A Policy Brief on Industrial Ecology

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Industrial Ecology

Industrial Ecology (IE) is an evolving framework that examines the impact of industry and technology on the biophysical environment. It is part of a larger concept called ecological modernization, which is concerned with the integration of environmental issues into production and consumption practices. IE specifically explores material and energy flows in industrial and consumer activities, the effects of these flows on the environment, and the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources (EDA 2004). IE seeks structural change at the macro-economic level (Murphy 2001). Some important components of IE include: material and energetic flows (“industrial metabolism”), dematerialization and decarbonization, life-cycle assessment, design for the environment (“eco-design”), eco-industrial parks (“industrial symbiosis”), and environmental policy (Institute of Industrial Ecology 2004).

Industrial Ecology helps companies become more competitive by improving their environmental performance and strategic planning. A key concept of IE is a closed-loop cycle. By reevaluating industrial processes, IE seeks to eliminate waste by making outputs new inputs. In this way, IE facilitates community development and maintains a sound industrial base and infrastructure without sacrificing the quality of the environments. IE applies not only to private sector manufacturing and service, but also to government operations, including the provisioning of infrastructure. Additionally, IE offers government agencies design policies and regulations that would improve environmental protection while building business competitiveness. The application of IE will improve the planning and performance of government operations locally, regionally, and nationally (Indigo Development 2003).

Industrial Metabolism

Industrial metabolism (IM) is the study of a material from start to finish through the economy (Columbia). It compares economy and industry to a living system, where consumed materials are converted into a form usable to the business or organism. In the end, consumers make use of the altered matter and byproducts that cannot be used or discarded. Industrial metabolism analyzes changes in the cycling of materials and focuses on recycling. IM represents a closing of the cycles by using waste from one process as the input source of another (Materials). Waste can either be recycled or be a dissipative loss (Ayres and Simonis 1994), and in the case of IM, all waste should be re-used.

Institutions must be able to communicate through participatory dialogue and be able to learn from each attempted policy. Industries must be able to take into account the metabolism or rate of change within the energy and material, on a broad scale, reaching over many industrial players (Hukkinen 1999). The relationships in IM are expressed by interactions between the supplier and demander, the maker and the buyer, etc. (Graedel and Allenby 1995). Because they are dealing with the uncertainties inherent in sustainability, there cannot be a large amount of reliability (Hukkinen 1999). But with establishing accountability systems and evaluating progress, a degree of reliability can be achieved (Hukkinen 1999). It is important for the institutions from the past to change their policies from short term profitability to long term management.
Interface, founded in 1973 by Ray Anderson, who was named co-chairman of the President’s Council on Sustainable Development in 1997, produces America’s first free-lay carpet tiles (Who We Are). Mike Bertolucci, the current President of Interface Research Corporation, commented on how industrial metabolism is incorporated into Interface: “Reduce, reuse, and recycle is the key element to companies that look to become more sustainable. The design of products facilitates dematerialization of the products and ease of their recycling. Ultimately, we can boost consumption with minimal material and energy requirements and then convert to renewables.”

Interface produces modular carpet, otherwise known as carpet tile, enabling customers to replace a piece of carpet when needed instead of the whole carpet. The company knowingly uses much petroleum in its manufacturing process, but unlike many other companies, it has been improving technologies and policies, and is recycling carpet and other petrochemical goods. Anderson’s “Evergreen Lease” implements a program to lease rather than sell carpet, ensuring that old carpets get returned for recycling (Arnst 1997). Interface is considering the use of materials made from natural versus oil based synthetic raw materials. For example, polylactic acid fibers come from corn, potatoes, soybeans, or some alternative starch-based agricultural waste product. Anderson hopes to never have to use another drop of oil (Bio-Based). These actions provide a way to close the cycle of metabolism; waste has been reused in the starting process.

