Policies and Conditions for Environmental Innovation and Management in Industry

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1. Introduction

This paper draws freely on ideas developed through the work of an expert group established by DG Research of the European Commission.[1] The group met in 2000 through to April 2001 with the task to examine research, technology development and innovation for a competitive and sustainable European production system. It sought to advise the EC on appropriate policies and actions for the period to 2020. It therefore specifically addressed future policies and conditions for environmental innovation and management in industry.

The aim, then, of this paper is to discuss policies and conditions for environmental innovation and management in industry. This is a critical issue. Industry harnesses technological innovations to provide artefacts or new materials in their products and services. Through this process industry generates wealth and contributes to the satisfaction of human needs but also adds significantly to environmental degradation. For example, to illustrate the scale of the direct environmental impacts of European industry. Industry contributed 26% of European N_2O releases and 23% of the green house gas, whilst manufacturing generated 26% of the waste produced by EU Member States (Environment in the European Union at the Turn of the Century: European Environmental Agency 1999: European Environment Agency; Copenhagen). While this gives a broad indication of the scale of industry's environmental impact it should be noted that these figures only represent the effects of industrial and manufacturing activity at production sites. The figures do not include the environmental impacts arising from the extraction of resources used by industry or the impacts and wastes associate with products in, or after, use.

European industry is then a significant actor in environmental degradation. Improving these environmental impacts, while remaining competitive, involves innovation. Only in this way can Europe move progressively toward more sustainable forms of development. The transformation required will involve industry to engage in change, with a mix of other societal actors, including the public sector and public policy makers. In particular, public policies are needed to support innovation and provide the conditions within which transformation, to a sustainable

[1] Although I will draw on the EG's work you should be aware that the comments in this paper are my own. I do not speak for the members of the expert group nor for that matter do I speak on behalf of the EC or DG12.

industrial economy, becomes possible. Not only do we need public policies that focus on industry by supporting and spurring innovation, these policies, and the structure developed for their implementation, can be viewed as a form of (social) innovation in their own right.

This paper explores critical issues about .what is implied by the need for innovation in public policy and industry. First, I want to devote part of the paper to addressing some of the key terms used in the title of the paper, in particular, the core notions of environmental innovation and environmental management. Frequently, these terms are used without recognising the wide variety of interpretations they can have. These introductory comments are then used to develop a conceptual model of the transition from innovation in environmental compliance driven industry to innovation in more sustainable forms of enterprise. This will be used as background to the work of the expert group. It leads into the second section of the paper where the main outcomes of the Expert Group's work are outlined. The final section sets out for discussion some key points that need to be addressed as we establish policies and conditions for environmental innovation and management by industry.

2. Definitions

Environmental innovation can take many forms. In an industrial context the notion of innovation is associated with purposeful, or designed change. These changes range in scope from modifications to production processes and technologies through new products/services and the technologies on which they are founded, to innovation in complex socio-technical systems. Examples of innovations in production processes include the move away from the use of CFCs in the manufacture of electronic components. Innovations leading to new products include the introduction of catalytic converters, or the advent of hybrid engines in automobiles. An example of innovation in complex socio-technical systems includes reconsideration of ways to meet societies' needs for mobility.

One of the key factors that underscores this hierarchy of innovations is the complexity of the issues and the number of actors who must engage in concerted change as the scope and boundary of the system addressed through innovation is expanded. For example, the introduction of CFC-free electronic components requires the identification of substitute cleaning agents and inevitably leads to changes in manufacturing processes. However, the consumer is left largely untouched by these innovations unless product functionality or price is affected. The introduction of catalytic converters, on the other hand, involves change to lead free fuels as well as the redesign of internal combustion engines, especially the development of hardened valves and valve seats, which no longer benefit from the protective effects of lead additives in fuel. This type of change means that automobile manufacturers and gasoline producers must collaborate, although they may have very different interests in existing and future combinations of technologies. However, this form of innovation has also obliged automobile users to adopt new habits and routines, buying lead free fuel and accepting the loss of power or higher fuel consumption that might follow from catalytic converters.

