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Industrial Ecology and Eco-Industrial Development − The UK's National Industrial Symbiosis Programme (NISP)

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Abstract

In recent years industrial ecology has been the subject of both academic and policy interest, as a means of implementing sustainable development. For some academic researchers, industrial ecology is seen as the 'science of sustainability', while for policy makers industrial ecology has seemed to offer new opportunities to combine environmental improvement, economic development and local regeneration through the construction of eco-industrial parks. Industrial ecology uses metaphors drawn from natural ecosystems to suggest that industrial production can be reconfigured into an 'industrial ecosystem' where firms are interconnected through the exchange of wastes and energy. This paper provides an outline of NISP, the national level scheme to promote industrial symbiosis in the UK which utilises an ICT-mediated database to collect information on material and energy flows.

1. Introduction

A concern for the environmental consequences of economic development appears to have become a permanent feature of the social and political landscape. Although these concerns pre-date the event itself, the Rio Earth Summit of 1996 played a key role in putting these environmental concerns onto national and international political agendas. One of the legacies of Rio has been the widespread adoption of sustainable development as the basis of environmental policies. Instead of assuming that economic development and environmental protection are inevitably incompatible, proponents of sustainable development argue that it allows the integration of economic, environmental and social aims. However, while sustainable development is now a mainstream component of policies around the world, its actual implementation is more problematic. How exactly can economic, environmental and social aims be reconciled and what kinds of measures should policy makers introduce? In the early twenty first century, these questions have taken on even greater importance with a growing recognition of the impacts that can result from enhanced global warming. Changing weather patterns and sea level rise as a consequence of global warming are now generally accepted as fact by the majority of scientific opinion and by politicians.

It is against this broader context that we can see why the concept of industrial ecology has begun to enter into both academic and policy debates. In the 1990s industrial ecology emerged as a concept that its proponents claim can deliver the win-win-win outcome of sustainable development. Ashford and Côté (1997), for example, term it a new unifying principle to operationalise sustainable development. At the heart of the concept is a deceptively simple argument that proposes a way to reduce or eliminate the negative impacts of economic development - by drawing upon the example of natural ecosystems we can create 'industrial ecosystems'. By mimicking nature, industry can shift from the current wasteful linear model of production to a circular economy, where natural resource inputs are reduced, wastes transformed into firm inputs and energy cascaded through the industrial ecosystem. The use of natural metaphors has been a powerful motivating factor that has captured the imagination of both policy makers and developers. To take just one example, promotional material for the Red Hills Ecoplex in Mississippi states: 'still think of "industrial park" as synonymous with "smoke stack", "pollution" and "expensive eyesore"? Fortunately it's time to think again…the EcoPlex mimics a natural, efficient ecosystem' (see McManus and Gibbs 2008 for a critique of the use of natural metaphors in industrial ecology). Industrial ecology differs from more commonplace efforts to 'green' industry in that it fosters cooperation between firms as opposed to focusing upon action at the level of the individual firm,

seeing firms as nodal points within a networked ecosystem. By cooperating with each other in an industrial ecosystem, it is proposed that businesses can improve their combined environmental performance by measures that will also increase profit margins.

Industrial ecology has increasingly developed as an academic subject, with its proponents drawn mainly from two broad disciplinary bases - engineering and business and management studies. Some of the latter group have added an additional benefit to be gained from industrial ecology policies - the regeneration of local areas and social gains through employment (Schlarb, 2001). Interestingly, few biologists or ecologists have been involved in these debates; although, in a rare example, Harte, a physicist and ecologist, has argued that natural ecosystems provide a poor model for designing business systems on the basis that the former are inherently unstable, wasteful and lack any moral direction (see Anonymous, 2001). Industrial ecology has also entered into the policy arena, with a growing number of local, regional and national initiatives to try and create industrial ecosystems in some form. Hence eco-industrial parks, regional industrial symbiosis projects and national circular economy strategies have all appeared in recent years (see Tudor et al., 2007; Mirata, 2004 and Fang et al., 2007, respectively, for details of these). Certainly, a key part of any future move towards a 'less unsustainable' society will necessitate major shifts in the way that industry operates. The prospects for this are open to substantial debate, given that the profit-driven organisation of production has been known to constrain some shifts towards sustainability. However, while mindful of the problems involved in overcoming the ecological contradictions of capitalism (see Gibbs, 2006), industrial ecology approaches may help to provide at least a temporary fix and involve 'relative (but significant) changes into more environmentally sound directions' (Mol, 2002: 97).

