the MUIO-LCA model to estimate consumption of cadmium, lead, nickel and zinc throughout the entire supply chain of each sector of the economy providing insight into the material intensity of products and processes. By coupling material and economic transaction data the MUIO-LCA model presented here provides a more complete picture of the movement of metals through the economy than either MFA or economic IO techniques alone could provide.

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A Comparative Analysis of EDIP Versions in the Case of Lead-Acid Batteries **(Theme A 4)**

Life Cycle Assessment (LCA) has a significant role to play in identifying and measuring the environmental costs of extended supply chains, i.e., chains involving both forward and reverse activities. LCA has often raised discussion and disagreements, especially regarding the stage of Impact Assessment (IA), where several different methods have been developed. Such methods have been continually evolving, since new findings regarding the interaction of man with the natural environment arise and the relevant significance of environmental impacts is subjected to frequent changes. This unstable situation may affect decision-making and especially long-term objectives, since decisions that have been taken e.g. a decade ago might have been different if brought to the present. Thus, a retrospective approach would provide new insights in the methods themselves as well as in the examined product systems. In this paper we focus on the method for Environmental Design of Industrial Products (EDIP), which has been internationally recognized as an expedient IA method. In particular, we investigate how the modifications made towards the evolution of the method from version 1997 to version 2003 may affect environmental decision-making. For the purposes of this paper we use the results of a case study regarding application of LCA in starter lead-acid batteries. Moreover, two alternative end-of-life scenarios are studied and compared using both EDIP versions. The first scenario deals with the recovery chain, that is, the flow of used products from consumers to recovery facilities. The second scenario deals with the disposal chain, in which used products are carried to landfills.

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Development of Quantitative Sustainability Assessment Tool (QSAT) for Bauxite Residue Management (Theme D 27)

Decisions on development and implementation of sustainable processes and technologies are surrounded by high degrees of uncertainty and absence of agreed indicators and metrics. The alumina industry therefore supported research to develop a Quantitative Sustainability Assessment Tool for evaluation of bauxite residue storage options. A leading practice sustainability assessment framework was applied to bauxite residue storage to develop a register of 14 Sustainability Issues. Next an indicator system was developed. This has three hierarchical levels, respectively Headline Performance Indicators (six, to measure performance against sustainability objectives), Key Performance Indicators (twenty-four, to measure the size and/or severity of sustainability impacts) and Performance Measures (flexible set, to measure operational contributions to sustainability impacts). Throughout a division is made between three types of indicators, namely: management indicators (rate the existence, comprehensiveness and resourcing of planning, management and reporting systems and practices in place for residue operations), condition indicators (describe condition of environment and communities that have in the past been, are currently being and/or could in future be impacted by residue operations), and operational indicators (quantify operational performance of bauxite residue storage system). An ordinal five level performance measurement scheme was developed for all indicators, and ideal values derived from sustainability ideals (‘back-casting’). The poster summarises the tool design and preliminary results from its application by industry. This example tool development shows that even with imperfect knowledge and uncertainty, quantified sustainability tools can be developed to aid in decision making on technology development and implementation.

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Alternative Transportation Fuels: An Evaluation of Distribution Methods for Hydrogen (Theme A 11)

Hydrogen is receiving considerable attention as an alternative fuel for transportation. Alternative fuels could reduce greenhouse gas emissions and promote US energy independence. The increasing cost of petroleum also makes the economics of alternative fuels more attractive. The infrastructure required to produce and deliver hydrogen will have large economic and environmental impacts. We analyze several scenarios for hydrogen production and distribution, evaluating the cost at the pump and life cycle environmental impacts. The scenarios include hydrogen production from natural gas and coal (central and distributed) and distribution via pipelines and truck. Environmental impacts are evaluated using an input-output life cycle analysis approach. Preliminary results indicate that hydrogen production via central station coal gasification with carbon dioxide capture results in 10-15% fewer greenhouse gas emissions as compared to production from natural gas; however, emissions of sulfur dioxide and nitrogen oxides are higher in the coal production scenario. Costs of hydrogen at the pump are similar between the pathways, but lower than 2006 gasoline prices. There are strong economies of scale in distribution paths, so that a major shift to alternative fuels is needed to achieve the most cost effective distribution methods. There is considerable uncertainty in our cost estimates, particularly for the feedstock costs for hydrogen production and the future price of petroleum.

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MFA and Disaster Recovery: Material Requirements for Rebuilding New Orleans
(Theme A 3)

The devastation wrought by Hurricanes Katrina and Rita makes for one of the largest natural disasters in U.S. history. In Louisiana, more than 200,000 homes experienced major or severe damage and an excess of 24 million tons of debris were produced. Flooding encompassed more than 80% of New Orleans. The scale of reconstruction efforts necessitates the inclusion of environmental performance considerations as part of the urban planning process. Concepts of industrial ecology specifically linking the quantification of material use through material flow analysis (MFA) and the services provided by those materials have been used to evaluate the environmental performance of different reconstruction scenarios for Orleans, Jefferson, Plaquemines, St. Bernard, and St. Tammany parishes. To study material use and availability within the context of pre-event stocks of major construction materials such as concrete, forest products, steel, copper, and gypsum in the built environment, I employ spatial analyses in GIS to visualize trends and potential challenges associated with different scenarios. The results of these analyses can be used by decision-makers to inform the planning process. More generally, the results of this study enhance our understanding of adaptive capacity in the face of natural disasters as well as discrete and incremental anthropogenic changes.