The purposeful redesign of mobility systems is even more complex. The overall architecture of the existing mobility system, with its vested interests and technological and social rigidities, has to be addressed. This involves many actors: producers and consumers; automobile and traffic engineers; town planners and many others.

Moving up the innovation hierarchy increases in the complexity of the issues, the number of actors involved in change, and the number of linked, multiple technological and social options, the innovations and new practices that need to be undertaken and the uncertainties that have to be considered.

Given the serious overuse of materials and resources arising as a result of our developed industrial life-styles and population pressures, the innovations demanded by any transition to sustainable development are likely to be at the more complex end of the hierarchy.

How does this relate to the issue of environmental innovation? This term has many meanings. A key issue is what makes an innovation environmental, rather than just an innovation? It is not simply that the drivers for change arises from the environment department of a company or an environmental ministry. I contend that a better perspective on what defines and innovation as environmental arises from the tautological, yet profound, idea that all innovations that involve resources, materials or social practices, which impact the quality or quantity of resource endowments or natural systems, are environmental. This perspective is profound because it means that virtually every economic actor - consumer, industry or service provider - is involved in 'environmental' innovation. Put another way, all industries that combine human ingenuity with materials and resources to produce products and services are engaged in the process of environmental innovation. Consequently there are no industries that can say they are not environmental industries.

Environmental innovations are also characterised by the demands that arise from the systemic nature of environmental impacts and the changes that result form those impacts. This implies that a necessary prerequisite for (environmental) innovation is the gathering of information about the systemic impacts of the innovation. However, gathering information tells us little about whether an innovation should be judged as good or bad. Indeed, the dualism between good and bad is not helpful because most innovations have distributed effects. That is innovations produce a range of effects, some regarded as good and others as bad. Moreover the distribution of these effects changes over time and space, from local to global. We know this from most studies aimed at determining the life-cycle impacts of new products.

Whether an innovation is, on balance, good or bad from an environmental point of view can be tested at two extremes. At one extreme is the question of whether, on balance, an innovation has more or less severe environmental impacts than the product or social activity it is designed to replace? Does product A have a better or worse environmental profile than product B? This is viewed as a weak test because it is only concerned to compare the environmental profile of a new product against an existing product. This weak test still involves a complex evaluation of the effects provoked by products in natural and resource systems. It also involves an assessment of whether the impacts, individually and in aggregate, are judged to be good or bad. There are many ways to form this assessment, from expert opinion to multi-criteria scoring systems or stakeholder consultation exercises.

A much more demanding test, however, is whether an innovation results in activities that can be conducted within the 'carrying capacity' of the environment - local, national, regional and global. This is more demanding because it requires an evaluation and assessment of the impact of the innovation in relation to the processes and sinks provided by environmental systems. This implies a sound working knowledge of the dynamics and fluxes of environmental systems together with an evaluation of how innovations affect the 'carrying-capacity' of those systems, at different spatial levels and over time.

Comparing these two tests helps to distinguish between environmental innovations, which on balance lead to less damage to environmental systems, from those that maintain or improve carrying-capacity. In my experience most innovations to date have been guided by the less demanding of these tests: do they cause less damage than the practices they replace? In this way innovations lead to environmental improvements or, what might more appropriately be seen as, reduced levels of environmental damage. I would contend that we have little way of knowing whether innovations of this kind are environmentally sustainable, without applying the carrying-capacity test.

Environmental management in industry can be characterised in a similar way. At it simplest environmental management involves the application of a (relatively) structured environmental information system to provide the basis for understanding and making decisions about the environmental consequences of industrial practices. At the next level this structured system may be used to make decisions about priorities for reducing environmental impacts. Often this involves attempts to integrate environmental assessment and choice with existing, conventional business processes – investment analyses, policies and mission statements and so on. We can, for example, distinguish between pollution control as an innovation where it is important to know the costs of control as well as the environmental returns from more advanced notion of pollution prevention. In pollution prevention integration has come to mean seeking out innovative designs that simultaneously reduce costs and/or improve productivity, and, lead to environmental improvements.

