BUILDING SUSTAINABLE INDUSTRIES FOR SUSTAINABLE SOCIETIES

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The greening of industry is a strategic research area where many paradigms converge, not a new field or discipline, nor a specialty of an existing discipline. These paradigms all share the assumption that industrial firms will play a vital role in the needed transition to a sustainable society. And they share the view that the transition will change firms in a profound way, influencing their strategies and instruments, identities, and relationships with their stakeholders (Groenewegen et al., 1995: 1).

The results of the Fourth Greening of Industry Network Conference, Research and Practice: Learning to Build Sustainable Societies, held in Toronto, Canada, 12–14 November 1995, are summarized. The Greening of Industry Network is concerned with the role of firms and industries in the transition to a sustainable society. The Network conferences, held annually at different locations around the world, promote this goal by bringing together diverse participants from industry, government, academia and various nongovernmental organizations. The conferences are venues for information exchange, learning and dialogue about diverse aspects of the greening of industry and possible pathways to a sustainable society.

The 1995 conference was co-ordinated by Professor Nigel Roome of the Erivan K. Haub Program in Business and the Environment at York University, Canada.

INTRODUCTION

Perhaps the most striking conclusion to be drawn from the 1995 Greening of Industry Network Conference is the different pace at which various aspects of the industry–environment relation are evolving during the 1990s. Within North America and Europe there is a palpable sense of progress among firms in environmental management. The diffusion of environmental management practices is occurring less rapidly elsewhere in the world and industry is only beginning to confront the difficult challenge of management for sustainability.

At least among the largely self-selected group of firms participating in the 1995 Network conference, environmental management is becoming part of accepted business practice. Within North America and Europe, knowledge of the basic tools of environmental management is diffusing among firms and within industries. Clear models of management strategy are emerging. There are, of course, leaders and laggards in industry, areas in which the pace of progress is slow, and disputes over the best regulatory approach towards greening. However, improvements in environmental performance are underway. The first section of this report reviews the wealth of case study material presented at the conference on emerging best practice in environmental management.
On an international and global scale, and especially in the developing and newly industrializing economies, the pattern of greening is more fragmented and far less evident, and is moving at a slower pace. The challenge of adopting an ethic of greening for industry world-wide still looms large. The institutional and organizational mechanisms of greening are unclear. The role of international organizations, such as the World Bank and UNDP, remains in dispute, as does the possibility of more localized initiatives at the regional and local scale. It is unclear whether environmental management practices developed in a North American and European context are transferable to the range of development conditions that comprise the international economy, from the so-called 'societies in transition' of Eastern Europe to the rapidly expanding economies of the Pacific Rim. The second segment of our report reviews the results of various case studies of the greening of industry on an international scale.

The growing confidence exhibited by North American and European firms in the area of environmental management stands in contrast with a shortage of ideas and initiatives regarding the role of industry in the sustainability transition. As Hall and Roome (1996: 9) suggest 'although current thinking provides us with some valuable pointers, there still exists a vacuum surrounding what comprises “sustainable strategies” – in terms of definition and process.' Plenary presentations by Alicia Barcena of the Earth Council and Jacqueline Aloisi de Laderel of UNEP reinforced the point that environmental management and the attendant improvements in environmental performance by industry are only one part of the move towards sustainability. Fundamental issues of population growth, economic development, equity and justice must also be addressed. Although there is a growing acceptance that (i) greening is compatible with the pursuit of profit and other business goals and (ii) firms themselves will be the central agent of change, it is far from clear whether these principles hold true for sustainability. In the twin issues of consumption and growth, for example, both the responsibility and the capacity of firms to respond are in doubt.

In the absence of clear management strategies for sustainability it is not surprising that the pace of change is slow. And yet the participants in the conference remain centrally concerned with ways to harness the skills and resources of firms towards the goal of sustainability. There are now a growing number of projects attempting to define creative first steps for firms interested in the issue of sustainability. The third segment of our report highlights ideas and information put forward at the conference about the role of firms in the sustainability transition.

