Analytic Tools for Industrial Ecology

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As human population, economies, and industrial activities continue to grow, so does the consumption of raw materials, energy, and pollution of the environment. The challenge to create sustainable industrialized systems requires a framework for balancing environmental and economic performance as a living system interdependent with natural systems (Lowe et al. 1997). Analytic tools for industrial ecology are the means to leave a “smaller footprint” on the environment. Examples of these tools include Cost-Benefit Analysis, Environmental Risk Assessment, Material Flow Accounting, Cumulative Energy Requirements Analysis, Environmental Input-Output Analysis, and Environmental Auditing, to name a few. The main purposes of all of these tools are to aid in decision-making and to connect the gaps between industry and the environment. However, tools are only as good as their data and a closer look at their methodology and application is required to make any kind of headway in the field of industrial ecology. Analytic tools can be broken down into materials and information flow. Life-Cycle Assessment represents a materials flow tool that focuses on a single product or function. Information systems are a more encompassing set of tools that form the basis for the realistic application of every other analytic tool.

**DEFINITION OF LIFE CYCLE ASSESSMENT**

Life cycle assessment (LCA) is, simply put, the modeling of the interaction between a product and the environment. LCAs compile the emissions (air, water, soil, waste etc.) and resource uses of a product much the same as a bookkeeper tallies up figures. The data usually describe the path of a product from "cradle to grave." This includes sourcing of raw materials, production of materials and the main product, and finally the usage of the product and disposal. LCAs are carried out in accordance with the International Standards Organization (ISO) norms
These norms spell out the standardized methods of LCA to help industry reach an agreement on the principles of this tool. The Society for Environmental Toxicology (SETAC) is a nonprofit organization well known for developing guidelines and methods for LCA. SETAC has international status as a think-tank for the general principles and framework of review and presentation of LCA findings (Nath et al. 1998). In 1993, SETAC authored a definition for LCA that has been accepted worldwide.

“The life-cycle assessment is an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and material usage and environmental releases, to assess the impact of those energy and material uses and releases on the environment, and to evaluate and implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation, and distribution; use/reuse/maintenance; recycling, and final disposal.” (SETAC 1993)

LCAs are developed in order to compare a product with respect to corresponding environmental impacts. In order to accomplish this, the entire life cycle of the product must be identified and all relevant forms of known environmental interventions should be accounted (Nath et al. 1998). Analytic tools that are related to LCA include: life-cycle assessment, design for environment, life-cycle cost accounting, eco-efficiency, environmental auditing or profiling, environmental benchmarking, and environmental performance evaluation (Lowe 1997).

METHODOLOGY

SETAC’s Code of Practice (1993) advises the use of the following five stages of LCA:

1. Planning
   * Statement of objectives
   * Definition of the product and its alternatives
   * Choice of system boundaries
   * Choice of environmental parameters
Current practices of LCA mainly focus on life-cycle inventory, life-cycle impact assessment, and life-cycle improvement. The main characteristic of this tool to keep in mind is the comprehensive nature of connecting environmental issues to the function of a product. The cradle-to-grave approach allows companies to study and compare different options to supply a given function while still considering changes in goods and services within the economy with respect to their environmental impacts (Wrisberg 2002).

INVENTORY

Inventory is a complete look at the inputs and outputs of the entire life of a specific product. This perspective removes a product from a single context and looks at a more inclusive and comprehensive bigger picture. The two kinds of inputs are environmental and economic inputs. Environmental includes raw materials and energy resources while economic includes the input of some kind of finished or semi-finished product (USEPA 2003).