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The Dawn of a New Iron Age? A Bottom-Up Analysis of China's Mutilevel In-Use Stocks of Iron **(Theme A 7)**

China is undergoing an expansion of steel production and use as large and rapid as no country has ever experienced. But surprisingly most studies on this steel boom so far centered on the flows such as output, trade, and use of steel products, leaving the stocks – another important factor – a corner. In-use iron stocks that provide the goods and services preserving the human living standards and commit the reservoirs of future secondary resources deserve more attention. Based upon a top-down analysis, Yale University's Stocks and Flows (STAF) project has examined the evolution of in-use iron stocks in the United States and discovered that per capita stocks might reach saturation (11-12 Mg/capita, 1 Mg = 1000 kg) since 1980. This study, from a bottom-up perspective, investigates the driving forces of the stock dynamics in China: people’s requirement of goods and services, and iron intensities of goods. Four basic categories (buildings, infrastructure, transportation equipment, and industrial and household equipment) and nearly one hundred subcategories of goods and services have been explored. As of 2004, China's iron stocks-in-use has been growing to 2.7 Pg (10^12 kg) as a whole or 2.1 Mg per capita (compared with 11-12 Mg/capita in the US). Of the total iron stocks, about 70% are devoted to buildings, 17% to infrastructure, 7% to transport equipment, and 6% to other equipment. The results of iron stocks at provincial, regional, urban, and rural levels display remarkable disparities: The average iron stocks-in-use for an urban Chinese resident are about 2.7 Mg, whereas they are only 1.6 Mg for a rural resident. The gap of the per capita stocks between coastal and western inland China is as significant as 1.2 Mg/capita. The analysis will help inform the future of iron demand and scrap availability in China and accordingly propose the long-term industrial, resource, trade, recycling, and environmental policies.

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Planning Eco-Industrial Parks under Uncertaintie
(Theme E 29)

Eco-industrial Park, an important implementation of industrial ecology, obtained much attention all over the world. However, to plan/build EIPs is a challenging job because of many inherent uncertainties, including market fluctuations, technological improvement and governmental policies. In order to support the planning of EIP, the goal of this work are to 1) analyze and model the uncertainties, and 2) propose the framework to plan EIPs under uncertainties . In our work, Important uncertainties mentioned above including time dependent uncertainties which affect EIP planning are described first. Combining probability distribution method and Fisher information (FI) theory are used to model the different uncertainties, such as market fluctuations, material supplying. The different distribution functions like normal, lognormal, uniform distributions deal with different uncertainty. The FI theory is proposed to model dynamic or time-dependent uncertainties. Based on the characteristics of EIPs, the EIP planning problem is described and fomulated into a multi-objective stochastic programming problem in simply way. Then the weight method is used to transfer the multi-objective stochastic programming problem into a single- objective stochastic programming problem. To solving the problem, we first describe the stochastic problem in a two-stage stochastic programming formulation. Then a strategy for solving the stochastic process problem is presented to use sampling technique to transfer the stochastic programming problem to a generalized optimization problem. Hammersley sequence sampling (HSS) is used as sampling techniques. Benders decomposition method is used to solve the optimization problem. Feasibility cuts based on dual theory is proposed to reduce sub-problems and enhance the feasibility of constraints. The new strategy will make the problem solving more efficient. Applicability of the proposed framework is illustrated in a case study.

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Forecasting Future Economic Growth under Alternative Energy Efficiency and Energy Intensity Scenarios **(Theme A 11)**

We describe the development of a simple yet robust macro-economic forecasting model in the tradition of system dynamics. It is called Resource Exergy Service (REXS). The model simulates historical economic growth and is able to provide forecasts for several decades into the 21st Century. The model was developed for the US and Austria. The model was calibrated by estimating the useful work provided by fuel energy inputs (coal, oil, gas, fuelwood, renewables, nuclear and biomass used for food and feed). Estimates of the efficiency of conversion of energy inputs into heat, light, motive power and electricity were used to quantify the amounts of useful work consumed in the economy. The model eliminates the need for an assumption of exogenously driven exponential growth along a so-called 'optimal trajectory', by incorporating the dynamics of technological change in terms of decreasing energy (exergy) intensity and endogenously increasing efficiency of conversion of fuel inputs to exergy services ('useful work'). In this model the traditional assumption of exogenous technological progress (or total factor productivity) increasing at a constant rate is replaced by two learning processes based respectively on (i) cumulative economic output and (ii) cumulative energy production experience. The initial results of the simulation for the period 2000-2050 have significant implications for future trends in economic output.

