'Design for the Environment' as Ecological Modernisation: Evaluating Technological Innovations Through Instruments of Environmental Policy-Making

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Abstract

The paper brings together ecological modernisation, the theory that informs most environmental policy-making in industrial countries, with technological innovations for the environmental design of products and processes in industry. The overall aim is to outline some implications for a new research agenda, which comprises strategies for environmental policy-making and 'design for the environment'.

The paper firstly provides an outline of sustainable development and ecological modernisation. Secondly, it explores different environmental policy-making approaches and tries to identify a relationship between ecological modernisation and different approaches for the implementation of environmental policies. Thirdly, the paper investigates the core characteristics of innovation and design in technological processes and how they are related to environmental issues. Finally, 'design for the environment' strategies are analysed regarding their relation to ecological modernisation and broader sustainability strategies.

The paper concludes that ecological modernisation and its relation to voluntary approaches to environmental policy-making may foster the uptake of environmental design in industrial production, but that ultimately it will not in itself be enough to lead the way towards more sustainable ways of industrial production patterns. There is a need to rethink environmental policy-making approaches and to develop broader strategies than 'design for the environment', which are able to meet the challenges presented by current environmental and social problems.

Introduction

The aim of this paper is to bring together the theory of ecological modernisation, which also forms the basis for environmental policy-making in industrial countries, with technological innovations for designing products and processes in a more environmentally conscious way. It therefore tries to combine social theory with practical applications of 'design for the environment'. In so doing, the purpose of this paper is less analytical than descriptive as it aims to outline perspectives for a new research agenda. Even though the theory of ecological modernisation (together with its implications on policy-making) features very prominently within the social sciences, its application on strategies for technological innovations for environmental design is new.

After outlining sustainable development and ecological modernisation as the two theoretical frameworks that underlie environmental policy-making in industrialised countries, the paper explores different environmental policy-making approaches. It tries to identify a relationship between ecological modernisation and different approaches for the implementation of environmental policies. In the next section, the paper investigates the core characteristics of innovation and design in technological processes and how they are related to environmental issues. Finally, 'design for the environment' strategies are analysed regarding their relation to ecological modernisation and broader sustainability strategies.

Sustainable development, ecological modernisation and environmental policy-making

It is an intriguing fact that at a time when philosophers had proclaimed the end of 'meta narratives' for the prescription of how society is made up—see especially the postmodernism debate—that social scientists and policy-makers alike have come to identify themselves with a new project intended to act as focus for human action and policy strategies: the concept of *sustainable development* (SD) (Meadowcroft 2000).

SD suggests a re-orientation of economic activity to prevent irreversible damage to the global environment. In so doing, it is 'not a question of choice *between* environmental protection and social advance, but rather a problem of selecting patterns of economic and social development that is compatible with sound environmental stewardship' (Meadowcroft

2000: 371). This means that SD calls for an *integrated approach of three different issues:* environmental protection, economic development, and social advance/welfare.

Overall, SD was explicitly formulated as a 'bridging' concept that could draw together apparently distinct policy domains, and unite different interests behind a common goal. And indeed, it became the watchword for policy-makers, companies and environmental groups alike. This is also due to the fact that there is no common definition what SD really means practically. However, this vagueness of the concept has also led to criticism, especially concerning the operationalisation of SD in terms of policy priorities.

This is where *ecological modernisation* (EM) comes into play. EM can be seen as part of the concept of SD, or 'the dominant interpretation of SD' (Connelly and Smith 1999: 57). As Dryzek (1997: 143) argues, EM 'has a much sharper focus than does SD on exactly what needs to be done with the capitalist political economy'. This, so the argument goes, would be especially important in a world largely determined by free trade, capital mobility and an overall commitment to market liberalisation. Therefore, EM is meant to provide both a theoretical and practical guide for an appropriate response to the environmental problematic (Gibbs 2000), and so it should inform strategies towards environmental policy-making.