Some factors exist that skew the inventory phase and must be included in the interpretation of the final data. It is important to concede that information found in the inventory...
is not the absolute truth, but still a very integral step towards product improvement and efficiency. The first factor involves system boundaries. In breaking the life cycle down into processes, it is not always clear how far one should go in including processes belonging to the product concerned. This involves, for example, oil used for product production and the impacts of transporting the oil, the steel needed to construct the vehicle the oil was transported in, and the raw material needed to produce this steel. The chain of events could be infinite so there needs to be a defined end-point when formulating the inventory. A second factor is the establishment of an allocation rule for processes that generate more than one product (i.e. electrolysis of salt). The third factor to consider is the occurrence of avoided impacts. These environmental impacts are considered and subtracted from the overall impacts of the initial product. For example, a waste incinerator certainly has many impacts associated with the process. However, it is important to recognize the amount of energy created replaces energy that would have been created in another way. Choice of technology and degree of data quality are the final factors considered. It is here that the complexity and weaknesses of LCA are exposed. The sheer amounts of information needed to compile the inputs and outputs of just one product take a huge amount of resources, expertise, and time. The continued development of efficiency and standard methods for this tool are essential for its survival within the US (USEPA 2003; Nath 1998; Wrisberg 2002).

**IMPACT ASSESSMENT**

After inventory of the product or process has been compiled, it can be rather daunting to interpret the massive amounts of incongruent data. The most important ingredient in LCA is to avoid nonsensical results (Nath et al. 1998). The solution is a life cycle impact assessment
(LCIA). Most consulting companies use one of two European methods for impact assessment. For example, the Swiss Ecopoints method is based on the distance-to-target principle (Pre Consultants 2003). SETAC suggests a general procedure for organizing inventory data for impact assessment. Categorization separates data into relevant classes according to the effect they have on the environment (i.e. ecotoxicity, greenhouse effect, smog, and human toxicity). Next, the group data are normalized in order to make data relevant to the known total effect of each class. This clarifies the contribution of the product or process to each environmental factor. Now that the data has been grouped and normalized it is possible to safely evaluate the overall effects with reference to a weighed importance. LCIA should include a wide range of impacts including ecological, human health, social, cultural, and economic. This is an attempt to truly put products in processes in the context of the society they intend to serve (Svoboda 1995).

**IMPROVEMENT ASSESSMENT**

The final stage of an LCA is utilizing the compiled data to make informed decisions and adjustments to the product life-cycle. Now that there is an established environmental profile of the system it is possible to identify opportunities to mitigate the environmental impact throughout the life-cycle. Improvement assessment involves further quantification and qualitative measures of improvement may involve changing waste techniques, raw material input, product design and even consumer usage (Svoboda 1995). This task is especially challenging as one of the many faults of this tool is the reliability and completeness of the information calculated in the prior steps.
LIFE-CYCLE ASSESSMENT IN PRACTICE

LCA methodology does not necessarily seek to arrive at a product-based answer but rather provides important new perspectives that transform industrial understanding toward environmentally conscious services and manufacturing processes. In the spirit of this logic, an example of a practical LCA would outline the examination of an industrial process for the purpose of higher appreciation and not the direct environmental solution. In current practices, LCAs only broaden the picture; they do not solve the problem. Two examples of problems where LCAs were used include the total cost analysis of the McDonalds burger and the environmental cost benefit analysis of polystyrene clamshell sandwich packaging versus paper based “quilt wrap.”

From a single drive-in restaurant in 1948, to the $13 billion organization 43 years later, McDonald’s Corporation has climbed to the largest food service organization in the world. (Svoboda: A 1995) McDonald’s Corporation operates over 12,400 restaurants in 59 countries. Further, in the US alone, 18 million people visit a McDonald’s every day (EDF 1991). With burgers holding the primary item on its menu, McDonald’s customers account for an immense amount of beef consumption. In fact, McDonald’s purchases more than 1% of all beef wholesaled in the US (Rifkin 1991).

However, during the final quarter of the 20th century, a new industrial perspective was evolving. Instead of uncontrolled, exponential resource consumption, many corporations began to predict the collapse of the ‘endless’ resource availability. A universal reality check occurred in 1992, after the United Nations Conference on Environment and Development (UNCED) held its Earth Summit. An international consciousness for sustainable development spread in both developed and developing nations. In the highly industrialized American frontier, such players
as industrial ecology and resource conservation were setting the stage for increased sustainable growth. The American industries that decided not to meet these new environmental challenges were chastised for their lack of support for future generations. Thus the Beyond Beef Coalition was born.