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Material Flow Analysis of Economic and Environmental System in Tianjin, China (Theme C 23)

The analysis of material flow in economy and environment system is one of important research fields of industrial ecology and circular economy. In this paper, material flow analysis (MFA) was applied in the case Tianjin, China, of which the time span lies between 1995 and 2004, known as the ninth and tenth five-year plan. During the time, the local GDP grew by 3.2 times, while the total material requirement also grew by 1.38 times. In addition, as one of four major municipalities directly under the Central Government of China, Tianjin's gross national product occupies the forefront in the whole country, so it has strong pertinence for detailed analysis. On the basis of referencing the researching results of Eurostat "Economy-wide Material Flow Accounts and Derived Indicators?A Methodological Guide", and combing with the characteristics of Chinese cities. Materials in MFA are firstly compartmentalized, mainly including non-biomass, biomass, emissions and wastes, dissipative use of products and dissipative losses of materials, finished products and semi-manufactured products, hidden flows, etc. Then, analysis indicators in Regional MFA are listed, in which input indicators, consumption indicators, output indicators, intensity and efficiency indicators are included. Subsequently, introduces data sources and disposing methods. Finally, according to analysis indicators and calculation formulae, we can get some results, such as total material requirement, saturation of environmental capacity, intensity of material consumption, material productivity. The results of this paper can help understand the characteristics of material consumption during the current development stage in Tianjin, China; moreover, it can provide basic quantitative results for urban society-economy-environment sustainable development plan, and to optimize and adjust the industry structure of the region.

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The Development of Eco-Industrial Parks and Networks in China **(Theme E 29)**

The Eco-Industrial Parks (E1Ps) is a new industrial symbiosis system, which is designed by the idea of circular economy and the principles of industrial ecology. The goal of eco-industrial parks is to recycle material in a closed way, use energy at multi-stages, and minimize waste from raw material, intermediary product, the waste to the product. Consequently, the best utilization of resources, energy, and investment will be realized, and the eco-industrial parks will obtain the overall development. The short of resources has become the bottleneck, which restricts the Chinese economy development; it has positive significance that the development of eco-industrial Parks can alleviate the resource short in china. The national environmental protection bureau has started to impel the practice of circular economy in 1999, and the creation of eco-industrial parks has been adopted as an official national policy in china, sixteen national eco-industrial parks have been authorized to construct at present. Certainly, the development of eco-industrial Parks will be impelled strongly in China. To begin with, this article introduces the development and situation of eco-industrial parks in china, and then, mainly discusses the networks of eco-industrial Parks according to principle of material flow and energy flow. Taking the waste reduction, reusing, recycling as rudder, integrating the material, energy and public services in the internal-enterprises and the inter-enterprises to reduce the amount of resource input, and enhance the utilization efficiency and productivity of resource and energy. The material recycling, the integrating energy utilization and sharing information in eco-industrial parks will be realized on the basis of building good networks in the end.

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Eco Industrial Parks in NRW (Theme E 29)

The German state of North Rhine-Westphalia's pilot project for "Eco Industrial Parks" aims to integrate ecological, economic, and social considerations into the planning, development and operation of new and existing industrial parks. Toward this end, the Ministry of Environment, Nature Protection, Agriculture and Consumer Protection is helping eight of the state's communities to realize sustainable planning for pilot projects involving an extremely broad range of commercial and industrial park typologies and development phases. The project stakeholders are the municipalities, economic development agencies, enterprises, and private investors. The project will a) reactivate, consolidate, re-plan, or refurbish existing commercial and industrial parks b) developing exemplary and appealing new facilities that meet high ecological standards and are ecologically compatible or c) implementing innovative approaches to commercial development such as the establishment of a virtual commercial space pool. Scenario specific solutions and objectives will be elaborated by the participating municipalities and investors with the assistance of state/regional agencies and the MUNLV NRW. This will lead to the development of sustainable concepts in the following arenas: • Recreational area management • Land use management • Building construction management • Energy resource management • Traffic management • Water resource management • Waste management • Business models• Social models. The overarching goal of the pilot project is to elaborate proposals for the development of sustainable commercial facilities in NRW and in so doing improve the employment situation in the state, enhance its citizens' quality of life, and achieve viable environmental stewardship.

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Exploring the Ecological Analogy: Testing Connectance and Biodiversity for Use in Industrial Ecology **(Theme E 29)**

The ecological metaphor of industrial ecology has proven to be a valuable tool for rethinking our relationships with the natural world. Indeed, the term industrial ecology has spawned an entire field of interdisciplinary research that explores the intimate linkages between industry and its underlying natural systems. Yet despite its growth over the past two decades, industrial ecology still lacks rigorous exploration of its foundational theories. Ecological comparisons have demonstrated power conceptually, but just how similar are industrial ecosystems to their natural namesakes? Stated another way, the qualitative value of the metaphor has been proven, but the quantitative strength of the industrial ecosystem analogy is still largely in question. This research begins to fill that knowledge gap, and tests whether some of the same analysis tools used in ecological food web research can be meaningfully applied to industrial systems. Specifically, I estimated connectance and biodiversity among businesses in Burnside Industrial Park, a large industrial development located in Halifax, NS. I conducted a telephone survey using a stratified random sampling protocol, and completed 153 surveys in total (response rate of 75%). The results demonstrate that ecological indicators can indeed be meaningfully translated to an industrial context, which suggests that the ecological sciences have more to contribute to quantitative analyses within industrial ecology. Eventually, this line of inquiry could lead to a formal suite of indicators for evaluating the performance of industrial ecosystems, or for comparing the relative performance of eco-industrial developments; however, more exploration of the potential of ecological indicators needs to be done before such lofty goals are realised.

