View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Institutional Repository of the Freie Universität Berlin

FORSCHUNGSSTELLE FÜR UMWELTPOLITIK
Freie Universität Berlin
Fachbereich Politik- und Sozialwissenschaften
Otto-Suhr-Institut für Politikwissenschaft

FFU-report 00-08

Forschungsstelle für Umweltpolitik

Ecological Modernization: Innovation and Diffusion of Policy and Technology

Martin Jänicke

For his suggestions and critical comments and advice,
I am especially grateful to Dr. Klaus Jacob (FFU)

FORSCHUNGSSTELLE FÜR UMWELTPOLITIK
Freie Universität Berlin
Fachbereich Politik- und Sozialwissenschaften
Otto-Suhr-Institut für Politikwissenschaft

Ihnestr. 22
14195 Berlin

telefon +49-30-838 566 87
fax +49-30-838 566 85
email ffu@zedat.fu-berlin.de
internet www.fu-berlin.de/ffu/

Table of contents

Summary

The article gives an analysis of the possibilities and limits of the concept of ecological modernization. The concept was used already in the early 1980s to describe the common field of ecology and economy. The focus was on technological progress reducing the environmental impact of production and consumption. Hajer and other authors had a broader definition of the concept. But it could make sense to differentiate technical / non-technical solutions (the latter being less compatible with the economic system). The limits to eco-modernization strategies and the need for “structural” solutions could possibly better be demonstrated by the earlier concept. A policy for ecological modernization may be defined as the sum of government actions aimed to stimulate environmental innovations and their diffusion. Higher eco-efficiency - instead of end-of-pipe measures - is its main objective. But innovation is a highly difficult task, especially for governments. No simple “instrumentalistic” solution is available. Therefore, a more complex policy pattern will be necessary. A more global policy approach would be the stimulation of “green” lead markets. As a rule a complex interplay between political and technical innovation and diffusion can be observed.

"Ecological modernization" describes, in its narrower technical-economic sense, the wide spectrum of possible environmental improvements that can be achieved through innovations beyond the purely end-of-pipe approaches. In sociological terms environmental problems, apart from their definition according to the respective social importance of those causing a problem and of those affected by it, can also be defined in terms of the technical options available. Normally an environmental problem for which we have a technical solution represents less eco-political difficulty than one requiring intervention in the established production, consumption, or transport structures. The concept of ecological modernization here presented deals with this technical potential.

In this context the mechanism for diffusing innovations acquires significance – especially when it comes to developing a *global strategy for ecological modernization*. Of particular interest in this process is the interplay between politics and technology.

This discussion paper – together with reference to our own previous work – is intended to present a general overview of the concept of ecological modernization and its possible perspectives. This paper defines the concept and examines various aspects for which it might be a suitable formula for integration.

1 Ecological modernization – idea and term

The term "ecological modernization" was coined in the early 1980s to provide a formula for the joint intersection between ecology and economy. The intention was that the urge for modernization in the developed market economies, driven by rationalization motives and competitive pressure, should be linked with the long-term requirement for an ex ante more environmentally benign technological development. This concept was developed in a study for the "Berliner Wissenschaftszentrum" (Jänicke 1984). It was adopted in these circles quite early on (Huber 1985, Simonis 1985, Zimmermann et al. 1990). The term "ecological modernization" was also used, in the above-mentioned sense, early in 1982 in an economics debate in the "Abgeordnetenhaus Berlin"[1] (Abgeordnetenhaus von Berlin 1982, 756 et seq.); moreover in the "alternative government declaration" issued by the editorial staff and advisory board of the magazine "Natur" following the German Bundestag elections in 1983 (Jänicke 1983). This document, based on the example of employment-boosting environmental innovations in the production, energy, traffic, and construction sectors, further explained the concept and at the same time linked it with the idea of reforming the German tax system along more ecological lines.