In response to the new environmental and health mindset and the ‘crimes’ committed by the beef industry, Beyond Beef began to analyze the life cycle of the McDonald’s burger. The findings illustrated a large imbalance between environmental costs and consumer costs. For example, as a result of 260 million acres of arid public land being leased to grazers from the federal government, in 1990, the US Bureau of Land Management reported that 70% of its holdings were in unacceptable condition (Svoboda: C 1995). “Overgrazing of public land had resulted insignificant soil loss and desertification” (Svoboda: C 1995). Further, by quantifying other energy requirements, it was found that livestock were engorging 40% of the world’s grain (Durning 1991). The creation of pastureland for cattle in Central America has cleared 25% of the forests since 1960 (A Reporter 1985). Furthermore, every pound of grain-fed beef requires about 2,500 gallons of water (Svoboda:C 1995). The list continues with the environmental costs of pesticides and fertilizers, increased CO$_2$ emissions due to deforestation, and the loss of biodiversity from alteration of habitat. Outside of ecological concerns, McDonald’s Corporation has questionable values on animal rights, public health, world hunger, and reduction of wastes (Svoboda:C 1995).

After the Life Cycle Inventory and Impact Analysis, Beyond Beef pursued a Life Cycle Improvement Analysis. In order to reduce American beef consumption, Beyond Beef alerted the consumers of the unpaid environmental, health, social and cultural costs of burgers. Their
campaign set the goal to reduce individual beef consumption by 50% as well as other goals to reduce the effects of cattle on the environment (Svoboda:C 1995).

A second example of McDonald’s LCA dealt with the use of polystyrene as a packaging material for fast food sandwiches. Due to the nature of the business, packaging plays a vital role in the transfer of perishable products to the customer. Therefore the quality and affordability have high standards that tend to overshadow the biological impact.

To address this, a task force was assembled to perform the LCA on the packaging material. To review what products were available, PRESCO, an independent and privately owned company that handles all of McDonald’s paper and plastic food service packaging, performed a full audit of all the packaging used in a restaurant (Svoboda:B 1995). Further, the task force requested relevant information from published literature, government sources and database information belonging to a group of specialists known as Franklin Associates, Ltd (Svoboda:B 1995).

The life cycle inventory found that there were many external environmental costs associated with the production of polystyrene. According to Svoboda (1995), a large amount of crude oil and natural gas is extracted and hydrocarbons are often released into the atmosphere as a byproduct. Further, transportation carries the risk of oil leaks or spills. Processing the natural gas often emits both hydrocarbons and sulfur dioxide as pollutants (Svoboda:B 1995). During another stage of creation of polystyrene, the production of benzene has been correlated with blood disorders and leukemia in workers exposed to high concentrations for extended amounts of time (Svoboda:B 1995).

To address the public concerns for the use of polystyrene, the life cycle improvement analysis revealed the role that paperboard could play in food packaging. This part of the LCA
demonstrated that paper offered an organic biodegradable alternative to the chemically produced polystyrene that required recycling plants (Svoboda:B 1995). Further environmental acclaim was given to the elimination of bleach when natural brown paper was used. Another goal of this improvement agenda was to use sustainable wood harvesting practices so that instead of exhausting the nonrenewable supply of natural gas, McDonald’s could progress toward sustainable consumption of paper products (Svoboda:B 1995).

WHY PERFORM AN LCA?

It remains that the overall feeling towards environmental management in the United States is still “less is best.” However, with continued trends in environmental regulation and market pressures, larger businesses are in fact finding it worth their while to evaluate their product. Becoming proactive in environmental management not only allows a company to identify opportunities for efficiency, but it also provides an environmental image that is proving to be a hand up in competitive strategies (USEPA 2003). In the case of the McDonalds Corporation, an LCA was performed at the company’s initiative in response to public outcry against wasteful packaging. As a result, polystyrene was phased out after fully assessing the associated environmental impacts. This simple change in packaging produced a good deed for all, as McDonalds fine tuned their operations to be more efficient as well as become more environmentally conscience. Alternatively, an assessment of the life cycle of a McDonald’s burger is not something that McDonalds would choose to take on themselves. When business is good it isn’t entirely appealing to look at operations holistically and ask how the environment is affected by a product. LCA then becomes a tool for not only industry but also for lawmakers and other organizations that represent public interest. LCA provides useful insights for public
policy making. More importantly, there is a level of life-cycle thinking that law makers can adopt when composing policies and regulations. Introducing LCA concepts into the rule-making process extends the regulatory analysis upstream and downstream and across all media to account for the effects of the proposed standard that may otherwise escape a traditional regulatory impact analysis (Ecocycle 2002; USEPA 2003).