ENVIRONMENTAL MANAGEMENT

By far the largest proportion of papers presented at the conference dealt with issues of environmental management. This emphasis on environmental management reflects the current state of the ‘greening of industry’ within North America and Europe. Industry’s attention remains focused on the evaluation of different forms of environmental management, and only secondarily on management for sustainability. Within the domain of environmental management, two broad issues receive attention, namely, the role of internal and external forces in initiating and sustaining a programme of environmental management, and the utility of different management tools for improving environmental performance (e.g. environmental policy statements, environmental audits, environmental standards and voluntary codes of management practice). We review ideas and information presented at the conference on these two themes and highlight three areas of emerging research in environmental management: finance, supply chains and performance indicators.

Identification of the mix of internal and external forces, and economic, political and cultural processes, that best promote the adoption and ongoing implementation of environmental management programmes is a high priority for researchers and policy-makers. Although the firms in attendance at the conference have generally adopted environmental management strategies of one kind or another, they are not representative of industry in general, many segments of which have yet to implement environmental management programmes. Further, there is considerable variation across countries in the extent to which environmental management practices have been adopted by firms. Research by Polonsky et al. (1995) is illustrative in this regard. In a survey of large Australian and British firms, these authors found significantly higher levels of environmental management activity (e.g. environmental audits) on the part of British firms.

The reasons behind this variation in the level of adoption of environmental management programmes are not fully understood. In general terms, researchers distinguish between a set of external driving forces (e.g. environmental regulation and pressure from environmental groups) and a set of forces that are primarily internal to a firm (e.g. employee participation in quality management programmes or corporate culture). One question of
interest to policy-makers is the relative importance of these external and internal processes in promoting the adoption of environmental management practices. Although the answers to this question remain preliminary, research presented at the conference suggests that whereas external forces are usually the important drivers of the adoption of an environmental management plan, the ongoing implementation of the plan is crucially dependent on the emergence of a set of internal supportive forces and the creation of a clear and organized constituency whose responsibility it is to address environmental issues. Research presented by Henriques and Sadorsky (1995) is important in this regard. Using data collected through a questionnaire survey of Canada’s largest firms, these workers examine why firms adopt environmental management plans. Pressure from external environmental groups and from environmental regulation is found to be of greater importance than processes internal to the firm, such as pressure from employees and from shareholders.

External drivers range from the growth of environmental movements to the implementation of new environmental regulations that require changes in management practice. One interesting category of driver that in some ways bridges the internal/external divide is the emergence of voluntary codes of conduct on the part of firms and industry groups. Often developed as a way of deflecting proposed involuntary legislation, industry codes of conduct are growing in importance at regional, national and international scales. How do these voluntary initiatives fare as instigators of change in management practice? Nash and Howard (1995) examine the influence of one illustrative programme, namely, the Responsible Care initiative in the US chemical industry. These authors report a modest, but uneven, response on the part of chemical firms who are signatories to the initiative. The analysis of these voluntary initiatives is unproblematically connected with top-down leadership. Case study research by Jones (1995) demonstrates the need for a more complex account of management practices at this and other firms. The analysis of the Body Shop reveals the limits to a strong culture approach to management and the emergence at the Body Shop of a mixed model that combines both unitarist and pluralist management cultures.

Achieving a sustained and virtuous circle of environmental management remains an elusive goal for firms. Sharma (1995) argues, based on case study research in the North American oil and gas industry, that firms taking a proactive stance towards the environment trigger a process of organizational learning and capacity building that serves as a platform for future improvements and innovations. Of particular importance are positive trust based relations established with external stakeholders. This theme is also supported by the study of Halme et al. (1995) of changing management paradigms in the Finnish paper industry. Here changes in external conditions (European packaging regulations) triggered a process of internal learning and organizational change. These papers suggest, in short, an interaction between internal and external environmental improvement on the part of most of the participating firms.