EM identifies a positive-sum game between economy and ecology. Rather than seeing environmental protection as a brake on growth, EM promotes the application of stringent environmental policy as a positive influence on economic efficiency and technological innovation (Gouldson and Murphy 1997; Mol 1996). Or, in other words, to include environmental considerations into the industrial production of modern societies. Some key features of EM, which are important for this research project, are (Mol and Sonnenfeld 2000): (1) Changing role of science and technology. Science and technology are not only judged for their role in the emergence of environmental problems, but also valued for their actual role in curing and preventing them. It highlights the preventive socio-technological approaches incorporating environmental considerations from the design stage of technological or organisational innovations.

(2) Increasing importance of market dynamics and economic agents. Producers, customers, consumers etc. are seen as carriers of ecological restructuring and reform (in addition to more conventional categories like state agencies and new social movements).

The question we want to investigate now is the relation of EM and styles of environmental policy-making. That is, does the theory of EM refer to a specific style of environmental policy-making? Assuming that this is the case, it would have important implications for environmental policy-making.

From the overall perspective, a distinction may be made between three different *environmental policy-making approaches* (Connelly and Smith 1999):

(a) 'Command and control' approaches

'Command and control' typically takes the form of legislation, the issuing of orders to industry or other societal actors, e.g. controls over the emission of effluent from a factory; an outright ban on a particular pollutant etc. Companies that exceed regulations will then be punished in some way. One problem with this is that punishment, by definition, follows the crime, and hence emerges only after the environmental damage has already been done. Furthermore, levels of fines may be inadequate to act as a deterrent: it may be cheaper for a company to pay fines than to change its production processes. And third, legislation creates no incentive for companies to go beyond rules or standards.

(b) Market-based approaches

They relate to a system within which polluters have an incentive not only to avoid pollution but also to reduce their polluting activities and, in so doing, gain a fiscal and/or economic advantage. This approach also seeks to internalise the external costs of pollution and resource depletion, e.g. 'polluter pays' principle (PPP). Examples are: green taxes payable in relation to the use of natural goods and resources (e.g. energy tax); or tradable permits, which allocate the right to use environmental resources in the form of permits and allowing these to be traded at a price determined by the market thus created.

(c) Voluntary or co-operative approaches

Environmental issues have given new impetus to the debate on the opportunities and limitations of managing social change. This must be seen within the context of new modes of a system of governance in industrialised countries. In recent years it has been recognised that there are some limitations with regard to more preventive forms of environmental policy. Therefore it is not only the nation-state that has influence/or capacity on policy developments (within the increasing complexity of industrial societies), but also other societal actors, e.g. industry (Jänicke 1997). This *'system of governance'*, as opposed to 'government', favours a co-operative form of environmental policy.

The most prominent examples of these co-operative forms within a new system of governance are voluntary agreements and environmental management systems. *Voluntary agreements* are negotiated contracts between national governments and—mostly—industrial associations where industry works voluntarily towards certain standards without regulatory burdens if they meet the targets (Berger 1999). What characterises voluntary or negotiated agreements, and sets them apart from other environmental policy instruments, is the pre-eminence of a horizontal co-operative process in which firms are seen as partners, even if they are considered as polluters as well. This process also includes the step of signing a contract (i.e. the 'voluntary agreement') ratifying the agreement between the two parties and describing their reciprocal commitment. The European Commission (1996) evaluated existing voluntary agreements and points to the main advantages of these in environmental policy-making: agreements encourage a proactive attitude on the part of industry; they are conducive to the adoption of effective, tailor-made solutions; and they enable targets to be achieved more rapidly (as regulations are costly and take a long time to be implemented).

The second prominent example is provided by the *environmental management systems* (EMS). They relate to environmental improvements at the company level. Environmental issues become important aspects and are included into the company's overall management system. This means EMS allow for a holistic view and strategy to incorporate environmental principles into a company's strategic decision-making. It can lead to an integrated process directed to the production and marketing of sustainable products and services; the assessment and preventive elimination of all forms of waste during company action and projects; and the active dialogue with all stakeholders of the company on environmental issues (Estók 2000).