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Application of FMEA to Establish a Risk Assessment Framework for Parts and Components in Green Supply Chain Management (Theme E 30)

Environmental risks within a supply chain management usually can be categorized into two aspects, suppliers' risks and parts risks. Suppliers' risks derive mainly from procurement, warehouse, process, and testing procedures, and enterprises usually implement severe selection and assessment for suppliers to mitigate this type of risks. However, solely apply this procedure won't ensure all the environmental risks be prevented. Furthermore, it is impossible for incoming quality control (IQC) unit to check hundreds and thousands of parts one by one. This implies that huge risks may be associated with parts which provided by the Original Equipment Manufacturing (OEM) and Original Design Manufacturing (ODM), and to develop a risk assessment framework for parts should be essential. This study, thus, utilized the Failure Modes and Effects Analysis (FMEA) to analyze and assess risks of parts regarding EU RoHS directive in the IQC) stage. It is based on a case of OEM/ODM manufacturer. The FMEA technique is considered as a risk assessment tool, and it is often used by industry for detecting potential defects of product design and process planning. In this study, a FEMA analysis consists of six risk factors, the occurrence (O) refers to the testing report and bill of material (BOM), the likelihood of being detected (D) refers to the likelihood of parts being detected, and severity (S) refers to the declaration statement, the source of parts, and the volume of products. By assigning scores 1 to 10 with respect to the severity of each factor and calculating the risk priority number (RPN), the risks of each parts can be determined. The RPN value can be used to prioritize which parts have high risk and enhance the inspection for IQC. Furthermore, this method also can mitigate the risk in the early stage of GSCM and assist procurement personnel to judge on the decision-making of parts/components.

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Combining Pinch Technology with Artificial Intelligence Method for Energy-saving (Theme F 35)

The process industries are energy intensive industries. Energy saving issue is considered as one of the most important objectives to attain industrial sustainable development. Process system engineering plays an important role to attain such energy saving task. Many methodologies and techniques have emerged such as evolutionary method, pinch technology, heat integration, mathematical programming and others. The goal of this work is to develop an integrated method for process energy saving, which combines pinch analysis and artificial intelligence method. The framework of the integrated method includes: 1) Based on the numerical simulation, the energy consumption of each section of a base case process was analyzed. 2) Total site simulation using process simulator-Pro/II ™. 3) The heat exchanger network (HEN) of the base case was built. Then optimal design of HEN is obtained using artificial intelligence method. 4) Energy utilization diagnosis and improvement on total site was done by pinch technology. The system composite curve, general composite curve and balanced composite curve were obtained to calculate the target of total site. Based on these, optimal alternatives are generated. The final solution is chosen according to the benefit-cost analysis. The styrene process as the practical industrial case demonstrates the feasibility of the integrated method. The results showed that the final solution for process modification could save 7.8 ton per hour high-pressure steam and 3.8 ton per hour middle-pressure steam. The saved energy cost could be 7 millions RMB/year. Applying this method, it is effective to identify and judge: 1) the potential of energy saving in total site, 2) the interaction between the total process and utility system, 3) the match of different level heat and power stream for cascade use. This method could be extended to apply in planning and improvement of energy system for industrial park or a specific region.

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The Experience of Jiangyin in China to Keep Sustainable and Harmonious Development
(Theme D 24)

Approved by the State Council, Jiangyin was recently awarded the title of “National Ecological City” by the State Administration of Environmental Protection. As an outstanding model for the south of Jiangsu, which is famous for rapid economic growth and town and village enterprises in China, Jiangyin integrated ecological construction and environmental protection with economic development and industrialization. It’s worthy to introduce the experience to achieve sustainable development of small cities in China’s urbanization. After an overall introduction of economic and social development, evironmental situation and problems in Jiangyin, the paper will focus on the transformation of development stragegies, governance measures, especially the industry centralization and ecological industrial park construction. Under the general planning of Jiangyin City, all the 16 towns have a industrial park to centralize its industries. These industrial parks are directly governed by towns, including infrastructure, investment and management, and also monitored by the the municipal government for corporation and the regional target. Two of such town ecological industrial parks will be introduced as cases. Besides, Jiangyin has taken full actions to clean its pollution sources. For the two main environmental problems of water pollution and SO2 emmision, 26 sewage factories were built to deal with the industrial wastewater and domestic sewage, speading to every town and industrial park; and desulfurization of fire power plant and use of clean energy help to reduce the SO2 pollution and suspended particulates. Promotion of circular economy and clean production, information disclosure of 300 industrial enterprises, establishment of green factories, together bring Jiangyin to be a harmonious developed city in China.

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Feasibility of Rapid Economy Growth with Zero Increase of Industrial Pollution in the Three Gorge Region (Theme C 21)

With the storage of Three Gorge Dam rising to normal level, the environment of this region is becoming extremely vulnerable. The regional industries with high energy consumption and heavy pollution are the main contributors of pollution to the area, which not only affects the water quality but presents a severe constraint to the sustainability of the regional economy. The aim of this research is to analyze the feasibility of a rapid growth of economy with zero-increase of industrial pollution emission in the Three Gorge Reservoir Area. The research was performed using these following methods and analysis: 1) An investigation of the current industrial structure and the cleaner production level of industrial process to identify the relation between the pollution and economy contribution percentages of varied industries; 2) A further analysis to establish the relationship of the total industrial pollutant emission change and the economy-growth rate; 3) A discussion on the feasibility of realizing the industry progress with the advanced Cleaner Production technologies and by structuring eco-industry ; 4) A list of advanced technologies and effective measures to ensure a rapid economy growth with zero-increase of industrial pollution emission;5) A planning of the circular economy program of the Three Gorge Reservoir Area. The results show that a rapid economy growth with zero-increase of industry pollutant emission in Three Gorge Reservoir Area is of great perspective.