In its most extreme form environmental management can be directed toward environmental sustainability. True environmental sustainability implies that only choices and innovations that operate within the carrying-capacity of environmental processes and systems can be viewed as feasible (sustainable) options. Environmental management based on this concept of carrying-capacity is regarded in this paper as 'strong' environmental sustainability, whereas, environmental management based simply on improving environmental impacts is a 'weaker' notion. At best, this weaker notion only leads in the direction of environmental sustainability. It is acknowledged that sustainability also has an important social dimension but for the purposes of this paper the discussion will be restricted to the environmental aspects of sustainability.

The idea of an innovation hierarchy and the differences between environmental management and sustainability can be used to develop a simple conceptual model of the transition that takes place in industry as it moves from environmental compliance to sustainable forms of enterprise. This is shown as figure 1. The figure is based of the relationship between four variables. The complexity of innovation, the scope of change, the strength of environmental management, and the set of actors actively involved in design for innovation.

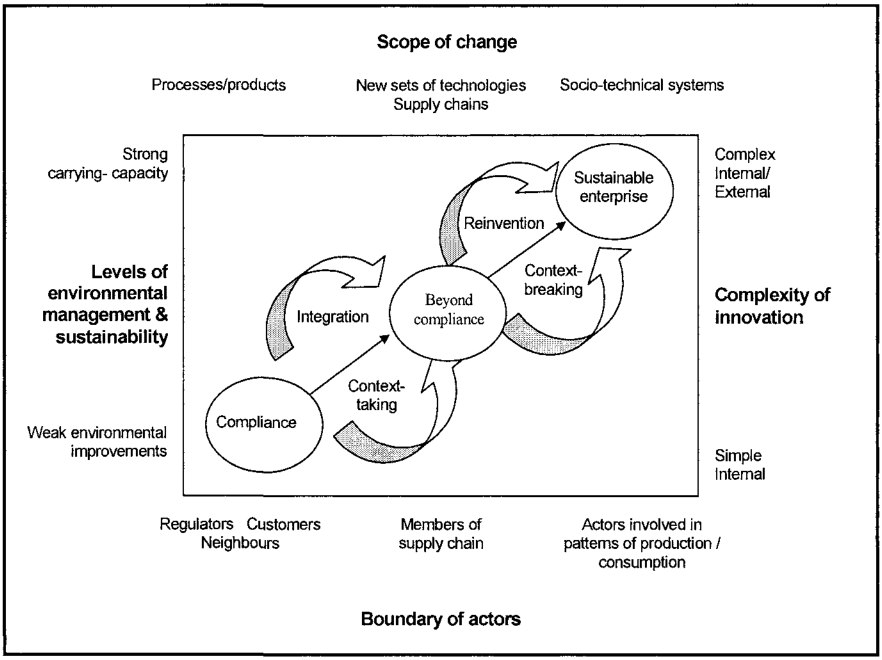

Fig. 1. Framework

The model suggests that in compliance-driven companies the scope of change is dominated by incremental improvements to processes and products, there are relatively weak environmental management systems in place and the main actors of concern to industry are regulators, customers and neighbours. The innovation process is mainly driven internally and is relatively simple. Sustainable enterprise, by contrast, has a scope of change that is based more on reformulating socio-technical systems. Here environmental management is very strong and highly connected with business processes, including the overall business strategy. The actors involved are those who shape and influence patterns of consumption as well as production in socio-technical systems. The innovation process is consequently relatively complex and involves linking actors internal and external to an industry in concerted change.