1 Translator's note: Abgeordnetenhaus, Berlin = Parliament (in those days before German unification) of West Berlin

Figure 1 *Model and examples of environmental policy approaches (Jänicke 1984, 1995)*

Curative approaches			Preventive approaches	
	Repair: Reduction / compensation of damage	*End-of-pipe treatment*: Clean-up technology	*Ecological modernization*: Clean(er) technology / Eco-efficiency	*Structural change*: Decrease of “dirty” industries / activities
Examples	Payments for noise damage	Passive noise protection	Less noisy motors	Alternative traffic modes, less traffic
Examples	Ex-post measures against forest damage	Desulfurization of coal power stations	More efficient power production and consumption; CHP; cleaner primary energy	Less power-intensive modes of production and consumption
Examples	Measures against damage caused by industrial waste	Waste incineration	Recycling	Reduction of waste-intensive sectors

The “ecological modernization” debate was limited in the 1980s basically to a small community of Berlin sociologists. Subsequently it came to exert a strong influence on political discussion of environmental issues in Germany in social-democratic circles, the trade unions, and later on also the Bündnis 90/die Grünen party. The “red-green” German government[2], in its coalition agreement of October 1998, expressly described a program of “ecological modernization”. In the environmental science debate, this term was already in widespread international use in the 1990s (Weale 1992, Hajer 1995, Cohen 1998, Mol/Sonnenfeld 2000, Murphy/Gouldson 2000).

Modernization, in its economic core, is the systematic, knowledge-based improvement of procedures and products. It is a compulsion inherent in capitalistic industrial societies which, given the pressure of competition for innovation in developed countries nowadays, has attained an additional significance. This compulsion incurs a number of problems and these have often been discussed. However, it is possible to influence its effects on technological progress. Indeed, exerting such influence is what “ecological modernization” means. This is a matter of changing the direction in which technical progress is developing. The compulsion to continuously improve procedures and products is now to be placed at the service of our environment. This is the original economic-technical core of the concept, i.e. the development and application of ecologically adapted and thus future-capable technologies. The emphasis is on the possibility of ecological-economic “win – win” solutions which can be achieved above all in cutting costs and succeeding in the competition for innovation.

Since what the less developed countries with their standard products mainly face on the world market is price competition, the real chance for highly developed industrialized countries lies

2 Translator's note: rot-grüne Koalition, red = SPD (Sozialdemokratische Partei Deutschlands), green = Bündnis 90/die Grünen

rather in competition in terms of quality and innovation where new, still unrivaled products can initially be more expensive. Developed countries after all have the qualifications and research capacity to keep on systematically bringing out new technological environmental improvements.

The environmental question thus increasingly also becomes a motor for economic modernization (Brickwedde 1997). The view that “environmental policy is contributing towards the modernisation Swedish enterprise” (Ministry of Environment 1996: 5) is typical here. Literature pleads for an appropriate strategy: “How an industry responds to environmental problems may, in fact, be a leading indicator of its overall competitiveness ... Successful environmentalists, regulatory agencies, and companies will ... build on the underlying economic logic that links the environment, resources productivity, innovation, and competitiveness" (Porter/van der Linde 1995, cf. Wallace 1995). A more recent empirical study conducted in 44 countries indeed shows a clear connection between eco-efficiency and competitive ability (Sturm/Wackernagel/Müller, 2000).

Ecological modernization starts beyond end-of-the pipe approaches (clean-up technology) and way beyond merely reparative measures (see Figure 1). It may come in the form of incremental improvement (cleaner technology) or radical innovation (clean technology), where innovation means the initial market introduction of a new technology. The latter may improve some or all of the phases of a product’s life cycle. Incremental improvement affects such different dimensions as materials intensity (efficient use of resources), energy intensity (efficient use of energy), surface intensity (efficient use of space), transport intensity (efficient logistics), or risk intensity (regarding plant, substances, products). Implicitly this also involves waste intensity, i.e. waste materials and harmful emissions (Jänicke 1984).