INFORMATION SYSTEMS IN INDUSTRIAL ECOLOGY

Industrial ecology requires abundant flows of data and elegant means of turning this data into information useful to stakeholders, including firms and industries (Lowe et al. 1997). For example, industrial ecology tools such as input/output models, materials flow analyses, and life cycle analyses are information-intensive. They require data from a number of sources, which may include firms, the Department of Commerce, the census, and other federal and state agencies (Lowe et al. 1997). Some types of data needed include information on pollutants, emissions, resource usage, material characteristics, production alternatives, government regulations, and technologies (Shaft et al. 1997; Shaft et al. 2002). Much of this data needs to be assembled and stored in advanced environmental, economic, and technical databases to create interorganizational information systems (Lowe et al. 1997; Sharfman and Ellington 1997). The information requirements of industrial ecology have created new markets for information providers, hardware and software companies, and systems integrators (Lowe et al. 1997). The field of knowledge management, which is intended to provide the right information to the right person at the right time, has also expanded to include environmental knowledge management (Wernick 2003).

Typical accounting and production information systems do not contain environmental information (Shaft et al. 2002). However, environmental monitoring and reporting information
systems have been developed over the past few decades in response to regulations requiring firms to report waste streams, such as the Toxic Release Inventory and sewage sludge (biosolids) regulations (Gibbons 1992; Kuchenrither et al. 1993). A number of environmental management information systems have been developed specifically to track wastes (Ornthal 1993). Spatial environmental information related to industry has also been incorporated into geographic information systems (GISs) (Kuchenrither et al. 1993; Özyurt and Realff 2002). Independent, third party audits that are required for many voluntary environmental programs use information systems to provide feedback to companies, communities, and agencies (Lowe et al. 1997). Many environmental information systems use information from Life Cycle Assessment as well. Clearly, some information markets are already responding to new demands of industrial ecology, but the field of industrial ecological information systems is still growing. One new development in the structure of information systems is neural net programming, in which information systems emulate the structure of the human brain through biomimicry (Lowe et al. 1997).

There are four general types of information systems important for industrial ecology (Shaft et al. 2002). Transaction processing systems (also known as data-processing systems) contain detailed information on internal and external transactions, including resource use and waste emissions. These systems generate much of the information that is used by other information systems for problem solving and reporting (Shaft et al. 1997; Shaft et al. 2002). Management information systems create routine reports to identify potential problems. They aid in compliance with environmental regulations and in planning for continuous improvement. Decision support systems are specialized to deal with problem-solving needs. They allow managers to interpret complex data such as variable environmental impacts (Shaft et al. 1997). Finally, executive information systems allow the user to start at summary data and then move
down through multiple data levels to access more detailed information. For example, an executive may see that total water use for a firm is high, and then look at more detailed data levels to find the exact location of the extra water use (Shaft et al. 2002).

An example of a new type of information system developed for industrial ecology is the Design for the Environment Information System (DEIS). DEIS is a database containing environmental, health and safety, social, economic, and regulatory data applicable to specific design options (Lowe et al. 1997). Also, the Swedish international logistics and transport firm ASG AB developed an interorganizational information system and software tools to facilitate the flow of environmental information between firms, and to improve the environmental performance of its suppliers (Shaft et al. 2002).