Aggeri (1999) argues that these new co-operative approaches in environmental policy-making are extending the traditional framework for evaluating public policy, according to which regulatory processes are regarded as purely political in nature, the result of pressure and negotiations, between defined actors or interest groups with clearly defined strategies. The argument is that this rather restricted viewpoint is not suitable for the evaluation of situations of great uncertainty, involving long periods of time and the wide range of actors and controversial issues which characterise contemporary environmental problems. This also has major repercussions on the role of the state and how environmental policy-making is conducted. Government bodies are characterised by an imperfect information framework of industrial (especially technological) aspects and mainly because of this, they also lack the necessary knowledge and expertise. Thus one can assume that the issue of public intervention is no longer one of defining, implementing and controlling measures, but rather one of co-ordinating innovation ('enabling state'). Aggeri (1999: 703) argues that for public policy, the main importance should be 'to co-ordinate complementary efforts to invent new technologies and organisations'.

In answering the question posed above, EM favours voluntary or co-operative approaches as it recognises the potential problems of national steering of policies in relation to the complexities faced by industrial societies and their environmental problems. Furthermore, it encourages the view that good environmental performance (eco-efficiency, resource management) has economic advantages (cost-savings through resource efficiency). That is to say, it points to the proactive stance, which is associated with voluntary or co-operative approaches. The importance of pro-activity on the side of industry is especially important when the focus is on innovation and design issues regarding environmental improvements of products and processes.

Thus, one hypothesis of this line of research is that voluntary or co-operative approaches of environmental policy-making are fostering the inclusion of environmental issues in the process of technological innovation and the design of products or processes. Important questions to ask for further research are: Do companies recognise the potentials of environmental issues in their production processes? Do they include environmental issues at all stages of products and processes? What policy approaches/instruments best promote ecological innovations in industry?

Innovation, design and the implications for the environment

The focus of this research project is to evaluate technological innovations in industry, especially concerning the use of 'design for the environment' strategies to include environmental issues into the development of products and processes, and how they can be promoted through environmental policy-making instruments. Before we get into the analysis of environmental design issues, we have to investigate the relations between innovation and design in industry and the implications for the environment.

In trying to define *innovation* in industry, Dosi (1988: 222) argues that innovation includes all stages of new economic activity, including 'the search for and discovery, experimentation, development, imitation and adoption of new products, new processes, and new organisational set-ups'. Regarded from the overall perspective, innovations may be either 'radical', involving discontinuous change and the introduction of new technologies and techniques, or 'incremental', which involve gradual improvements of existing technologies and techniques. It is apparent that innovations are not adopted solely on the basis of isolated characteristics, such as cost or quality, but on the extent of their compatibility with existing systems or structures. A consequence of this is that new technologies and techniques must be introduced into systems, which have often been developed for, and adopted to, older technologies and techniques. Depending on the ability of an innovation to influence existing systems, an innovation which requires only incremental change is more likely to be adopted than one requiring more radical change. As a consequence, change normally takes place within particular trajectories in an evolutionary way. Therefore, Murphy and Gouldson (2000: 36) summarise that 'the rationality of actors choosing whether to develop or use a new innovation is [...] bounded by the nature of the existing system'. However, the ability of a new technology or technique to influence existing systems or structures varies over time, particularly as a result of the dynamic and self-reinforcing impact of scale and learning effects (Kemp 1993). These effects mean that new innovations commonly achieve improvements in quality and reductions in costs as their production expands and as experience with their application accumulates.

These characteristics of the innovation process are reflected in the various options available to companies seeking to improve their environmental performance. Companies typically face a number of choices related to technological and organisational options that can incrementally improve the environmental performance of existing operations and to the strategic options that offer the potential for more radical change. Companies usually face a choice between two kinds of *innovations for environmental improvements*. On the one hand, *control technologies or end-of-pipe innovations*, which are additions to production processes capturing and/or treating waste emissions in order to limit their environmental impacts. These innovations normally do not require a significant re-design of the processes or products with which they are associated. On the other hand, there are '*innovations at source*' (e.g. clean technologies, recycling channels, green products etc.) which aim at reducing environmental impacts by re-engineering the whole technology or product, in other words they 'integrate environmental considerations into their design to avoid or reduce their impact on the environment' (Murphy and Gouldson 2000: 36). The compatibility of these 'innovations at source' with existing systems is usually more limited. Following the above argument, this can mean that 'innovations at source' are less widely adopted by industry.