The model suggests that the transition from compliance to beyond compliance is centred on internal integration of environmental and business processes while accepting the context provided by markets. The bridges that contribute to the process of integration include notions such as quality, organisational learning, pollution prevention or full cost accounting. The transition from beyond-compliance to sustainability is centred on notions of reinventing the company, together with its relationships with others in the socio-technical systems in which its products/services are embedded. As a result innovative product offered by industry are a part of larger scale, context-breaking change. It is suggested that the bridge to this type of innovation is found in processes that involve industry in collaborative problem-finding and the identification and implementation of solutions involving technological and social change. This represents a form of organisational and social learning based on continuously reforming collaborative structures.

If the transition to environmentally sustainable industry is to be accomplished in the long term it will involve a shift from innovation built on internally integrated technological change to innovations based on integrated arenas for innovation. These involve highly collaborative, multi-actor processes, where industry is one of the key actors.

With this model in mind we can now turn to the main conclusions of the expert group.

3. Outcomes of the Work of the Expert Group on Policies and Actions for Sustainable and Competitive European Production Systems

Through its work the expert group developed a vision of a European system of industrial production which would guide more environmentally sustainable innovations for the prospective period to 2020. In this vision:

Human ingenuity (knowledge and technology), capital, resources and needs are harnessed and governed so people can live better lives while consuming less material resources and energy. This system is sustainable when production and consumption support the quality of individual and social life, in ways that are economically successful while respecting environmental limits within the changing context of local-global conditions.

The key condition to the realisation of this vision is a more integrated view of the arena of innovation, with a focus on sufficiency. The thinking that guided this orientation, fits with the notion that, innovations have to be designed by actors who know a specific production system. The report's central argument is that this orientation is the necessary pre-requisite for new policies, actions and practices customised to the needs of different systems.

A more integrated arena for innovation sees production and consumption as key parts of an overall socio-technical system. Socio-technical systems include technologies, products and materials 'in use' and human systems. Examples of socio-technical systems are information and communication, mobility, or household services, such as clean clothes or nutrition. Innovations arise in these arenas through purposeful processes of change that engage many actors (producers, consumers and others). An integrated arena requires other conditions. It brings together economic, environmental, social and scientific concerns. It requires solutions tailored to specific socio-technical systems and localities under the influence of national, European and global pressures. A particular issue that affects all such arenas is the way globalisation creates new axes for the governance of technological and social innovations. This means future innovation must be governed in ways that are responsive to global competitiveness and innovation, environmental concerns and social needs, while harmonising public policies and business strategies through collaboration and joint action. This is not easy. It runs counter to most existing policies and practices for RTD&I. It has implications for the orientation of environmental and industrial policies as well as industrial practice.

This outlook builds on a number of trends in manufacturing and adopts some known and simple principles. For example, production is becoming progressively more resource efficient, there is an increasing number of examples of closed-loop production on which to draw, and manufacturers are increasingly addressing consumers' needs for product performance. There is also a strong link between the development of knowledge and innovation, as the foundation for competitiveness, and, the achievement of environmental and social sustainability. This link is provided by ideas about learning organisations and multi-actor (social) learning platforms. These emphasise collaborative processes for developing visions, systems thinking, problem finding and problem solving, and resolving barriers to change and joint action.

The innovations arising out of this process are either context-taking or context-breaking and fit within one of two archetypes – efficiency and sufficiency. Efficiency is a linear concept seeking lower inputs for a given activity. Sufficiency is concerned with the search for, and implementation of, new ways to meet human needs. Sufficiency addresses the services required to meet needs and the performance of material products. Illustrations of sufficiency are selling flooring services not carpets, providing photocopied documents rather than photocopiers, or selling clean clothes rather than washing machines. In sufficiency solutions manufacturers retain ownership of the material in physical products and sell the service performance of those products to customers.

There are a limited but growing number of innovations that illustrate the sufficiency archetype. Implementing these innovations is beset with institutional, organisational and managerial obstacles. Some obstacles are generic others are specific to individual innovations and socio-technical systems. Development and implementation of sufficiency solutions requires these obstacles to be overcome as part of the innovation process.