ECO-INDUSTRIAL PARKS

The products that firms market are only a small proportion of their process results (Ehrenfeld and Gertler 1997). Eco-industrial parks (EIPs) attempt to remedy this dilemma by linking firms so that the waste by-products of one firm can become inputs for another firm. This strategy, known as industrial symbioses or industrial ecosystems, creates linkages between firms to raise efficiency of material and energy flows, measured at the scale of the system as a whole (Ehrenfeld and Gertler 1997). In order for an industrial symbiosis to be economically feasible, all firms involved need to realize cost savings high enough to offset transaction costs, discovery costs, and risks (Ehrenfeld and Gertler 1997). Some benefits of industrial symbioses are reduced costs of inputs (because by-products from other firms are generally less expensive than virgin materials) and reduced waste disposal costs. Additionally, eco-industrial parks reduce transportation costs by collocating firms that participate in industrial symbioses.
A substantial obstacle to the creation of industrial symbioses and eco-industrial parks is that they require exchanges of large amounts of information about nearby industries and their inputs and outputs. At a minimum, information is needed on materials used, energy required, and wastes generated (Lowe et al. 1997). This information can be difficult or costly to obtain, especially in the United States, where corporate information is rarely shared or made publicly available unless required by federal regulation (Ehrenfeld and Gertler 1997; Hogen and Underwood 1984).

One of the most successful eco-industrial parks to date is in Kalundborg, Denmark. Kalundborg is a small isolated town of 12,000 residents, which creates a tight-knit community (Ehrenfeld and Gertler 1997). Managers and employees interact socially with each other and with their counterparts in other firms, which has led to information sharing and a sense of trust. Sweden, and to a lesser extent, Germany, also have cultural traditions of collaboration among firms, research institutions, and the government (Frankl and Rubik 1998). Such a situation is less common in other countries, and especially in the United States (Copius Peereboom et al. 1999). In the absence of a cultural context for information exchange, institutional mechanisms need to be put in place to facilitate information sharing. The U.S. Environmental Protection Agency’s (EPA’s) Facility Synergy Tool (FaST) is an example of such a mechanism. FaST can be used in conjunction with the Designing Industrial Ecosystems Tool (DIET) to plan eco-industrial parks. GISs can also be used in conjunction with other tools to plan eco-industrial parks (Özyurt and Realff 2002). In Europe, the closest counterpart to FaST and DIET is ECOPARK, a software decision-support system with databases on materials used by firms, technologies, laws and regulations, government assistance, and products made from recycled and recovered materials (Lowe et al. 1997).
Once an eco-industrial park (EIP) is created, its management requires a system-wide information system that supports intercompany communications, informs members of local environmental conditions, and provides feedback on EIP performance (Lowe et al. 1997). In order for expansion of the EIP to be possible, its information system also needs to be accessible to outside companies so that they can explore the benefits of working with the park (Lowe et al. 1997).

INACCURACIES

Even when information about firms’ inputs and outputs is published and publicly available, it is not always accurate. This may be because of inherent uncertainties in the data, or because the information was manipulated in order to alter the implications of the report. The latter is known as “sweetheart” reporting (Copius Peereboom et al. 1999). A study by Copius Peereboom et al. found that information about high environmental impact substances and easily determined emissions and environmental impacts were accurately reported and did not vary significantly among reports in the same industry (1999). This may be because there is less uncertainty associated with such information, or because transparency is high due to federal regulations. Environmental data are inherently ambiguous and equivocal (Shaft et al. 1997). Additionally, data are often incomplete or difficult to obtain, so they are estimated (Copius Peereboom et al. 1999; Lowe et al. 1997). A good information system should provide indications of the level of reliability of the information (Lowe et al. 1997). However, accuracy and precision of data are often not reported.

Data elements that tend to lead to uncertainty and inaccurate information include the following: geographic, temporal, and technological representativeness; categorization of
substances; naming of substance categories; category definitions; system boundaries; and allocation method (Copius Peereboom et al. 1999). How each of these inaccuracies influence the end result can be calculated, so that the most influential data elements can be researched further and the data can be checked for accuracy (Copius Peereboom et al. 1999).

**RISK AND UNCERTAINTY ABOUT THE FUTURE**

Another possible difficulty with eco-industrial parks and industrial symbioses is that the firm that buys by-products from another firm assumes the risk of depending on that single supplier. If the supplier of the by-products cannot produce a constant, predictable supply, the buyer may need to invest in another standby supply source (Ehrenfeld and Gertler 1997). Similarly, the seller accepts the risk that any type of upset at the buying facility can interrupt the outflow of the supplier’s by-products. Such an interruption would effectively turn the unwanted by-products into waste, which would then need to be disposed of (Ehrenfeld and Gertler 1997). The U.S. EPA Regulatory, Economics, and Logistics Tool (REaLiTy) was designed to identify the possibility of such dilemmas in eco-industrial parks, in addition to other logistical, economic, and regulatory constraints (Industrial Economics, Incorporated 1998).