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Physical Input Monetary Output Analysis (Theme A 6)

Economy-wide Material Flow Analysis (EW-MFA) is one of the most important methods to study Industrial Ecology on economy-wide systems. The physical dimension of the economy can be illustrated by EW-MFA. There are a lot of case studies of EW-MFA both in developed and developing countries. However, the framework of EW-MFA considers the economic system as a 'black box'. It is hard to study how the inside structure and activities of the economic system could influence the material metabolism of the system. On the other hand, Physical Input-Output Tables (PIOT) is regarded as one of the most powerful approaches for studying on that issue. However, data availability and quality are the most serious limitation for the application of PIOT, especially in countries where statistic data are poor. Although physical input-output data are limited in most countries, there is plenty of monetary input-output data, which also include important information of economic structure, available in some countries. Thus, we developed a new methodology called Physical Input Monetary Output Analysis (PIMO). This method connects advantages of EW-MFA and Input-Output Analysis together, using physical input data generated by the former and monetary output data generated by the latter. PIMO regards materials input into and output from the economy as physical input into the economy. Characteristics of economic structures are represented by monetary input-output data. Those two sets of data are related by price-weight coefficients. Based on PIMO framework, we can build mass balances for either the entire economic system or individual economic sectors.

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Material Metabolism of Economic System: Physical Input Monetary Output Analysis for China (Theme C 23)

The material metabolism of economic systems is one of the most important technical areas in the study of sustainability. From the Industrial Revolution onwards, the great spurt in modern economic growth has basically relied on substantial and increasing amounts of material consumption and waste emissions. China, in the last two or three decades, could be a typical example of this unsustainable development. In this paper, the material metabolism of China is studied from a macro perspective. Specifically, the material metabolism of China from 1990 to 2003 is explored using an Economy-wide Material Flow Analysis (EW-MFA) framework. The relationships between economic sectors, which cause the nonlinear and complex features of the system, are explored by Input-Output Analysis (IOA) using Monetary Input-Output Tables (MIOT) of China in 1997 and 2002. To combine the EW-MFA and IOA approaches, a Physical Input Monetary Output (PIMO) model is created. A set of scenarios are set up and analyzed to determine the physical dimension of China's economic growth from 2005 to 2010 using the PIMO model. To set up the PIMO table, the economic system was divided into 43 sectors, with 15 material categories of input and output. There were also 10 specific water containments studied in this paper. Based on the PIMO table for China in 2005, 15 scenarios were designed for material metabolism in 2010, using different assumptions regarding economic structure and the evolution of manufacturing technology.

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Lifestyle Changes and their Influence on Substance Flow in Households of Asian Mega-cities (Theme A 14)

As a part of a project which aimed to evaluate the relationships between the developmental stage of cities and various environmental problems including subsurface environment, the objective of the research is to analyze the influence of long-term life style changes to the material and substance balance in household, industry, and business sectors. Three mega-cities (Tokyo, Seoul and Taipei) were chosen for the case study. They are all mega-cities at coastal area but in different economic development stage and suffered or are suffering severe subsurface environmental problems. The most common sources of human-induced groundwater contamination can be grouped into four categories: waste disposal practices; storage and handling of materials and wastes; agricultural activities; and saline water intrusion. Because this research is aimed of analysis the groundwater contamination induced by human activities with urbanization, the analysis concentrated on emission from household consumption and following waste disposal practices. C, N, P were selected for investigation in this study because (1) these substances are included in the main emissions of human activities, (2) the consumption of goods containing these substance is greatly influenced by the urbanization level of cities, (3) the data related these substances are easy available. Material Flow Analysis and Substance Flow Analysis were used for the analysis. From the food balance sheet and household consumption statistical, the paste ten years' food consumption was used as main input of C, N, P. And the outputs are mainly in solid waste and waste water disposal activities. The waste recycling activities have great influence to reduce of emission of C, N, P. Tokyo has relative lower emission to environment with complete disposal capacities, but for Seoul and Taipei, with the construction of disposal facilities, emission reduce sharply in recent years.

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A Case Study of Global Sustainable Development Indices by Integrated Assessment Model Linked with LCIA (Theme D 27)

Energy and material systems are assessed from a viewpoint of sustainable development for several world regions in the 21st century. An integrated assessment model (IAM) is extended by linking with life cycle impact assessment (LCIA) in this study. The integrated assessment model GRAPE (Global Relationship Assessment to Protect Environment), which has linkages among the sub-models of macro economy, energy system, land use and climate change, is extended to be coupled with a new sub-model that explicitly deals with the metal supply and demand systems including mining, refining and recycling of iron and steel, aluminum and copper. The model endogenously calculates environmental impacts such as CO_2 and SOx emissions according to energy consumption, land use changes by urbanization, land cultivation, mineral resources mining, etc. These impacts are converted to external costs and are internalized by deducting them from gross domestic products. The parameters on the marginal willingness-to-pay to prevent environmental impacts provided by LIME (Lifecycle Impact assessment Method based on Endpoint modeling) are assumed as proxy for the marginal external costs. Some preliminary simulation results are shown by using the extended GRAPE/LIME model.