If external forces often trigger a movement towards environmental management, what sustains the management initiative over time and, in particular, how durable are firms’ commitments to environmental management once external incentives and drivers are removed? As many in industry have noted, having a plan does not guarantee implementation. Several papers at the conference emphasized the importance of processes internal to the firm in achieving a self-reinforcing dynamic of environmental management. Among the issues researchers have examined are the background and professional experience of the chief executive officer (Stanwick and Stanwick, 1995) and the role of a vanguard of highly motivated key employees (Meima, 1995). The latter paper, based on case study research in Sweden, forcefully demonstrates that the motivation for change can come from the bottom up, as well as from corporate leadership. In the Swedish case, an employee vanguard of highly motivated workers provided momentum for the firm. In other instances, environmental management is driven from the top by a visionary leader. Perhaps the most frequently cited example of this top-down leadership is Anita Roddick and the Body Shop, a company that has been described as the inventor of ‘sustainable retailing’.

It is often presumed that the greening of the Body Shop is unproblematically connected with top-down leadership. Case study analysis by Jones (1995) demonstrates the need for a more complex account of management practices at this and other firms. The analysis of the Body Shop reveals the limits to a strong culture approach to management and the emergence at the Body Shop of a mixed model that combines both unitarist and pluralist management cultures.
forces in maintaining a dynamic of continuous improvement. Both papers highlight the value of a particular set of external relations, namely, those based on trust and co-operation.

The notion that sustained improvement in environmental management requires a more consensual approach towards environmental policy-making, and in particular to co-operative, consensus building relations among industry, environmentalists and government regulators, is central to the current policy debate around industry-environmental issues in the USA and other countries. This theme of collaboration is examined by Lober (1995) in a case study of a co-operative paper task force set up by a group of US corporations, regulators and environmental groups. Lober argues that a confluence of circumstances, ranging from the public’s evaluation of the seriousness of environmental problems to the availability of various innovative technologies, have opened a ‘window for collaboration’ among industry, environmental groups and regulators during the 1990s.

Industry, of course, has shown a strong preference for voluntary approaches to environmental management. De Clercq et al. (1996) show that even for regulatory approaches that firms resist (e.g. ecotaxes), there is a large benefit to including industry in co-operative consultations over the design of regulatory programmes. Programmes imposed without consultation beg a conflictual response and often fail to meet their intended goals.

If researchers and policy-makers are most interested in the drivers of environmental management, the firms attending this conference were most interested in evaluating the different tools available for environmental management. These firms were already involved in environmental management and sought information on the merits or otherwise of specific tools and instruments, as well as different organizational strategies. It is important in this regard to highlight the kind of information that is valued most by firms. Although researchers often look for systematic cross-sectional data, the firms in attendance placed particular value on specific examples of successful environmental management (what one participant referred to as an inventory of success stories). Moreover, information provided by firms that are judged to be successful by other performance standards (e.g. high growth in sales and profits) is judged to be particularly valuable. Presumably, the rationale here is based on the premise that a firm with successful management strategies in general is also likely to develop effective approaches to environmental management.

One of the clearest illustration of this phenomenon is the level of interest in the environmental management activities of ATT, Hewlett Packard and other dynamic high technology firms. Dambach and Allenby (1995) describe the application of a Total Quality Management approach to environmental issues at ATT. These workers document significant improvements in environmental performance linked to the application of a design for the environment management strategy and the creation of an independent design for the environment organizational unit at the company. Dambach and Allenby report, for example, the total elimination of CFCs from ATT’s manufacturing operations in 1993 and a 96% decrease in toxic air emissions over the period 1987–1994. The strategies used by ATT have become a blueprint to be adopted by other firms.

Academic researchers and policy-makers on their part are interested in consistent and systematic data on environmental manufacturing practices and environmental performance. As there are few large-scale published data sets that deal with environmental management practices, many researchers have resorted to collecting their own survey data. Although these surveys provide useful insights, they often suffer from a lack of systematic information on environmental performance. The value of larger scale databases is demonstrated by research using the US toxic release inventory. A paper by Ruiz-Quintanilla et al. (1996) is illustrative of the use of these data. These workers demonstrate a link between the level and type of employee participation in pollution prevention and reduction in industrial toxic emissions. Other sources of information, such as voluntary disclosures in annual reports for US firms examined by Buhr and Freedman (1995), and by Halme et al. (1995) in a study of the pulp and paper industry, apparently yield only a small amount of useful data.