The original, essentially technology-related concept of ecological modernization here outlined nowadays enjoys broader acceptance and has been supplemented with the idea of modernizing the *social* process in environmental aspects. Hajer distinguishes here between a “techno-corporatist” variant and a “reflexive” variant of the ecological modernization theory (Hajer 1995, cf. Beck 1986, Prittwitz 1993), where the latter includes the whole development direction of the social process. One can also distinguish, similarly, between an economic-technical variant and an institutional-cultural variant of ecological modernization (Mol/Spaargaren, 2000: 20).

Figure 2 Two concepts of ecological modernization (adapted from Mol/Sonnenfeld 2000)

TWO CONCEPTS OF ECOLOGICAL MODERNIZATION
• **“Technocratic” – Ecological modernization as economic-technical transformation**: – Incremental and radical innovations to increase eco-efficiency including the social technology to stimulate such innovations (and their diffusion)
• **“Sociocratic” – Ecological modernization as social-institutional transformation:** – Change of life-styles, consumption patterns, institutions, and paradigms (inter-generation solidarity, sufficiency) – “Reflexive ecological modernization” (Beck, Hajer)

Although I have always stressed the close inter-connection between ecological and political modernization myself (Jänicke 1993, cf. Tatenhove/Arts/Leroy 2000), I recommend to restrict the use of the “ecological modernization” term to increasing levels of eco-efficiency. This may include political innovations to promote environmentally positive technical innovations and their diffusion just as much as environment-relieving *social* innovations (leasing, contracting, eco-funds, etc.). This version of the “ecological modernization” concept thus concerns the innovative path of environmental policy along system-compliant lines where solutions to environmental problems emerge and diffuse as marketable supplies and services. We must distinguish between this system-compliant and successful path taken by environmental policy and the very much more difficult, so far often unsuccessful, but indispensable path of ecological restructuring beyond the merely technical options. Problem-solving in the form of ecological restructuring affects systems of behavior which – irrespective of technical eco-efficiency improvements – stand out by their high environmental intensity. Examples for restructuring the economic system along environmentally positive lines are the running down of environmentally intensive basic and raw materials industries, mining, and nuclear power. I will set out later on that it is an illusion to believe that ecological modernization (in the narrower sense) always leads to the environment-relieving sectoral restructuring of the economy. At this juncture therefore we need a distinction between the various concepts. In the wider sense ecological restructuring may be thought to include any environmentally positive changes in the infrastructure, traffic structure, housing structure, even in established consumer habits and life-style. The distinguishing feature in all these structural solutions is that they involve no marketable technologies and thus cannot use the inherent logic of the economic system as their driving force. Rather they rely on political-social mechanisms and capacities being set up, which require a disproportionately greater effort.

Therefore I plead for retaining the “ecological modernization” concept in its original economic-technical version - in order to draw sharp and unmistakable boundaries for this concept. Other authors have made this important distinction within the concept of ecological modernization. Structural solutions are regarded as the “strong” variant of ecological modernization (Mol/ Spaargaren 2000). They take account of the fact we have emphasized here, namely that structural solutions indeed need stronger players, stronger capacities, and a stronger sense of re-orientation than currently exist; (see Chapter 7). Precisely for this reason clearer conceptual distinctions would seem advisable.

2 The special characteristics of environmental innovations

Taking as our point of departure this narrower, economic-technical version of the ecological modernization concept, certain strategic questions arise, namely: What are the driving forces of this process and how can they be reinforced? In this context certain special characteristics of environmental innovations must be considered.

In research into economic innovations there is a predominant approach in which companies and their socio-economic radius of action stand in the foreground. The role played by the state and by politics is seen primarily in its provision of the infrastructure needed for the generation, transfer, and application of knowledge. Research policy and state promotion of research institutions are the central aspects (OECD, 1999).