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The Potential Amounts of Recovered Materials from Waste Electrical and Electronic Equipments Using Self-Disassembling Fastener (Theme F 33)

In Japan, legal systems for end-of-life electrical and electronic equipments were enforced in 2001, and attendant technologies for the recycling have been developed, resulting in the achievement of the legal recycling rate. However, as for current shredding recycling systems in Japan, most of valuable metals are actually dissipated into the recycled base metals. To overcome this problem, implementation of the design for disassembly (DfD) would be one of the effective strategies. In such a light, author has actually developed a self- disassembling fastener. The fastener partly consists of a hydrogen storing material and breaks by the exposure to hydrogen at an appropriate temperature and pressure, leading to easy and rapid disassembling. The purpose of this study is to estimate the potential amount of recovered materials such as Fe, Cu, Al-based components, etc. from waste electrical and electronic equipments (WEEE) using the self-disassembling fastener. The target electrical and electronic equipments (EEE) were CRT TV (CRT), liquid-crystal display TV (LCD), plasma display panel TV (PDP), refrigerator, air conditioner, washing machine, microwave oven and cleaner. The number of the WEEE was estimated dynamically using the population balance model, in which the domestic numbers possession (statistical data), the volume of shipment (statistical data), lifetime distribution (Weibull distribution function) and the future number of possession (logistic approximation) were input. The dynamic change of material compositions for the WEEE was also considered. The estimation was performed for the new decade by assuming that the self-disassembling fastener was introduced to all the equipments in 2005, and can separate only fastener-jointed components. The efficiency of the recycling system using the developed fastener was evaluated by comparing the current shredding recycling system, and further refinement was discussed.

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Pilot Scale Experiments of SMRH, a New Technology of Cleaner Production of Diosgenin from Dioscorea Zingiberensis (Theme F 34)

SMRH (Saccharification - Membrane Retrieval - Hydrolysis) technology, a new approach of cleaner production of diosgenin from Dioscorea Zingiberensis was tested on a pilot scale. ?-Amylase and saccharifying enzyme were adopted for hydrolysis of starch of Dioscorea Zingiberensis to obtain sugar and membrane technology was used to separate starch sugar and sapogenin. During this process, the starch sugar was retrieved as by-product and the yield and quality of diosgenin were greatly increased as well. The reason for diosgenin yield increase was analyzed. Pilot experiments at levels of tons indicated that by this enzyme-membrane technology, starch was successfully separated in the form of starch sugar before acid hydrolysis, with yield of starch sugar exceeded 90%, and with increase in diosgenin extraction that was 21% higher than that of traditional technology. Water used to wash yam was reduced from 800-900 tons per ton diosgenin product to 90-100 tons so that the total amount of washing water was reduced. The technologies of multi-enzyme hydrolysis of starch, membrane separation of starch sugar before acid hydrolysis and recovery acid from mother liquor by membrane integration were adopted, which result in acidic wastewater reduced from 400 tons per ton of diosgenin product to 110-120 tons and COD of the wastewater changed from 50-10kg COD per ton wastewater to 20- 30kg and the biodegradability of wastewater greatly improved. Solid residue after diosgenin extraction was recycled as well to produce solid fuel.

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Possibilities and Challenges in Establishing Sustainability Informatics: Creation of Data and Informatino Commons (Theme F 34)

In taking steps to achieve global sustainability, it is of critical importance to make appropriate use of data and information on diverse aspects ranging from natural environment and artifacts to economy and culture. While data and information have been produced and accumulated at an accelerating rate within each field, they are not necessarily shared or disseminated effectively beyond established disciplinary boundaries. Data and information commons is expected to function as an essential part of intellectual infrastructure for utilizing enormous amounts and types of data and information collaboratively among people with diverging experience and expertise. The characteristics of data and information commons are examined, including the type, size, content, location, ownership, data providers, access policy, and user characteristics. Technical issues include networking of databases for data sharing and data mining, utilization of metadata based on ontology, and standardization of platforms for integration. Economic, management, and organizational aspects will also be discussed, including the incentive structure of relevant actors involved in creation, distribution, and use of data, possibilities and challenges in establishing business models based on the market mechanisms, organizations suitable for efficient and effective management of information commons, division of roles of universities, private companies, and public research institutes based on their different functions. The disciplinary characteristics of the behavior of the providers and users of data and information would be different. Creation of legal and institutional frameworks for data sharing and integration in compatible with the incentive structure specific to each field would be important, notably, intellectual property rights and protection of privacy. Public policy issues, including harmonization of patent systems, process of establishing international standards, open access policy for research results supported by public funds, as well as ethical issues such as inter-generational equity and digital divide between the industrialized and developing countries, will also be discussed.