Depending on the nature of the problem and innovation, the requirements of public intervention and public policy-making will change. Regarding 'innovations at source', one can assume that the larger the number of actors involved, the larger the number of transformation stages and the higher the level of uncertainty, the greater the need for a strong co-ordination scheme. Market-based approaches in policy-making produce strong incentives for industry but provide no indications on which technological paths should be explored. 'Command and control' approaches neither offer incentives nor do they offer sufficient guidance for co-ordination. By contrast, voluntary or co-operative approaches provide weaker incentives, but generally include stronger co-ordination schemes (i.e., defined objectives, designation of responsibilities, know-how transfer rules, monitoring schemes etc.) (Aggeri 1999). One can, therefore, draw up the hypothesis that voluntary or co-operative approaches are more appropriate for the adoption of 'innovations at source'.

Companies can also improve their environmental performance through organisational change and the introduction of new managerial techniques. The application of an *environmental management system* is one of the most common organisational innovations in business with the aim to develop an integrated organisation system. Murphy and Gouldson (2000: 37) argue that the organisational innovations 'can also have an impact on the environment into which new technologies must be introduced, thereby enhancing the potential for clean technologies to be integrated into existing systems'. Thus for any further research there is the hypothesis that the introduction of environmental management systems fosters the introduction of 'innovations at source' for environmental improvements.

The other important issue we must investigate for its implications on the environment is *design*. People very often associate 'design' solely with fashion and status symbols. Design decisions are not only concerned with appearance, however, but also with ergonomics, ease of manufacture, efficient use of materials, user friendliness and often the incorporation of innovative technologies, components and materials. Overall, 'design' refers to the creation concepts, plans and ideas, and to the representation of these ideas so as to provide the instructions for making something (i.e., a product, a material, a component, a process etc.) that did not exist before, or not in quite that form (Walsh 1996). Aubert (1982, cited in Walsh 1996: 513) defines design as 'the very core of innovation, the moment when a new object is imagined, devised and shaped in prototype form'. Elsewhere Aubert (1985, cited in Walsh 1996) says that design introduces technology into the social fabric. So even the most radical technological innovations must be embodied in usable form via the design process.

One can distinguish between pre-production design processes, leading from a basic idea to an original technological innovation, and post-production design processes or successive re-design, component change and evolution. Furthermore, design clearly plays an important role in the realisation of the radical invention as an innovation. Systemic innovations in particular, need a great deal of design co-ordination in development and commercialisation because systematic adjustments to other parts of the system need to be made.

In regard to *public policy* an important aspect in promoting design effectiveness, innovative performance and competitiveness, is to provide firms not only with information, encouragement, advice and subsidies to encourage their use of professional designers, but to provide advice and information about the organisation of design activities. Thus the *management of design aspects* is of crucial importance: the function of a strategy and management in proposing and implementing design issues (Walsh 1996). This argument can lead to the hypothesis that the whole management of design can best be guaranteed not through legislation or marked-based approaches, but through voluntary or co-operative approaches. Furthermore, it is important to give design a high profile in overall corporate strategies, and to promote design awareness throughout the enterprise. This points to the systematic use of an integrated environmental management system.

Thus design is a crucial element in defining products and processes as it outlines all crucial aspects at the beginning. Therefore, for any environmental strategy of industrial production, the design stage is of prime importance. For research this implies that strategies for ecological modernisation must embrace 'design for the environment' as important for bringing about more environmentally friendly production and recycling or re-manufacturing policies. The next section will elaborate on different applications of 'design for the environment'.

Design for the environment

The development of strategies towards 'design for the environment' involves three stages: green design; eco-design or life-cycle design; sustainable product-service systems. The starting point for investigations into 'design for the environment' issues was the realisation that major environmental impacts arise from materials choices and from the use and disposal of products. Some engineers and designers thus began to think in terms of developing *'greener' products* (Roy 2000). This involved developing products which, for example, were more energy efficient, avoided use of toxic materials, or which could easily be disassembled for recycling. Companies, especially multinationals, began to integrate 'green product design' as part of their corporate strategy.