A number of obstacles to sufficiency and, especially to the collaborative processes on which organisational and social learning for sufficiency is based, were identified. In a European context these include the many different management styles and cultures. Similarly collaborative processes are affected by different cultural and linguistic conditions. These differences should not be overcome by reducing the diversity of the European system, as diversity is a potential source of innovation. Rather, what is required is the move toward a more overarching level of management, which is self-reflective and knowledgeable about the contributions and values of different management styles and cultures.

There are structural problems due to lack of coherence and the perverse incentives in the overall mix of policies. For example taxes, subsidies, capital write-offs, and trade agreements are often contradictory and do not support economic and environmental efficiency let alone sufficiency.

At the institutional level there is weak participation by the private sector in public policy making and weak collaboration between private and non-governmental interests. This is associated with relatively low levels of co-operation and collaboration in research and innovation and an absence of initiatives that bring together potential partners across sectors and interests. In particular consumer groups and other actors outside of business and the public sectors have difficulties to engage effectively in learning and innovation programs. And when these do arise there are poor mechanisms to diffuse good practice in learning and knowledge development.

While at the organisational level there is risk aversion in committing resources and forging new organisational collaborations around innovations together with a low disposition of organisations to support life-long learning at all levels of enterprises.

At the level of individual managers there are shortages of capabilities in systemic thinking and systems integration. And, a scarcity of facilitation skills and the skills to support multi-actor, multi-disciplinary, multi-functional, multi-sectoral processes.

These deficiencies are underscored by the continuing confusion between environmental management and sustainable development.

Accelerating the shift toward conditions that foster sufficiency requires broader, more flexible, policy instruments than are provided by the present support for collaborative R&D projects. For example the group took the view that new conditions were needed. These included ideas such as: 100% funding of search exercises for key socio-technical systems to enable the generation of ideas about, and commitments to, sufficiency solutions through the moderation of material consumption and sustainable product service offerings. It is possible to envision funding support for the remodelling of R&D infrastructure and the innovation system so that it better reflects the new demands for knowledge, the new context for interaction with industry and the requirements for new skills and competencies.

An important new element of the innovation infrastructure would be the establishment of international competence networks as a basis for research and the dissemination of research results. These networks should be set up for a period of 5-10 years (maximum), equipped with a (relatively) stable budget and working to a remit that emphasises communications. These competence networks should form nodes in a broad Europe-wide communications and co-operation network.

In the same way RTD&I policy administration could be restructured better to reflect the participative processes that are being encouraged for RTD&I. What this means is that policy administration should be multi-disciplinary and participative, experimental and possibly open to continuous interaction with EU experts and supported RTD&I partnerships. This might involve experimentation with continuous process evaluation and mid-term corrections in projects.

In response to the deficiencies of the present system of RTD&I and the obstacles to sufficiency in Europe the expert group went on to advocate a 'design framework for innovation'. This would be based around six concurrent processes. These were:

1. Generating ideas for innovative approaches to sufficiency strategies for selected socio-technical systems.
2. Improving understanding of Socio-Technical Systems.
3. Resolving the barriers to change and establishing the feasibility of new solutions.
4. Supporting the development and adoption of enabling technologies.
5. Engaging a variety of relevant actors to participate in the process of organisational and social learning and change.
6. Demonstrating and disseminating these processes and their outcomes to others.

Each element is the overall process is discussed in more detail below.

Generating ideas for innovative approaches to sufficiency strategies for selected socio-technical systems would involve mechanisms such as 'foresight forums'. These would bring together societal groups to generate new ideas and learn about the expectations of any set of relevant actors for competitiveness within the framework of sustainability in relation to specific socio-technical systems.

Developing approaches that go beyond marginal improvements involves maximum encouragement for maverick, or wild card, approaches to RTD&I through a continuously open call within the theme Competitive and Sustainable Development. This to be matched by specific funds designated for innovations, which have merit but do not meet traditional criteria.