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The Effect of Contamination of Tramp Elements on Ferrous Material Flow: Analysis by Dynamic Waste Input Output Model (Theme A 6)

For constructing a sound material-cycle society, resource or material recovery has been promoted, whereas many industrial products with advanced functions are equipped with circuit boards, motors and wiring harnesses. These electric devices or equipments contain much kind of metals, such as copper, lead, zinc and so on. Ferrous material or products are widely in use as basement metal. The total amount of iron consumption is 127,485 thousand ton, 45,850 thousand ton of which comes from scraps in Japan. End-of-Life Vehicle and ferrous material recovered from construction waste are major resources of secondary ferrous material as obsolete scraps. However for sound ferrous material cycle, copper replacement from iron and steel scraps is very important. As the usage of scraps in steelmaking process has been increased, the accumulation impurities (Cu, Pu, Sn) which are known as “tramp elements” becomes a big problem because of their harmful effect on the mechanical properties and formability of steel products. On the other hand, we don't have an appropriate method to estimate environmental effects of contamination of such impurity elements from the dynamical viewpoint for a sustainable iron and steel material circulation. Here we deal with the contamination of tramp elements and the harmful effect of sound material circulation, whereby following points are considered respectively, 1) the amount accumulation and waste generation of ferrous materials 2) copper elimination from ferrous scraps 3) contamination of copper in iron and steel products. We apply Dynamic Waste Input Output (DWIO) model to study ferrous material flow through the scenario analysis, we will be able to estimate environmental loads and economic effects caused by removal or acceptance of tramp elements.

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Used Automobile Battery Recycling in Asia
(Theme A 2)

In this paper, we showed one primitive result of used car battery flows on Asia scales and overviewed current situation of lead recycling in Asia. Lead recycling in Asia still causes environmental pollution dues to lack of modern technology or lack of infrastructure. We review the current system in Japan for the collection of used lead acid batteries. There are several problems with the current system. The three main problems are: (1) an increase in the number of imported batteries, (2) double standard with regard to domestic and foreign prices, (3) an increase in the number of used batteries being exported. In principle, used batteries have been exported as secondhand goods. This type of trade won't therefore violate domestic laws, or even the Basel convention. However, some of those batteries are in fact reused and recycled in the importing countries, or re-exported to other parts of Asia, and are being reused or recycled without the necessary environmental protection measures. As well as collecting both domestic and international used car battery flow data, the analytical methods is also discussed.

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The Study of Copper Cycle in China (Theme A 1)

A model of Cu-flow in the life cycle of copper product was put forward and analyzed. The status quo of copper cycle in China from 1998 to 2003 was analyzed according to this model, from which the following data were obtained. The average life cycle of copper products was 30 years. The use ratio of copper scraps in copper production and manufacture, the materials self-support ratio in copper production and manufacture were 26.60%, 15.75%, 47.05% and 57.91%, respectively. The materials self-support ratio in copper production and manufacture declined year by year in recent years on the whole, and the latter dropped more quickly. The average index of copper ore and copper scrap from 1998 to 2003 were 0.8416t/t and 0.3040t/t, respectively, and copper resource efficiency was 1.1932t/t. Copper scraps were mostly imported from foreign countries because of shortage in recent years in China. Here the reasons related to copper scraps deficiency were also demonstrated. But we can forecast: when copper production was in a slow rise or in a steady state in China, the deficiency of copper scraps may be mitigated; when copper production was in a steady state for a very long time, copper scraps may become relatively abundant. According to the status of copper industry in China, the raw materials of copper production and manufacture have to depend on oversea markets heavily in recent years, and at the same time, the copper scraps using proportion and efficiency in copper industry should be improved. Statistical entropy analysis was carried out on the analytic results of copper cycle in 2002. The variation rate of relative statistical entropy (RSE) in the whole life cycle was –7.86%. Some measures of reducing statistical entropy in the copper products life cycle were put forward and the variation of statistical entropy after improvement was described.

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Conceptual Program of Sustainable Product Development of Dniepr River Industrial Region Based on the Systematic Approach **(Theme A 3)**

It would be possible to consider the interaction between nature and man on the basis of a complex systematic approach founded on the apprehension of the fact, that technical equipment is only a part of the whole system. Hence, the tendency to harmonize the relationship of nature with technical equipment, where the operation of industrial complexes is tied not only to the technogenic activity of man and the use of technological objects, but also to the state of natural environment becomes evident. The ideal solution of the problem would be the creation of a nature-technical system allowing the achievement of high technical indices at a favorable ecological condition. As far as it is frequently impossible to reduce the level of negative influence of manufacturers on the environment without a change of technological processes, the conservation activity should be directed toward improvement of acting, or creation of predominantly new technological processes. Thus, there needs to be a system of quantitative valuation of industrial objects' ecologization degree, and degree of ecosystems' destruction for acceptance of the justified decisions, directed on ecologization of industrial and agricultural manufacturers and rehabilitation of territories polluted by toxic substances. An important problem is the integration of processes of acceptance of the decisions in the field of environment and development, improvement of the transfer system and analytical methods. A complex of measures by valuation of consequences of the decisions in economic, social and ecological spheres is necessary. It is necessary not only at the level of separate projects, but also at the level of policy and programs. The analysis should include valuation of costs, profits and risks.