As our understanding of environmental management evolves, different themes emerge as priorities for further research. We highlight three areas that are likely to be of particular importance based on information presented at the conference. The first area concerns the role of finance and financial institutions in the greening of industry. White (1996) provides an overview of some of the direct ways in which finance is involved in greening, including green investing, green mutual funds and eco-banking. White also discusses the growing interest in hazard risk assessment by insurance companies. Beyond particular financial instruments, the character of the financial system itself requires analysis. One feature of finance that distinguishes it from manufacturing and other industrial sectors is the fluidity and mobility of capital. To what extent do these characteristics work in favour or against greening and the sustainability transition? More generally, is finance
capital likely to be a leader or a laggard relative to greening and sustaining?

A second area of interest is supply chain management and the role that manufacturer–supplier relations might have in environmental management. Green et al. (1996) argue that green supply, and especially supply chain management, are likely to be a greater force than green consumerism in improving the environmental performance of industry. Analysis of supply chains from an environmental perspective is a complex task. Thus Bouman et al. (1995) note 'environmental actions taken by single elements of a supply chain – or even by one organization and its suppliers – can be environmentally suboptimal'. These workers argue that in the long term internalization of environmental costs will probably lead to the development of integrated management of supply chains. In the short and medium term, an important role is identified for government in promoting supply chain management through the provision of information, as a participant in supply chains, and as a regulator.

The final area of research regarding environmental management that we would highlight is the growing interest in environmental indicators. Several papers presented at the conference dealt with the development of a robust set of indicators of environmental management and performance. Bartolomeo (1995) provides a general introduction to the issue of environmental indicators, reviewing the range of performance, process and system features that might be measured. Of particular interest are indicators of the movement towards sustainability. In this regard, Rennings and Wiggering (1995) distinguish between indicators of weak and strong sustainability. Measures of weak sustainability are generally based on neo-classical economic theory and assume that manufactured capital (e.g. income) and natural capital (e.g. environmental deterioration) are close substitutes. A second approach, premised on a concept of strong sustainability, measures the growth/decline of natural capital directly, rejecting the appropriateness of substitution. There is as yet little agreement as to what an operational measure of strong sustainability might involve.

GREENING OF INDUSTRY ON AN INTERNATIONAL SCALE

The adoption of environmental management systems by firms outside North America and Europe, and more generally the greening of industry on an international scale, are slow and highly fragmented processes. There are, however, examples of success, although serious structural obstacles remain to be addressed. In addition, experience in implementing environmental management systems outside North America and Europe (e.g. in East Asia) remains poorly documented.

Saeed (1995) provides a good case study of the incorporation of environmental concerns and environmental management strategies by firms in developing economies. The focus of the case study is the planning process for the port of Qasim in Pakistan. The municipality of Qasim in 1992 carried out an environmental audit of the port facility, focusing on water pollution attendant on oil transfer and industrial activities. The port was the first government agency in Pakistan to conduct such an audit. Despite the success of the audit, Saeed raises numerous concerns about the ongoing implementation of the plan.

Policy-makers promoting the application of environmental management strategies in developing countries face a multitude of challenges. For example, the level of compliance with environmental laws is often very poor. Many of these difficulties are highlighted in the case study of pollution prevention activities in the city of Amritsar in India reported by Cheema and Sidhu (1995). In this instance, compliance is undermined by the large numbers of small firms and factories that make up the industrial base of the region and by the limited resources available to the government to implement environmental laws. Cheema and Sidhu's analysis highlights the difficulty of pursuing a primarily statutory approach to environmental management in India. In the absence of a civic infrastructure and sufficient resources for monitoring environmental performance (e.g. through environmental pressure groups and other constituencies), the enforcement of laws is weak.