In the "Forschungsverbund Innovative Wirkungen Umweltpolitischer Instrumente" (FIU) funded by the BMBF, "environmental innovations" were understood to be those innovations which resulted in an "improvement in environmental quality" (Klemmer/Lehr/Löbbe, 1999: 29). However, environmental innovations also tend increasingly to stand out by virtue of characteristics such as the following:

Environment-related innovation and diffusion processes are to a large degree politically determined (Porter/van der Linde, 1995; Wallace, 1995; Kemp, 1997; Hemmelskamp, 1999). The state plays a role in environmental innovations which goes far beyond its technology-political significance. Markets for environmental innovations are very usually state-regulated markets. In this context NGOs such as Greenpeace can also play a market-creating role (e.g. the CFC-free refrigerator or the 3-liters-per-100-kilometers car).

Environmental innovations are to a very high degree problem-specific. Since they are reactions to particular problem situations, usually already existing or foreseeable worldwide, they tend to have a better chance of meeting with worldwide demand. Insofar, they refer to the "future global needs" (Beise, 1999: 3) which are so important for lead markets and which represent a specific potential for international diffusion.

This fact reduces, even though in a very general sense, the long-term uncertainty of trying to predict potential demand conditions as normally encountered with "normal" consumer preferences. As, on the one hand, the world's population and industrial production increase and, on the other hand, the global environment's capacity to absorb the effects tends rather to decrease, the possible dimensions of the demand for environmental efficiency at least offer innovators some sort of guiding framework.

Innovations both in environmental technology and in environmental policy can nowadays count on a broad spectrum of transfer mechanisms beyond the market which – from the OECD, by way of the World Bank, right through to Greenpeace – help their rapid diffusion on the world market. Ecopolitical pioneer measures taken by states and the international orientation along "best practice" lines (benchmarking) serve to further reinforce these mechanisms.

These specific characteristics favor environmental innovations. There are also, however, factors restricting and hindering such innovations, namely the traditional end-of-pipe orientation (Hauff/Solbach, 1999) or the vested interests of environmentally intensive industries. Thus, an overall balance should be differentiated. However, the above-mentioned favorable specifics are highly significant when it comes to explaining the now undisputed fact that environmental policy (at least in its modernization variant) does not figure among the globalization losers – unlike fiscal or social policies; (see below).

3 Innovation-friendly control mechanisms in environmental policy

But how can environmental innovations be induced politically? In the present situation, politics in this respect is confronted by a task of considerable difficulty. Innovations are influenced by a number of especially dynamic and complex factors. This is no less true for environmental innovations (Jänicke/Weidner, 1995; Conrad, 1996). Politics always acts in a climate of deep uncertainty as to the effects of its actions (Luhmann, 1986). When it comes to the effects of innovations this political uncertainty can only be deeper. Environmental innovators in particular often prefer not to wait until a suitable policy has been passed and enacted (Jacob, 1999) but often rely instead on the government's recognition that a problem exists and on the early phases of policy formulation. Whereas with "normal" innovations state and politics form only one factor among many influencing the radius of action open to the potentially innovative company, environmental innovations benefit from the state's clearly stronger role.

The notion that state regulation and control by means of specific instruments could achieve specific innovation effects has, in the light of subsequent empirical investigations, met with growing skepticism. Initially this "instrumentalism" was increasingly criticized by empirical researchers in environmental policy; subsequently, however, this was relativized by representatives of the empirical environmental economy (Klemmer/Lehr/Löbbe, 1999; Hemmelskamp/Rennings/Leone, 2000; OECD, 1999a).

The afore-mentioned FIU combined project, backed by the BMBF, proposed a different political model which was developed on the basis of empirical innovation cases (plus theoretical analysis) and is said to take better account of the complexity of influencing factors. Here, not only the fabric of effects caused by said instruments but also the political style (Richardson, 1982) and the constellation of players play a particular role.

This proposed innovation-oriented political model is shown in the following overview (Jänicke et al., 2000; Blazejczak et al,. 1999):

ELEMENTS OF AN INNOVATION-FRIENDLY POLICY FRAMEWORK

Instruments are innovation-friendly if ...

- they provide economic incentives,
- they act in combination,
- they are based on strategic planning and goal formulation,
- they support innovation as a process and take account of the different phases of innovation/diffusion.