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Integrated Assessment for Emerging Chemicals of Concern **(Theme D 27)**

Industry's environmental design has evolved from pollution prevention in 1980s to sustainability that integrates economic, societal, and environmental considerations. In this study we demonstrate how an integrated approach to sustainability can be used to evaluate an emerging chemical of concern (i.e., decabromodiphenyl ether). The goal of this study is to provide a methodology that can be used to prevent a potential environmental crisis early on in the design phase. Decabromodiphenyl ether (DBDPE) is widely used as a flame retardant. It is added to consumer products manufactured from plastic, polyurethane foam, and textiles. Fire safety standards require the end products (e.g. computers, carpets, upholstery) to contain flame retardant chemicals that help delay the onset and spread of fire. Since compounds like DBDPE replaced polybrominated biphenyls, the demand for them has increased for use in flame retardant textiles. An additive process that incorporates the chemical into the consumer product ultimately allows the chemical to partition into the environment over the product's lifetime. DBDPE is a persistent organic pollutant with a similar structure to polychlorinated biphenyls and has been classified as a possible human carcinogen. While the flame retardant ability of this chemical has improved human safety and lessoned property damage, there is still great uncertainty in the hazard posed by DBDPE and its breakdown products. This study will integrate a physical/chemical property estimation model, a chemical fate and transport model and an economic input-output life cycle assessment model to quantify environmental impact of DBDPE during its production, manufacturing of the end products, consumer use and end-of-life stages. The study will answer questions, e.g. "which chemicals, among DBDPE, its breakdown products, and other chemicals involved in the production and manufacturing, pose high impact during the life of the product?" The results, in turn, will provide guidance on preventing potential impact.

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ThermoLCA – A Software Tool for Thermodynamic Life Cycle Assessment (Theme A 4)

Over the last few decades, many researchers across various disciplines have explored the use of thermodynamic methods such as energy, exergy and cumulative exergy analysis, for life cycle assessment. Among the benefits of thermodynamic approaches are their reliance on the scientifically rigorous laws of thermodynamics, ability to represent all types of material and energy streams in consistent units, and relevance to the behavior of ecological, industrial, and economic systems as networks of energy flow and transformation. Energy analysis only captures the first law of thermodynamics, and focuses on the energy balance between energetic (mainly fossil fuel) inputs and energy content of the resulting products. Methods based on exergy analysis can account for both laws, and are better at capturing the quality of material and energy resource inputs and outputs. Despite these efforts, the lack of software makes it difficult to apply these methods. This work will describe a new tool, ThermoLCA, that we are developing for LCA with various thermodynamic methods. The current version of ThermoLCA combines the 1997 economic input-output model of the U.S. economy with information about resources consumed by and emissions from each sector. This tool permits four types of analyses – mass, energy, industrial cumulative exergy consumption (ICEC), and ecological cumulative exergy consumption (ECEC) for selected sectors. Mass and energy analyses provide information about consumption of various material and energy resources in the economic network. ICEC analysis quantifies the total exergy consumed in the economy, starting from natural resources, while ECEC analysis extends ICEC by also accounting for the exergy consumed in ecological processes for producing the natural resources. The results of ThermoLCA are presented via hierarchical metrics and energy flow diagrams. Its benefits will be demonstrated via common case studies. The ability of ThermoLCA to complement (not replace) traditional LCA will also be described.

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Environmental and Economic Implications of Bioenergy in Ontario, Canada (Theme D 27)

Utilizing biomass to produce energy can potentially improve the environmental performance and sustainability of the transport and electricity sectors. We developed life cycle and economic models to compare the environmental and economic tradeoffs between generating electricity from biomass coal cofiring in existing coal power plants versus displacing gasoline with cellulosic ethanol in light-duty vehicles in Ontario, Canada. Our study inventories nearterm biomass supply in the province, quantifies environmental metrics [energy use, greenhouse gas (GHG) and select air pollutant emissions] associated with the production of electricity and ethanol from biomass, determines the incremental costs of switching from fossil fuels to biomass, and compares the cost-effectiveness of GHG and air pollutant emissions abatement achieved through the use of the bioenergy. The results suggest that implementing a biomass co-firing rate of 10% would result in an annual reduction in greenhouse gas emissions of approximately 2.3 million metric tons (Mt) CO_2-equiv (7% of emissions from the Province's coal power plants) and the substitution of gasoline with ethanol/gasoline blends has the potential to reduce annual provincial light-duty vehicle fleet emissions between 1.3 and 2.5 Mt CO_2-equiv (3.5 to 7% of the fleet emissions). At current crude oil prices ($70/bbl), the use of biomass for electricity generation is more cost-effective for mitigating GHG emissions ($22/metric ton (t) CO_2-equiv for a 10% co-firing rate) than ethanol ($92/t CO_2-equiv). Although utilizing cellulosic ethanol in light-duty vehicles is expected to be somewhat more costly than biomass co-firing, factors including the uncertainty in crude oil prices, the province's commitment to selling gasoline blended with 5% ethanol, as well as there being few alternative options for large scale GHG emissions reductions in the transport sector, all increase the potential attractiveness of the ethanol option.

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Plan C: China's Development under the Scarcity of Natural Capital **(Theme C 22)**

The critical issue of China's modernization is whether it can free itself from the traditional modernization Plan Based on the relatively abundant natural capital, and innovatively create a developmental model of a big country under the scarcity of natural capital. This is why China is so keen on the circular economy and economical use of resources. Focused on this issue, this paper summarizes the theoretical elements of the development under the scarcity of natural capital, points out that Plan C is the strategic choice for China's future development, emphasizes that China needs to enhance the new industrialization, new urbanization and new modernization based on the restriction of natural capital, and discusses the technological and mechanistic support required to realize development under the scarcity of natural capital.