Cebon and Sastry (1995) provide further insight into the challenges facing the greening of industry in India. This case study is interesting in that it focuses on an example of policy failure, namely, the collapse of an energy conservation programme in Bombay. The case involves an international partnership to increase the use of energy efficient lighting in Bombay. Cebon and Sastry argue that the programme failed because of the limited range of choice of partners available in India (exchange thickness) and the limited choice in institutional options available to the programme (institutional thickness).

It is widely acknowledged that the pace of industrial growth in many developing countries makes the greening of industry a particular priority. In the absence of greener manufacturing, the impacts of industrial growth on air and water pollution, energy consumption and attendant
greenhouse gas emissions will be dramatic, potentially offsetting gains achieved in North America and Europe. Several researchers at the conference chose, however, to treat the anticipated growth of newly industrializing economies as an opportunity for, rather than an obstacle to, greening. In general terms this argument is based on the opportunity to shape industrial development from the 'bottom up'.

Wallace (1995) sees in newly industrializing economies the opportunity to harness industrialization as an agent of greening and possibly of sustainability. His research stresses that it is the responsibility of multinational corporations to build environmental concerns into their foreign direct investment projects in developing countries. Because such a high proportion of the infrastructure and industrial capital of newly industrializing economies has yet to be built, there exists the opportunity to build in, rather than retrofit, best available technologies.

Trends in environmental performance in newly industrializing economies cast doubt, however, on such optimistic scenarios. Experience suggests that developing countries tend to adopt mature technologies rather than the more costly best available technologies promoted in advanced industrial economies. The typical pattern is that described in Lee’s (1995) paper on environmental policy and industry in South Korea. In this country, the environment emerged as a key issue for industry only in the late 1980s, i.e. only after the major phase of rapid industrialization had taken place. In general terms, environmental policy and regulation in South Korea is still focused on ‘command and control’ approaches and suffers from the many weaknesses identified in Europe and North America a decade or more ago, such as the lack of enforcement attention for small and medium-sized firms.

One area of environmental management in which progress is being made is in the adoption of ISO 14,000 and other international standards. Most of the major South Korean multinationals are now participating in these initiatives. Researchers have long argued that international standards, even of a modest level, are an important vehicle for diffusing environmental management systems. As ISO 14,000 and other programmes establish procedural rather than performance standards, questions have been raised as to the actual impact on environmental performance.

As policy-makers seek to promote the greening of industry on an international scale, it is vital that we understand the extent to which international agencies can be influential in facilitating and promoting the process. Norberg-Bohm (1995) provides an insight into this issue through an analysis of the relative significance of domestic and international interests in determining the path of technology change in the Mexican electric power sector. Norberg-Bohm concludes that, although international efforts can sometimes be directly influential – for example, by structuring trade agreements to favour environmentally sound technologies – another useful strategy is to use development aid to strengthen the political capital of domestic actors who favour green technologies, i.e. to act indirectly through domestic interests.

FIRMS, INDUSTRIES AND SUSTAINABILITY

What will be the contribution of firms and industries to the sustainability transition? Firms are clearly the key agents in environmental management and in the greening of industry. But are the needs of the sustainability transition such that firms will be able to transform themselves in ways that allow an effective response to the challenge?

Attempts to address these questions typically begin by distinguishing between environmental management and management for sustainability. Clarke (1995) sums up the difference as follows:

Conventionally, environmental management appears to refer to all those policies and practices, largely within a utilitarian ethical frame of reference, which direct an organization’s activities towards product stewardship, bring economic values into economic analysis and allow for new relationships across the supply chain. Management for sustainability, however, reflects policies and practices, underpinned by principles of justice, respect, equity, stewardship, precaution and futurity, which fundamentally question and reshape environmental, social, economic and political relationships and which enable the equitable redistribution of wealth and opportunity within and between generations and societies.

The implication is that management for sustainability requires the incorporation of additional values and interests beyond those historically recognized by firms and industries.

Roome (1995) argues that a commitment to sustainability does not mean that economic decisions and profit seeking are to be rejected, but it does require that other values such as justice and futurity enter into the management process (for an alternative view, see Welford, 1995). From the
perspective of industry, the principal challenge is to find ways that firms can leverage their existing economic interests in support of sustainability. This perspective is illustrated by comments made at the conference by John Brady of the Northumbrian Water Group.