Dematerialization

Dematerialization is defined as "the reduction of total material and energy throughput of any product and service, and thus the limitation of its environmental impact. This includes reduction of raw materials at the production stage, of energy and material inputs at the use stage, and of waste at the disposal stage" (Association 2004). In relation to the field of industrial ecology, dematerialization refers to the de-coupling of economic growth and resource use, and advocates a reduction in the quantity of materials required to serve economic functions (Herman 1989). It differs from industrial metabolism in that it looks at stages in the production process and the materials used in that process, rather than looking at how a specific material is used from start to finish. The extent to which dematerialization initiatives have been implemented can be assessed at every stage of the production and consumption chain: “resource savings in material extraction, improved eco-design of products, technological innovations in the production process, environmentally conscious consumption patterns, and recycling of waste” (Association 2004). Intensive research in materials science and engineering, sensitive to environmental properties, is essential for the pursuits of dematerialization (Wernick 1998).

Decarbonization, the reduction of carbon dioxide emissions, is an important pursuit of dematerialization, as emissions reductions are directly connected to minimizing resource use in industrial processes (Wernick 1998). This will necessitate a shift in the materials industry “from the current domination by extractive industries toward providers that offer complete materials management services, including recycled, reused, and refurbished materials rather than only virgin materials” (Graedel 1995). Dematerialization in the energy industry is exemplified by the recent move by utilities to deal with growing electricity demand in a new way. Utilities in 19 states have chosen to invest in energy conservation as an alternative to expanding production...
capacity; “They can continue to show a good return on investment while at the same time meeting demand, and without incurring the environmental impact of increased electricity generating capacity (Graedel 1995).

Limits to dematerialization have been highlighted in “revenge theory,” which proposes that “human societies face unintended and often ironic consequences of their own mechanical, chemical, medical, social, and financial ingenuity” (Tenner 1996). Dematerialization initiatives are most successfully implemented through public policy which provides both regulation and incentive to accomplish its objectives. Product design should allow for recycling primary materials, as well as the incorporation of waste-minimizing technologies. Such dematerialization trends will continue to produce smaller, lighter products, complemented by the replacement of material goods by non-material substitutes (Association 2004). “Broad-based implementation requires the involvement of the market, and synergism of economic, social, and environmental benefits (triple-win-strategies) should be used as much as possible” (Bartelmus 1997).

Life Cycle Assessment

Incorporating both industrial metabolism and dematerialization, life cycle assessment (LCA) evaluates the entire process: where the materials come from, where they will be going, what they will be doing while there are there, and once they are used, what will happen to them. LCA is used to determine the total environmental impact a product will have from cradle-to-grave. There are multiple definitions for LCA. The International Organization for Standardization (ISO 14040) has standardized this methodology and defined it:

LCA is a technique for assessing the environmental aspects and potential impacts associated with a product by compiling an inventory of relevant inputs and outputs of a system; evaluating … and interpreting the results of the inventory and impact phases in relation to the objectives of the study (Ayres 2003).

There are three basic stages in LCA: inventory analysis, impact analysis, and improvement analysis. A detailed explanation of each stage of LCA will reveal a complicated process. This is often a cause for criticism, noting that in a real world situation it would be too cumbersome to be useful. It would be better to have a tool to identify problem areas quickly so that designers could proceed on to more important issues. Additionally, it is questioned if LCA studies can perform the same value added services to both simple and complex product issues, such as disposable diapers and automobiles respectively (Graedel 1995). Noting these questions, LCA is a new mythology and as more products are assessed the process with become more useful and efficient.

By looking at the entire life cycle of a product, companies have been able eliminate costs (both financial and environmental) associated with growth of a business. In redesigning a product life cycle, biological processes are looked at as a model, where waste equals food and everything that is created can be recreated into something else: cradle-to-cradle rather than cradle-to-grave (McDonough 2002). The goal of LCA is to eliminate inefficiencies and harmful materials, and to minimize waste.
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In considering this goal, it is important to recognize the associated policy implications. Graedel and Allenby (1995) point out that there is no real precise definition of ‘waste’ by a legal entity. They provide five definitions of waste used by different legal entities ranging from waste being a material not directly used in another process to waste not existing, just residues. They highlight that because of the inconsistent use of ‘waste’ and its meaning, corporations will be able to dispose of wastes differently and the restrictions and limitations differ drastically. Another component is if a corporation decides to sell their waste to another corporation, will the ensuing transportation of waste negate the positive impact of the exchange? These are questions that can only be answer with time, as society learns more about the concept and process.