2. Implementing Industrial Ecology: Eco-industrial Development

Although industrial ecology has been described as the 'science of sustainability' (Allenby, 1999), the field is still in its early stages. Moreover, much academic and policy work has been so far been largely speculative, theorising what could be done to create an industrial ecosystem. The one example of what could be achieved that is cited time and again in the literature is the town of Kalundborg in Denmark (see Jacobsen, 2003 for more details and www.symbiosis.dk for the official website). At Kalundborg a web of waste and energy exchanges developed connecting the local city administration, a power plant, a refinery, a fish farm, a pharmaceuticals plant and a wallboard manufacturer. It is estimated that waste exchanges at Kalundborg comprise some 2.9 million tons of materials each year, collective water consumption has been reduced by 25% and the power station has reduced water use by 60% through recycling (Chertow, 2004).

For many industrial ecologists the example of Kalundborg has seemed to offer support for their ideas. Here, voluntary cooperation between individual companies and other participants has developed organically over time to create something like an industrial ecosystem. For some, this indicated that if such a system could develop organically, much more might be achieved through purposeful planning.

For example, Hawken (1993: 63) after musing on the lessons from Kalundborg states 'imagine what a team of designers were to come up with if they were to start from scratch, locating and specifying industries and factories that had potentially synergistic and symbiotic relationships'. Indeed, Kalundborg is frequently cited as *the* industrial ecology exemplar in the literature and has often been used to justify policies to establish industrial ecology projects - for example the four eco-industrial demonstration sites designated by the US President's Council on Sustainable Development (Martin et al., 1998). From the late 1990s onwards, a consensus emerged that the creation of eco-industrial parks at a specific bounded location could be a valid means of implementing industrial ecology and achieving Hawken's aim of a planned Kalundborg. An initial definition of an eco-industrial park by leading US practitioners was: „a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials…the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realise if it optimised its individual performance" (Lowe and Warren, 1996: 7.8). A number of local and regional projects have subsequently been initiated to plan and actively develop EIPs in the USA, Europe, Asia and Australasia (see

amongst others BCSD, 2002; Erkman and Ramaswamy, 2003; Lowe, 2003; Chiu and Yong, 2004; Eilering and Vermeulen, 2004; Heeres et al., 2004; Mirata, 2004).

Much debate has been engendered within the industrial ecology community as to whether developments that involve interactions among member businesses and between them and their natural environment (i.e. by-product exchanges or symbioses) are a defining feature of EIPs. For Lowe (2002: 2) 'the critical elements are the interactions among the park's member businesses and the community's relationship with its community and natural environment'. Lowe (2002) is essentially concerned with the end product of EIP development and does not consider features such as 'green architecture', landscaping features or a cluster of recycling companies as constituting a valid EIP. By contrast, other authors suggest that an incremental approach to EIP development should be adopted. For example, North and Giannini-Spohn (1999, cited in Schlarb, 2001: 12) argue that EIP development can involve a 'palette of strategies for increasing resource efficiency. While the ideal EIP or IE network would incorporate all of these strategies in the long-term, companies participating initially might add strategies incrementally as the business case for each becomes stronger'. Indeed Schlarb (2001: 1) suggests that although the 'unique contribution [of eco-industrial development] is its emphasis on inter-firm exchange linkages', there are a number of other strategies that can be adopted to promote resource efficiency.

In adopting an incremental approach, while materials and energy interchanges may be the ultimate goal of EIPs, given the difficulty of achieving these they should perhaps be seen as a medium to long-term target, rather than the defining feature of the initial development. Some authors have suggested that the development of exchanges and networks can not be introduced through policy and are best left to market forces (Desrochers, 2002) and that EIP development is an overambitious task (Chertow, 1999). Chertow (2000: 322) also cautions against considering waste exchanges and traditional recycling industries as evidence of industrial symbiosis as they 'accomplish various input/output savings on a trade by trade basis, rather than continuously'. Whereas Lowe (2002) dismisses a collection of bilateral exchanges as inadequate to warrant definition as an EIP, conversely Chertow (2000) proposes establishing bilateral exchanges within an EIP as an initial step, as opposed to trying to establish a complex network from the outset.As is evident from this brief overview, there is considerable debate over what defines and constitutes an EIP and on how industrial ecology can be implemented. While it is possible to be sympathetic to the argument that creating industrial ecology is a long term and incremental process, it can be argued that some degree of waste and energy exchanges and inter-organisational networking must eventually be present by definition. Otherwise, as O'Rourke et al. (1996: 90) argue this would mean 'IE is vague and broad enough to serve as the catchword for many different arguments'.