Green design typically just reacts to environmental regulation, however, or pursues commercial aims and tends to focus on single environmental issues such as materials choice or waste disposal. Thus, green design has its severe limitations. In particular, an environmentally beneficial change in one aspect of a product's design may have adverse environmental effects elsewhere in its life cycle, which may outweigh the benefits. For example, the avoidance of a potentially toxic material may reduce a product's durability.

Thus systematic approaches to 'design for the environment' emerged in the 1990s, known as *eco-design* or *life cycle design*. Eder (2000: 9) defines eco-design as the 'systematic incorporation of environmental factors into product design and development'. The aim is to reduce and balance the adverse impact of manufactured products on the environment by considering the product's whole life cycle:

- beginning with the extraction of raw materials from which the product is to be made;
- the processes to be employed to manufacture a product;
- the distribution of the product to the customer/consumer;
- the use of the product by the final consumer/user; and
- the entire waste management (reuse, remanufacture, recycling or final disposal).

Eco-design is a relatively new approach to product development, but is gaining acceptance in an increasing number of companies, especially in the electrical, electronics, and domestic appliance sector (Roy 2000). Overall, eco-design is concerned with the *management of natural resources*: Generally, *materials management* is a difficult undertaking. The material selection process is exacerbated by the observation that several thousand chemicals are manufactured in industrial quantities and new ones are being developed continually. However, there are two basic rules (Thompson 1999): to minimise waste generation during the extraction of raw materials and also during the life cycle of the product; and to maximise reuse, remanufacture and recycling throughout the product's service life. A crucial element of materials management is the *material utilisation*. This involves the selection of low-impact (i.e. renewable, recycled) materials and the reduction of the volume of materials in a product. The latter could lead to the reduction in the consumption of raw materials, a reduction in pollution associated with extraction and refinement of the material, a reduction in the pollution and energy consumption during the subsequent manufacturing phase, and a reduction in the volume of material entering landfills (Thompson 1999).

The second goal of materials management is to *use recycled materials* or *re-manufactured parts rather than virgin materials* whenever possible. Some of the design issues to be addressed before materials can be economically recycled are: minimisation of the number of different materials in a product; selection of easily recycled materials; product disassembly; and facilitating material identification. In order to recycle a material, it must first be identified and it must be separated from other materials. Material recycling is facilitated when products contain the smallest number of different materials. The recycling of any material is enhanced when parts can be easily separated through the implementation of 'design for disassembly' rules (Thompson 1999).

Products that are most easily re-manufactured are those with a small number of design changes each year. This re-manufacturing philosophy encourages the development of modular designs, where a dated module can be replaced by a state-of-the-art module; standardisation that permits one part to be used in several different products; and the implementation of 'design for disassembly' principles, which facilitate the dissection and separation of products into individual parts (Thompson 1999). Products have been typically discarded into the waste stream once their performance no longer satisfies. This situation can be altered by an *extended service life* of products, including new styles, new technological features and new maintenance protocols. Products should be designed employing 'design for maintenance' principles so that worn parts can be easily replaced and that the durability of the whole product can be extended.

Energy conversion is the primary cause of pollution and global warming. It is imperative, therefore, that designers should strive to create *energy-efficient products* and seek environmentally-friendly sources of power. Obviously, products that consume energy must be designed to minimise the consumption of energy and use it efficiently. Thus the power consumption of a product should be considered at the conceptual design stage (Thompson 1999). Other important issues concerning the materials management are the reduction of environmental impacts arising from the *packaging and distribution* of the product. Here suppliers often play a crucial role as the packaging of delivered products is in their hands. Furthermore, the reduction of environmental impacts arising from the *use of the product* can be a design issue, especially when end users are included and wishes and potential problems are included in the design of a product (Roy 2000).