Improving understanding of socio-technical systems could be brought about through the development of participative forums that establish the key actors involved in specific socio-technical systems, and, identify and map the specific characteristics of those systems together with each actors' needs and interests. This would establish the basis for inputs and contributions by these actors to collaborative action.

Resolving the barriers to change and establishing the feasibility of new solutions means addressing knowledge transfer problems and organisational barriers for companies, which want to adopt competitive strategies for sufficiency. It also means devising appropriate cost-accounting and financial control mechanisms that reflect the true economics of material recovery and material assets held in product-related service performance systems. This would need to be supported by schemes that seek to develop competence in designing for service-performance rather than in producing products so workers can become service providers. The support of inter-firm co-operation using information technology & knowledge management and logistics, especially on reverse supply chains and take-back schemes. Establishing and resolving the barriers that arise from the demand for venture capital oriented toward competitive sustainable development projects. And, finally, identifying a policy mix that supports sufficiency in specific socio-technical systems.

Supporting the development and adoption of enabling technologies places an emphasis on basic science and research in technologies, which allow decentralisation of production systems. This highlights areas that include information and communication technologies, biotechnology and micro and nano-technologies. These represent important enabling technologies in the areas of dematerialization and resource productivity.

Engaging a variety of relevant actors to participate in the process of organisational and social learning and change would have to incorporate societal and environmental actors together with management of business in the programme committees of the Framework Programme. It would oblige a broadening of the knowledge base on sustainability innovation mechanisms in manufacturing practice, together with socio-economic research on sustainability management and innovation management within competitive frameworks. It might benefit from the introduction of a voucher system for societal groups, which would allow them – if collaborating – to give research grants.

These processes would need to be able to draw on improved professional support and function effectively. This could include the development of the contribution of socio-economic experts as a support input/vision to RTD&I on social needs. Training participants in effective multi-actor procedures and the facilitation of processes.

Demonstrating and disseminating these processes and their outcomes to others places a need on the assessment and development of a policy-mix that encompasses legislation and taxation allowing technical alternatives (through R&D for technology) to be examined in advance of drafting directives. It could harness R&D in the hard sciences in support of areas of public sector spending where the objective is the promotion of competitive and sustainable solutions.

It would benefit from action research that was able to demonstration of the principles that underpin future production systems demonstrate participation in action. Ideas that would enhance this approach include multi-actor Implementation Forums for RTD&I and sustainability combined with competitiveness at levels appropriate to specific socio-technical systems. Database and resource guide on good practices in SMEs involved in competitive approaches to sufficiency. This would be especially valuable for companies not in existing networks. Finally the group saw scope for socio-economic shadowing of the process of mainstream RTD&I research with monitoring in real time, with the express objective of presenting challenges, learning and disseminating rather than evaluation policy implementation.

This design framework should be guided by principles such as – lightness, flexibility, durability, adaptability, and closed material loops. The framework involves processes based on collaboration for mutual learning and action. Together these principles and processes provide the elements of a 'design guide for sufficiency'.

4. Conclusions

This final section draws out some key points that need to be addressed if we are to establish policies and conditions for innovation by industry that improves competitiveness within the framework of sustainability.

The most important points to emerge from the paper are that the conditions for environmentally sustainable innovations can not be defined in terms of a set of hard parameters. Rather conditions are seen more in terms of principles that circumscribe the innovation process and provide guidance on the boundaries to that process. These principles are seen as recursive. That is, the same principles apply to the interactions between all actors engaged in environmental innovation as a form of organisational and social learning, whatever their level in an organisation.

Three particular principles are identified to illustrate this point. These concern open-ended learning, multi-actor processes and flexibility.

In the case of open-ended learning the argument of the expert group is that innovation directed to problem-solving is not really appropriate for environmentally sustainable innovation given the present need to address fundamental flaws in the (un)sustainability of existing socio-technical systems. The current approach to incremental forms of environmental improvement is based on problem-solving that takes the existing system as a given. Technological bottle-necks are viewed as problems, which actors then set about resolving mainly through technological solutions.