Brady provides the following operational definition of sustainability for firms: 'Within legal, customer and other stakeholder boundaries, an environmentally sustainable policy would mean year on year reductions in resource consumption, wastes and emissions. In essence this approach calls for a dematerialization of a business's activities'. He then goes on to say, however: 'Sustainability needs to be reformed to deliver tangible benefits, preferably measured in pound notes (or dollars) for it to find suitable points of entry into businesses'. Although some may dispute the feasibility of accommodating these different values – profits, justice, equity and futurity – it is clear that one of the key challenges ahead is to harness the capacities of firms and industries towards the goal of sustainability.

The ambiguity and uncertainty concerning the role of firms in sustainability is also manifest in a continuing debate over the potential for an incremental, step by step approach to the sustainability transition. Is environmental management, for example, a precursor and foundation for sustainable management, or does sustainable management require a radical break with existing management systems and forms of economic decision-making? Jorgensen and Remmen (1995) use case studies of Danish industry to argue that the answer to this question depends on whether or not firms are able to create and sustain an internal ethic and dynamic of continuous environmental improvement. Hoffman and Ehrenfeld (1995) suggest, by contrast, that a revolutionary shift in management paradigms will be required. These workers argue that progress to date in corporate environmentalism has been largely evolutionary; it has not included a transformative shift in ethics and values and will not be sufficient to meet the challenge of sustainability.

Belz and Schneidewind (1995) suggest that one of the steps firms engaged with the sustainability transition must take is to go beyond a decision-frame based primarily on efficiency to a consideration of issues of need. On one level this involves the trade-off between 'efficiency' and 'sufficiency'. It also involves building into management systems not just a consideration of the best way to make a particular product, but how to meet a particular need in an environmentally benign way.

Nowhere are both the obstacles and the opportunities for firms to contribute to the sustainability transition clearer than in the domain of technology development. Although issues of population and consumption also need to be addressed, most researchers agree that the development and widespread adoption of greener technologies, such as renewable energy and biodegradable materials, will be central to the world's ability to meet environmental, economic and other goals. Clarke (1995) explores the extent to which firms have begun to consider the management of technology in the sustainability transition. Among the sample of businesses studied in the UK and Canada, she finds no clearly articulated vision of what the concept and practice of sustainable technology management might entail. The research stresses instead the degree to which firms experience a process of lock-in, or path dependency, both as a strictly technological phenomenon and also as a socio-cultural phenomenon. This theme of path dependency also emerges in a case study of technological change in the zinc production industry by Moors et al. (1995). In this industry, R&D is currently focused on the near term and on incremental innovation. Inter-firm and international co-operation are seen as central to supporting longer term technological innovation.

CONCLUSIONS

Participants came to the 1995 Greening of Industry Network conference with a variety of goals, interests and experiences. Many in industry sought to provide and to receive information on best practice environmental management tools and strategies, including life cycle analysis, supply chain management and green accounting. One contribution of the conference and of the Network is to serve as a kind of clearing house for information. The number of venues for such information exchange are now increasing rapidly in the form of trade shows, management seminars and the like, many of which operate on a far larger scale than that of the Greening of Industry Network Conference. It is important in this regard to highlight the distinctive features of the conference, namely, the range of participants – from industry, government, academia and elsewhere – and the modest size of the event that allows a higher level of engagement among the participants. These characteristics are likely to be of particular importance as the discussion shifts from topics of environmental management to questions of sustainability. If progress is to be made on the issue of industrial growth and sustainability, space must be created for firms to take risks and explore possibilities outside the normal, highly constrained, scope of business decisions. Thus a second contribution of the conference is to build up
the stock of social capital among network participants, facilitating greater experimentation on the part of firms, in co-operation with academic researchers and policy-makers.

We share a sense that the growing confidence expressed by industry at the 1995 conference within the domain of environmental management creates an opportunity to move forward more rapidly on issues of sustainability. The general agenda of priority issues has been well summarized elsewhere (see, for example, Fischer and Schot, 1993; Clarke and Georg, 1995). We suggest here instead three areas in which network participants and others might explore further the role of firms in the transition to sustainability.