This is not to suggest that networking and interchange are easy to develop or that Kalundborg can readily be replicated through policy. Indeed, past work by the author has indicated the problems involved in developing eco-industrial parks in Europe and the USA (Gibbs and Deutz, 2005, 2007; Gibbs, Deutz and Proctor, 2005). Indeed, as the next section shows, the main national level programme in the UK as adopted a regionally-based eco-industrial network approach rather than focusing solely on EIPs.

3. The UK's National Industrial Symbiosis Programme

Currently, the UK's main activities to develop industrial symbiosis are at the national scale led by the National Industrial Symbiosis Programme (NISP), which is constituted by sub-programmes in the UK's 12 regions and nations. From 2000, under the support of Business Council for Sustainable Development – United Kingdom (BCSD-UK), industrial symbiosis networks were gradually built from the regional to the national scale, and then a national industrial symbiosis programme (NISP) was launched (Mirata, 2004). NISP was the first non-profit coordinating body for by-product reuse on a national scale. In its mission, NISP describes its role as to "help to create commercial opportunities through the exchange of all resources, including materials, energy and water and sharing assets, logistics and expertise" (NISP, 2008). NISP's main approaches to promote the progress of industrial symbiosis are through training companies to 'think symbiotically', through data collection and by provid-

ing technical assistance (Laybourn and Clark, 2004). According to Mirata and Pearce (2006) and Bailey (2006), four main phases to develop industrial symbiosis programmes in individual regions have occurred:

3.1 Step 1: Awareness Raising and Recruitment

A range of means have been used to raise business awareness to become involved in the industrial symbiosis activities, such as leaflets and an on-line promotional video. A number of slogans, such as 'diverse networking', 'increasing profit' and 'win-win-win', are used to attract company interest (NISP workshop leaflet, 2009). Regional synergy workshops are held periodically to bring interested businesses together to initiate communications platforms and identify which businesses desire to be involved in the industrial symbiosis networks. During the workshop programme, NISP's mission, details of successful case studies and the potential benefits of the industrial symbiosis are introduced. Attendees from companies are required to fill in the resource/waste available information, (see Table 1) and exchange the information with others to identify the potential to co-operate with other businesses.

Following the workshop programme, the regional co-ordinator and steering group members work with the identified businesses to achieve synergies.

3.2 Step 2: Data Collection

Quantitative and qualitative information on material/energy flows of the participating companies are collected by NISP through site visits. These data are governed by a confidential agreement if necessary, and are stored into a special designed information database which enables NISP to identify potential synergies at the regional scale.

Your Details									
Name									
Company									
The Stuff I HAVE – that someone else might want									
Type of Resource				Quantity/Volume		Availability (Frequency/Duration)		Location	Additional Information
Material? Logistics?	Capacity? Water?	Energy? Expertise?	Land?	Tonnes? KW?	Litres? Items?	Continuous? One-off?	Batch? Seasonal?	Postcode? Town?	Contaminated?
The Stuff I NEED – that someone else might have									
Type of Resource				Quantity/Volume		Availability (Frequency/Duration)		Location	Additional Information
Material? Logistics?	Capacity? Water?	Energy? Expertise?	Land?	Tonnes? KW?	Litres? Items?	Continuous? One-off?	Batch? Seasonal?	Postcode? Town?	Contaminated?

(Source: http://www.maygurney.co.uk/supply/downloads/nisp_slides.pdf)

3.3 Step 3: Analysis and Identification of Synergies

The database is used to process input information, and then engender the matching of supply to demand within the network based on analysing each company's needs in terms of the supply and demand for materials, resources and facilities.

3.4 Step 4: Implementation and Support

The last but most important step is to put the identified synergies in to practice. Specialists in NISP assist companies to identify potential technical, financial barriers and solutions. Implementing industrial symbiosis at a regional scale with the assistance of a coordinating body has proved to be fruitful. In 2007, over six thousand businesses including all industrial sectors, were working with NISP (NISP, 2007). Some achievements of the programme during the 14 months from April 2005 to June 2006 include "1,483,646 tonnes diverted from landfill; 1,827,756 tonnes of virgin material saved; 386,775,000 litres potable water savings…" (Laybourn, 2007, p.14). Performance analysis for NISP activities for the year 2005/2006 showed that the ration of cost savings to investment in symbiotic activity was approximately 42:1 (Agarwal and Strachan, 2007).

As a non-profit coordinating body to promote industrial symbiosis, the success factor of NISP is to emphasis the creation of business opportunities rather than push businesses to reduce pollution. According to one of NISP's practitioners (Bailey, 2007), the key to negotiation includes "talking business when talking to businesses" and "developing trust, building relationships". While the ICT database may be useful to identify potential symbioses and exchanges, face-to-face communications and direct engagement with companies is still of key importance.

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