In contrast what is proposed by the expert group is not problem solving but a more open, problem-finding approach. In this approach overall socio-technical systems are addressed. More environmentally sustainable socio-technical systems are envisioned through multi-actor processes. Agreed visions of future, more sustainable, socio-technical system are developed. Only then is it possible to establish the barriers and problems that need to be resolved in moving toward that vision, given present reality. This approach posses real issues for public policy because it demands faith in the success of an open-ended process that begins without concrete and measurable targets.

For example problem-solving may begin with a target such as the reduction in automobile carbon emissions through the introduction of an efficient catalytic converter. Success against this target can be assessed by various hard measures. Problem-finding requires support for a process, the outcomes of which are not clear at the beginning of the process. Indeed, the moment policy makers, or other actors, seek to define desired, hard outcomes, the more the process of problem-finding is circumscribed and tends to become less open to bringing about the breakthroughs that are needed.

In the case of problem-finding, targets and outcomes are 'soft'. They demand the adoption of processes (for example multi-actor search processes) where hard outcomes are defined through the process itself. In terms of public policy this may mean the continuous interaction between policy-makers and the other actors immediately involved in the innovation processes, which have been stimulated by public policy. Open-ended processes also imply the possibility of a series of iterative mid-course adjustments as the process unfolds and as the process shifts from envisioning the future to taking concrete steps to make that desired future a reality.

Secondly, if environmentally sustainable innovation is a multi-actor, multi-disciplinary, multi-sector, multi-functional process, then the principle of problem finding applies not only to the platforms used to identify the needs innovation must address, the same conditions apply to the administration of the policy process in support of those innovations. For example, if the aim of public policy is to foster multi-actor, multi-disciplinary collaborative innovation then the administrative mechanism used to review and assess proposals for public support must also have a multi-actor, multi-disciplinary character. This means that the administrative structure by which public funds are allocated should employ multi-disciplinary teams or individuals in proposal evaluation. Yet these teams are hard to manage and individuals with multi-disciplinary skills are hard to find. The development of multi-disciplinary skills, and skills in the facilitation of multi-disciplinary processes, runs counter to our existing system for education and research, which provides for the development of policy makers and industry practitioners engaged in innovation.

The third important consideration is that environmental sustainability is defined in relation to the specific demands of a socio-technical system and the local conditions under which those systems operate. At the same time these socio-technical systems innovations develop in the context of global and regional pressures. These two sources of influence – global/regional, on the one hand, and local demands, on the other can prove paradoxical. For example, innovation has to be sensitive to local environmental conditions and yet solutions are often influenced by, say national or regional tax structures and other elements of the policy-mix. More often than not, this means that the existing mix of public policies constrains the possibilities for innovation.

It is necessary, then, to move toward a framework for public policy that is more sensitive to local circumstances and the demands arising from local innovation rather than the demands for national or regional administrative efficiency and consistency. Yet this shift is hard to imagine. A clear example of this paradox is found in the debate in the WTO, between those who argue the right of nation states to establish environmental policies that are fitting for their local (national) conditions and the demands for global free trade, which is unencumbered by the variability of local restrictions. In the same way, tax regimes set at national or regional level are not normally open to modification in the light of local demands. Consequently, actors involved in socio-technical innovation often have their choices limited by the framework, or mix, of policies within which they operate.

The claim of this paper is not to that hard, instrumental top-down processes should be replaced by softer, more flexible bottom-up approaches based on problem-finding, conditioned by ideas of carrying-capacity and precaution. The real challenge is to develop a form of continuous iteration between the policy framework and the demands of local environmental and specific socio-technical systems. This demands more flexible and open bureaucracies and more open and flexible industrial commitment to learning and change with a mix of actors. Indeed I contend that these are hallmarks of the kinds of process of organisational and social learning that lead to the social and technological innovations that we need to secure sustainability.