Life Cycle Analysis

It is widely agreed that life cycle analysis is one of the most useful management tools available for promoting broader considerations of environmental performance. And yet as Berkhout (1996) suggests, the systematic application of life cycle analysis in business decisions is still in its infancy. Berkhout provides an overview of existing applications of life cycle analysis in manufacturing industries. Some of the provocative results that often emerge from the use of this technique are illustrated by the analysis of Gabel et al. (1996) of the pulp and paper industry. Here they conclude, for example, that the current public policy emphasis on recycling may be short-sighted if it undermines R&D investment towards longer term alternatives: 'If this investment is discouraged, the continual short run advantage of recycling will be a self-fulfilling prophecy'.

There is clearly a general need for the more extensive use of life cycle analysis and a broader dissemination of the results of these studies. One of the major opportunities today, however, is for industry and policy-makers to add value to life cycle analysis by examining the institutional constraints to pursuing different options. Much of the current work on life cycle analysis tends to an under-socialized understanding of the challenge of the sustainability transition. This point is emphasized by Groenewegen (1995), who warns against the biologism inherent in concepts such as industrial metabolism and life cycle analysis (see also Ayres and Simonis, 1994). It is unclear whether the optimum path from the materials/technology perspective (identified by life cycle analysis) will coincide with strategies that are optimum from an institutional perspective. Joint optimization may favour a third alternative technology strategy.

Regional Industrial Ecologies

One of the exciting lines of analysis in sustainability research today is the development of regional industrial ecologies, i.e. the analysis of the capacity of response at the local and regional level to the challenge of sustainability. Related to concepts of bioregionalism, regional industrial ecologies explore opportunities for reconfiguring industrial environmental systems at the local level. Heller and Nelson (1995) discuss a pilot project in northeastern New Jersey that entails a detailed inventory of environmental/economic conditions within the region and promotes bottom-up solutions to environmental problems through co-operative consensus building among firms, environmental groups and other constituencies. Another example of such a regional industrial ecology is the ECOPROFIT programme in Graz, Austria, which is described by Grabher and Schnitzer (1995). In this case, the regional government has become extensively involved in promoting training and education in environmental management. An important aspect of the Austrian programme is the search for intra-regional linkages that reduce environmental load. As discussed by Wallner and Fresner (1999), these linkages vary from a focus on technology to information exchange and add up to a multi-layered regional network. Industry working in partnership with local environmental groups and regulators represents the leading edge of a new emergent paradigm of environmental policy. These partnerships are thus a key priority for firms and policy-makers interested in additional pathways to sustainability.

Technology Assessments

The last area we would highlight is technology assessment. We use this term to refer to the process by which industry and public policy-makers assess technology options for the future. We believe that of the range of capacities of firms and industries that might be harnessed towards the goal of sustainability, it is the domain of technology development that is most likely to yield positive results in the short and medium term. As discussed earlier, the problems to be overcome here are the tendency towards technological and organizational lock-in.

Various approaches have been developed to address problems of path dependency and the tendency to short-term analysis in technology development, including constructive technology assessment and back casting (Rip et al., 1995). Vergragt and Noort (1996) illustrate the use of these concepts in exploring possible pathways towards the construction of a ship fuelled by
hydrogen using a polymer fuel cell. Other possibilities include 'technology mapping', a process in which a wide range of constituencies examines the technology selection process and attempts to (re)-open technology pathways that are not recognized or are prematurely closed.

Summary

Based on ideas and information presented at the 1995 Greening of Industry Conference, we believe that a window of opportunity is now opening that will allow creative new dialogue and experimentation around the role of industry in the sustainability transition. The aggressive promotion of bold experimentation must be a high priority for the Network. There are clearly costs and risks to firms engaged in backcasting, life cycle assessment and other first steps in management for sustainability. These obstacles can be alleviated through innovative new partnerships among firms, policy-makers and the research community.

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