A **policy style** is innovation-friendly if …

- it is based on dialog and consensus,
- it is calculable, reliable, and has continuity,
- it is decisive, proactive, and demanding,
- it is open and flexible,
- it is management-oriented.

A **configuration of actors** is innovation-friendly, if it …

- favors horizontal and vertical policy integration,
- the various objectives of regulation are networked,
- the network between regulator and regulated is a tight one,
- the relevant stakeholders are included in the network.

The core of the matter is a strategy which strengthens the ecological motivation of potential innovators, improves their situation regarding the available information, and above all cuts their investment risk by providing calculable data. Not until the second step does it become necessary to start promoting diffusion of ecologically adapted technology. A strategy of ecological modernization will begin with clear target data but with "soft" instruments and regard regulations and official directives as the very last resort (Wallace, 1995; Jacob/Jänicke, 1998). The guiding axiom is: The more credibly the state threatens specifications and sanctions right from the outset, the more effective the "softer" instruments will work.

A rather management-oriented approach of this nature suggests itself when it comes to *targeted* environmental innovations in which potential innovators and target groups can be addressed directly. At the same time, however, it is important to promote innovations in a broadly effective, *general* way by addressing a wider spectrum of possible innovators less specifically and directly. In this situation classical regulation and control by means of broadly effective instruments would still seem appropriate.

Recently, with a broadly effective set of instruments applied as part of innovation-oriented environmental policy, it has been above all environmental levies and energy taxes that have gained in significance. Of course state provision of the necessary infrastructure for research, development, and knowledge transfer – as innovation research has always stressed – is also critically important. State-run "green" R&D programs play an important role in the innovation-oriented pioneer countries in environmental protection (e.g. the Netherlands, Denmark, and Sweden).

Another important aspect is cooperative environmental planning as defined by "Agenda 21". This contains elements of classical regulation and control and of public management systems. The use of strategic target data in the cooperative planning approach reduces the business risks involved in suitable innovation processes and offers innovators more reliably calculable investment conditions. If, for example, a hazardous substance has to be withdrawn from the market before a specified deadline, the potential supplier of a substitute substance has greater certainty with respect to the profitability of his research and investment planning. Moreover, sustained environmental planning can create motives for innovation insofar as it is linked to a broad target-oriented debate on specific problem situations. Modern environmental planning is usually associated with the formation of networks, among other things favoring the exchange of information so important for innovations.

4 Political diffusion of innovations and the globalization of environmental policy

As stated previously innovations in environmental technology and their diffusion are characterized by the fact that they are to a large extent influenced and favored by environmental policy. How innovations in environmental policy for their part come to be and which structures and situational factors favor them are questions that have often been examined - not only in international comparisons but also in particular in individual US states; (literature: Jänicke, 1996; Kern, 2000). How innovations in environmental policy are diffused is, by way of contrast, still largely uncharted territory in environmental policy analysis (Kern, 2000; Jörgens, 1996).

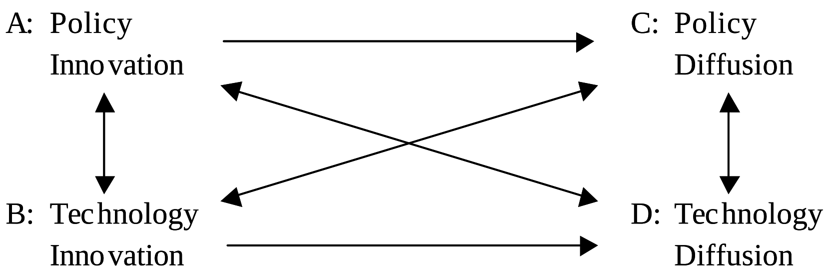
The Forschungsstelle für Umweltpolitik (Environmental Policy Research Unit) at the Freie Universität Berlin (Free University of Berlin) has been looking into this topic for a number of years. During this time there have also been methodological innovations: To sum up, national state policy innovations and their international diffusion can be used to describe, in quantitative terms i.e. in simplified form, the development of global environmental policy (Kern/Jörgens/Jänicke, 1999). It is possible, by way of policy monitoring, to treat innovations in environmental policy as indicators and evaluate these accordingly (from the establishment of an environment ministry right through to the introduction of a CO_2 tax). It is also possible in the same way to assess the significance of and changes in the pioneer countries and the role of certain strategic countries without which rapid diffusion would not succeed. This procedure also allows us to deduce, from the diffusion rate, the level of difficulty involved in solving a problem. Monitoring individual measures in this way (as policy output) is of course not the same as proper effects analysis; but the method of empirically describing national and global policy developments with the aid of policy indicators can still be considered a step forward in environmental policy research.