**FaST, DIET, AND REaLiTy**

Three information system tools have been designed by the U.S. EPA’s Office of Policy, Planning, and Evaluation to aid in creating industrial symbioses, designing eco-industrial parks, and screening these symbioses and parks for potential future problems. The Facility Synergy Tool, or FaST, is a database and interactive software tool that helps planners and facility personnel to identify potential materials and energy exchanges (Giannini-Spohn 1999;
Karabinakis 2002). The Designing Industrial Ecosystems Tool, also known as DIET, is a decision support system that uses FaST data to optimize eco-efficiency and explore tradeoffs (Giannini-Spohn 1999). The Regulatory, Economic, and Logistics Tool, referred to as REaLiTy, is a database on potential constraints to industrial symbioses (Industrial Economics, Incorporated 1998). These decision support tools can be used in conjunction to give EIP planners a starting point in the development of EIPs (Industrial Economics, Incorporated 1998, Giannini-Spohn 2003).

**AN APPLICATION OF FaST, DIET, AND REaLiTy**

The EPA and Industrial Economics, Incorporated (IEc) apply FaST, DIET, and REaLiTy in a case study of a proposed eco-industrial park (EIP) in Burlington, Vermont. The EIP would be located on a 10-acre site in the Intervale, an area chiefly comprised of community gardens, recreational space, and wetlands. As the community discusses plans for the proposed park, analytic tools such as decision support models can help decision makers develop a shared vision for the EIP (Industrial Economics, Incorporated 1998). The site currently contains four “anchor facilities” that would be integrated into a larger eco-industrial park: the McNeil wood-burning power plant, 400 acres of private and community farms in Intervale, a composting facility, and the Waste Wood Depot that provides woodchips for the power plant.

To identify potential linkages, planners analyze the input and output flows of current and potential facilities. The Facility Synergy Tool (FaST) collects the industry profiles of different facilities in a Microsoft Access database where the user can search for possible input/output matches (Giannini-Spohn 2003A). Figure 1 demonstrates linkages of energy, water, and
materials among the anchor facilities (shaded boxes), potential on-site facilities (solid border), and off-site business (dashed border).

Figure 1

FaST identifies possible exchanges among firms such as an aquaculture facility, fertilizer manufacturer, insectary, and cement manufacturer. For example, an offsite ice cream manufacturer provides ice cream slurry to the composting facility, which specializes in handling this type of input stream. The ice cream manufacturer also transmits its wastewater to the Living Technologies facility, which treats organic wastewater with plants and microbes before providing treated water to the aquaculture facility, farms, and greenhouses (Industrial Economics, Incorporated 1998).

Once FaST identifies potential exchanges, the planner can export the data to the Designing Industrial Ecosystems Tool (DIET) for further evaluation (Industrial Economics, Incorporated 1998). The key objective of DIET is optimization. The user can specify the importance and assign weights to environmental benefits, cost savings, and job creation. Through this “what if…” analysis, planners can organize an eco-efficient EIP. Taking these weights into consideration, the support tool suggests a set of facilities for co-location and off-site participation. For example, in the Burlington EIP, if equal weights are assigned to environmental benefits, cost savings, and job creation, approximately 500 people will be employed across all firms involved. Yet, if the planner wishes to create the greatest number of jobs, than as many as 800 people can be employed by increasing the maximum acres for the EIP and employing more individuals in labor-intensive facilities like the ice cream manufacturer (Industrial Economics, Incorporated 1998). Given the area of the EIP and the production levels of each firm, DIET goes as far as providing quantitative estimates of flows and suggests the physical size of on-site facilities and footprint of off-site firms (Industrial Economics, Incorporated 1998). The figure below shows how DIET tabulates the maximum and minimum size of each facility involved in the EIP.
In addition to balancing economic, social, and environmental needs, DIET can also minimize costs. Industrial symbiosis allows the facilities to reduce the cost of input materials as well as the cost of non-product output treatment, storage, and disposal. Based on these quantified flows, DIET estimates cost savings for each facility. DIET serves as a great link between FaST and REaLiTy.