**Eco-Design**

Eco-design, or design for the environment, is a way of incorporating sustainable features into every day products. In creating these products, industrial metabolism and dematerialization are considered. Evaluating the entire life cycle of the product is of primary importance. Eco-design looks into every detail of a product to minimize its environmental impact (USEP). Products made from sustainable resources that contain the maximum recyclable content and recyclability are the future of achieving ecological sustainability. One notable definition by the European Environment Agency states that eco-design is “the integration of environmental aspects into the product development process, by balancing ecological and economic requirements. [It] considers environmental aspects at all stages of the … process, striving for … the lowest … environmental impact throughout the product life cycle” (EEA 2004).

Even though eco-design is a step in the right direction, current products using this methodology are not completely sustainable because a combination of recycled materials and virgin materials is used. Some reasons for this are that we are not obtaining the desired amount of recyclables needed to make ecologically designed products. Policy surrounding this concept should create incentive for consumers to recycle and reuse everyday products. Current eco-design, however, can be seen building components and manufacturing processes.

Green buildings are a primary example of eco-design. They incorporate life cycle assessment in evaluating the role that each component will play not only in the construction process but also throughout the entire operation of the building. McDonough Baungart Design Chemistry (MBDC) has created an upholstery fabric that is a blend of pesticide-residue-free wool and organically grown ramie, dyed and processed entirely with non-toxic chemicals (MBDC). This product helps to improve the indoor environmental quality of a building, which is a major component of attaining a green building certification (LEED) from the US Green Building Council (USGBC). Phil Stoehry, a representative from MBDC, points out that “business is on the front line in making sustainable development a reality. That means all companies need to take a hard look at how they make their products and deliver their services.”

Manufacturing is another process that employs eco-design. This can be seen in packaging of materials to the plastic covering on cell phones and on disposable cameras. AT&T has a wireless recycle and reuse program that invites customers on a tax-deductible proposal to turn in used cell phones. According to the U.S. EPA, tons of electronic waste ends up in landfills each
year (USEPA). AT&T and other businesses that develop programs like this have the ability to move eco-design forward.

The need for eco-design becomes apparent with declining natural resources. Policy should address regulations that force business to develop products that result in recycling and reusing, as well as consumers purchasing products made from recycled materials. Eco-design will only prosper through creating sustainable communities involving the active participation of the local government, other institutions, individual citizens, and businesses like AT&T and MBDC (USEP).

**Eco-Industrial Parks**

Eco-Industrial Parks (EIPs) focus on symbiotic relationships in which companies utilize the waste materials or energy of others. EIPs are an excellent example of contemporary governance, in that they involve both the private and public sectors, and the community. EIPs have a larger vision of sustainable community development, which can be looked at as a “closed loop” or one that keeps markets and profits within the local economy (GAIA 2004).

The concept of eco-industrial parks has gained considerable enthusiasm across the United States and in other parts of the world, including Europe, Asia, Africa, and Australia (Cote 1998). The U.S. Department of Commerce, the Economic Development Administration (EDA), funds several EIPs in the United States, including: Port of Cape Charles Sustainable Technologies Industrial Park, North Hampton County; Virginia and the Brownsville, Texas Eco-Industrial Park; Fairfield Eco-Industrial Park in Baltimore, MD; and Chattanooga, TN Southside SMART Park (EDA 2004). Of the U.S. eco-industrial park projects, the most innovative is the Green Institute’s eco-industrial park in Minneapolis, Minnesota. The Green Institute is based on ecological design, with green architecture addressing issues such as energy conservation, responsible materials selection, and climate control. The Green Institute also provides green jobs for low-income people in the local community, tenants whom manufacture or service environmentally beneficial products, and reuse of waste materials and by-products (Cote 1998). According to Andrew Lambert from the Green Institute, “The Phillips Eco-Enterprise Center (PEEC) is an innovative model that delivers energy conservation and efficiency programs to low-income renters, landlords, non-English speakers and small businesses - all of which are groups that are often overlooked and underserved by utilities and energy assistance programs.” PEEC works with Xcel Energy Inc., the local energy provider, to facilitate “the cooperative business model, with its guiding principles of democracy, grassroots organizing, empowerment and cooperation among cooperatives, to most effectively deliver badly needed conservation and efficiency programs in the community.” In this way, PEEC is hoping to create incentives for “landlords, small business owners, and renters to invest in energy efficient appliances and to upgrade their homes, creating a positive economic impact on the local community.”