Eco-design, however, also has its limitations. It is essentially an attempt to enable existing patterns of production and consumption to continue into the future without, however, harming the environment to the same extent as is done at present. But eco-design is unlikely to be enough when dealing with the pressures on the environment posed by other societal issues. In order to begin to tackle wider environmental and social issues and to move towards a more sustainable world, it has been estimated that energy and resource flows as well as per capita waste and pollution production in the industrialised countries must be reduced by anything from 4 to 20 times (Roy 2000). Broader strategies than eco-design will thus need to be used, which will also include a broader perspective on society and the wider implications of industry-environment relations than ecological modernisation strategies do.

This wider challenge for environmental protection has led to the concept of *sustainable product design* and a move towards *sustainable product-service systems*. This new way of thinking would involve not only the inclusion of leading edge eco-design issues, but also organisational and social innovations like (Roy 2000): new patterns of ownership such as leasing, to give manufacturers interest in designing for durability and to enable products to be returned for refurbishing or recycling; radical changes such as shared/community use of products, thus requiring fewer physical goods to provide the same volume of services; replacing a product—e.g. replacing a telephone answering machine with a 'de-materialised' answering service; or even questioning whether the product or function is really needed. It would be important for further research to investigate how much of this new thinking of sustainable product design and services is already a part of the companies' strategies and management goals.

Eder (2000), by reflecting upon the empirical findings from two research projects, identifies the following *policy implications* following the outcomes of the studies: First, it should be noted that communicative approaches making the clear statement that an environmental product policy and 'design for the environment' could be crucial in gaining a competitive advantage might be very powerful. Policy should support communicative approaches. Furthermore, a credible general policy aimed at reducing emissions, closing substance cycles, and source-oriented measures probably will form an important basis in itself. In part, such a policy could be developed in co-operation with industry, together with the implementation of take-back schemes and source-oriented measures to deal with certain harmful sources.

Conclusion

The aim of this paper was to bring together ecological modernisation, the theory that informs most environmental policy-making in industrialised countries, with technological innovations for the environmental design of products and processes in industry. The paper tried to outline some implications for a new research agenda, which comprises strategies for environmental policy-making and 'design for the environment'.

Ecological modernisation favours voluntary or co-operative approaches to policy-making. It is especially the proactive stance of those approaches, which corresponds to the EM's notion of a positive interrelation between environmental protection, economic efficiency and technological innovation. These voluntary or co-operative approaches will also be more likely to foster environmental 'innovations at source' which are otherwise less likely to be adopted because they are more difficult to bring in line with existing systems and processes. Voluntary approaches can bring about 'innovation at source' strategies in a broader manner since they comprise co-ordination schemes.

Environmental design must be regarded as part of those 'innovations at source'. Public policy must foster their application very broadly by also providing advice and information about the organisation of design activities. Thus the management of design aspects is of crucial importance. This can lead to the hypothesis that the whole management of design can be best guaranteed through voluntary or co-operative approaches.

The development of strategies towards 'design for the environment' involves three stages. Green design, however, merely reacts to environmental regulation or pursues the commercial aims of companies. What is more, an environmentally beneficial change in one aspect of the product's design may have adverse environmental effects elsewhere in its life cycle, which could outweigh the benefits. Eco-design or life cycle design, with its acclaimed systematic incorporation of environmental issues into product design and development, is nevertheless essentially an attempt to enable existing patterns of production and consumption to continue—but without harming the environment to the same extent as is done at present. The argument goes that eco-design is not enough when dealing with the pressures on the environment posed by other societal issues related to technological innovation and design.

As Roy (2000) suggests, broader strategies than eco-design will have to be adopted to take up the challenge presented by current environmental and societal problems. Sustainable product design and sustainable product-service systems are presented as the way forward. These new strategies would not only include eco-design issues, but also organisational and social innovations alike. Broadly speaking, EM and its relation to voluntary or co-operative approaches to environmental policy-making may foster the uptake of environmental design in industrial production and processes, but it will ultimately not be enough to lead the way towards more sustainable ways of industrial production patterns—taking the concept of sustainable development as a base, with its integration of environmental protection, economic development, and social advance is promising. There is also a need to rethink environmental policy-making approaches for achieving this goal. It is rather questionable if voluntary or co-operative approaches have the capacity to lead towards sustainable development.

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