The Regulatory, Economic, and Logistics Tool (REaLiTy) checks the EIP model developed by FaST and DIET for potential constraints and risks. Set up as a database, REaLiTy requires updated information on environmental regulation, market behavior, and logistical issues. Planners can use REaLiTy to address seasonal and temporal fluctuations of input/output streams as well as specific input and process requirements for facilities. For example, the cement kiln
dust provided to the fertilizer manufacturer can be considerably variable in quantity and content depending on the manufacturing process and fluctuations in cement production (Industrial Economics, Incorporated 1998). Currently acceptable contents of kiln dust could also come under regulation in the future. In addition, since wastewater treatment is highly dependent on a continuous source of wastewater, planners should secure a reliable source such as a local brewery before investing in building the Living Technologies facility. This final step in the modeling process is absolutely crucial before any development begins.

LIMITATIONS AND FUTURE OF FaST, DIET, AND REaLiTy

As mentioned earlier, information systems, especially decision support systems like FaST, DIET, and REaLiTy, have their limitations. Suzanne Giannini-Spohn and IEc stress the fact that these tools are “scoping” models, not detailed systems. Although DIET provides quantitative estimates, these numbers only provide a general framework, not a guarantee (Industrial Economics, Incorporated 1998). The tools rely on models and incomplete information. Stakeholders need to understand that these tools are designed to guide their search for solutions, not to automatically provide error-proof answers (Lowe et al. 1997). Information systems should be accessible to a general audience in addition to specialists (Lowe et al. 1997). Yet, the Center for Ecological Technology tested FaST and concluded that the software required advanced experience with Microsoft Access (Dubester 2000). The software also contains search flaws leading to mismatched exchanges (Dubester 2000, Giannini-Spohn 2003B). Despite their limitations, FaST, DIET, and REaLiTy provide an interactive modeling system to facilitate in the development of EIPs such as the Burlington Eco-Industrial Park. These decision support tools
can help park planners, government officials, firms, and community members identify common goals for developing an EIP in their community.

Unfortunately, the systems have not been updated since their initial development in 1999 and only FaST is currently available for application. Due to budget constraints in 2000, the EPA Division of Urban and Economic Development canceled funding for eco-industrial development (Giannini-Spohn 2003C). Despite the low probability that FaST, DIET, and REaLiTy will be updated and improved in the near future, these tools are good representatives of the few inter-organizational information systems designed for industrial symbiosis. The EPA’s initial investment exhibits the importance of decision support tools in the development of industrial ecology.

Market demand for “green” products and increased awareness in environmental management will only lead to further development of industrial ecology. Analytic tools are necessary to make the concept of industrial ecology a reality. This is done by eliminating linear systems and including more types of disciplines, more reliable information, and a better way of thinking about product functions with a connection to economic, social, human health, and environmental impacts. However, efforts to be proactive in environmental management are hindered by the complexities of many of these tools as well as a lack of incentive for businesses to self employ these tools. As it stands, there is a certain market advantage for companies that can afford the cost, time, and expertise required for tools such as life-cycle assessment and information systems. Analytic tools are often criticized for their attempts to harness and quantify such a daunting amount of information. These tools are not offering the absolute truth about what is to be done. They are designed to assist and further inform decision-makers with more
encompassing options and information. With time, efforts to streamline and improve the
efficiency of these tools will continue to progress along with our understanding and demand for
more efficient industrial systems. This demand can only be made a reality with analytic tools.
The existing foundation of tools provides a promising platform for sustainable development.
Works Cited


---. Telephone Interview. 5 May 2003. (Giannini-Spohn 2003A)

---. <giannini-spochn.suzanne@epamail.epa.gov> “Eco-Industrial planning software.” Personal e-mail. 5 May 2003. (Giannini-Spohn 2003B)

---. <giannini-spochn.suzanne@epamail.epa.gov> “Re: Information Systems.” Personal e-mail. 6 May 2003. (Giannini-Spohn 2003C)