Ecological business parks have also gained popularity in Europe; one classic example is located in Kalundborg, Denmark. Kalundborg is a community located west of Copenhagen, where five major industrial partners exchange energy and material flows to recycle and reuse waste materials: a coal-fired power plant (Asnaes Power Station), a refinery (Statoil Oil), a pharmaceutical and industrial enzyme plant (Gyproc), a wallboard company (Novo Nordisk),
and the town’s heating facility (the City of Kalundborg) have developed one-on-one trade systems to exchange steam, hot water, and materials like gypsum, sulfuric acid and biotech sludge (Lowe 2003). Originally, the motivation behind most of the exchanges was to reduce costs by seeking income-producing uses for “waste” products. Gradually, however, the managers and town residents realized that through their transactions they were generating environmental benefits as well (Indigo Development 2003).

Eco-Industrial Park: Kalundborg, Denmark

Policy Implications

IE is a concept which “focuses on reducing the environmental problems, and on innovations that can significantly improve environmental performance” (Lown 2003). Industrial Ecology offers significant potential for U.S environmental policy. Its current lack of presence in US environmental policy is undoubtedly linked to the lack of convincing evidence. The United States Environmental Protection Agency has initiated a number of innovative industrial ecology type policies. IE policies have already been in use in Europe and Japan. But policies of this type run countercurrent to US environmental policy because the national government has “developed an emphasis on quantification of environmental risks and on the scientific evolution of environmental policy” (Thomas 2003). Essentially, the US is rather reactive whereas other nations, such as the European Union and Japan, are proactive when it comes to introducing new environmental policy tactics. Due to our reactive policy transformation, fundamental research in Industrial Ecology is needed before policy is adopted in the US. The US government (particularly the USEPA), actors in the market, and several NGO’s are in the process of explicitly stating theories, testing against real data, establishing limitations and ranges of applicability for IE.

The state has been an important actor through its innovation spurring research projects and proposals and as a “direct and indirect market customer” (Graedel and Allenby 1995). However, private industry has been handed the challenge of incorporating the technology in a voluntary approach. Unfortunately, the market is not going to change unaided. Government has the ability to “encourage environmentally preferable technologies and industrial ecology principles,” but
due to scientific uncertainty regarding benefits and costs of IE policy implications, policies have failed (Graedel and Allenby 1995).

The EPA has recognized the need for “industrial ecology for a sustainable future” (Allen 2003). With the growing and changing economy, classic environmental approaches are no longer sufficient at tackling remaining environmental issues. Regulations such as the Resource Recovery and Conservation Act are counterproductive. The RCRA’s definitional constraints have the effect of “institutionalizing the linear manufacturing paradigm, rather then guide industry toward sustainability” (Graedel and Allenby 1995).

The relevant parties recognize that industry posses the wherewithal to incorporate industrial ecology in its practice. It is a matter of creating policies that provide incentives. Partnerships especially between government, researchers, and business are the essential ingredient necessary for making IE a realistic goal for public policy. If IE is going to be brought to the forefront of the US environmental regime the roles of various institutions will be expected to change. Policies, which give industries incentives to practice industrial ecology, must be created. This creation and implementation of such policies should involve government regulators, industrial spokesmen, research analysts, environmental groups and local communities.
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Bibliography


Bertolucci, Dr. Michael, President of Interface Research Corporation, Chairman of the Envirosense Consortium, Inc., and Senior Vice President of Interface, Inc. Telephone Interview. April 15, 2004.


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