The result shows, for example, that the globalization of environmental policy, insofar as this is reflected at state level, can indeed be described using the analytic concept of innovation diffusion: Standard solutions in pioneer countries are diffused worldwide, thus causing a substantial measure of convergence in policy formulation at national state level – irrespective of extremely different capacities for action. Unlike in the 1970s, when for example the USA or Japan had a major innovative function in global environmental policy, nowadays innovations in environmental policy emerge strikingly often in small EU countries tightly integrated in the global market (Jänicke, 1998). The - reformed - institutional fabric of the EU seems comparatively favorable both for innovations and for their diffusion (Héritier et al., 1994). The EU must firstly, at least in principle, accept a “high level of protection” in member states; it must secondly seek to harmonize innovations in environmental policy implemented at national state level. Pioneer countries, for their part, often have an interest in anchoring their policy innovations within the EU framework in order to thus minimize their subsequent need to adapt to European policy. It is also often a matter of “Europeanizing” certain national pioneer measures favoring the particular country’s domestic industry. If diffusion takes place not by way of EU harmonization but from one country to the next, the policy innovation in question will often need first to be incorporated by one of the more influential EU countries before it achieves the necessary widespread impact. For example, the CO_2/energy tax was already introduced in the Netherlands and the Scandinavian countries in the early 1990s - but the system did not receive the decisive push towards European diffusion until the red-green coalition government in Germany adopted it. The CO_2 tax is an example of “horizontal” diffusion. It has yet to be established as a European measure.

The diffusion of innovations in environmental policy thus takes place both directly from one country to another, i.e. by way of imitative political learning or “lesson drawing” (Rose, 1993) and by way of international institutions (e.g. OECD, UNEP, World Bank), organizations (e.g. Greenpeace), or expert-networks (e.g. the International Network of Green Planners). It is striking how rapidly many innovations in environmental policy are diffused. Environment ministries have, in a period of just under 30 years, clearly asserted their position in the industrialized countries. Environmental plans, as defined under “Agenda 21”, just ten years after the Rio Conference (1992), are going to be more or less in place worldwide – though in extremely disparate quality. However, in other cases (e.g. soil protection legislation) the diffusion rate is clearly curbed by the difficulty of solving the problems involved.

5 Interchange between diffusion of innovations in environmental policy and environmental technology

Figure 3 Diffusion patterns of Environmental Innovation



Policy induced Diffusion

- Technology Forcing A ⇒ B ⇒ C ⇒ D
  e.g. Car Emission Standards & Technologies
- Political Initiative A ⇒ B ⇒ D ⇒ C
  e.g. Cadmium substutites
- Political Dominance A ⇒ C ⇒ B ⇒ D
  no example yet ?

Technology induced Diffusion

- Technological Initiative B ⇒ A ⇒ C ⇒ D
  e.g. desulphurization technologies
- Technological Dominance B ⇒ A ⇒ D ⇒ C
  e.g. CHP Technologies
- Autonomous Diffusion B ⇒ D
  e.g. Energy efficient technologies

Environmental technologies are nearly always diffused by political mechanisms; (for more information regarding national domestic diffusion paths, see OECD 1999a: 51 et seq.). This can be attributed to the highly symbiotic fabric of interwoven interests. Suppliers of environmental technology seek the support of politicians - and politicians are always looking out for technological options – because precisely these are much easier to implement than any sort of structural intervention.

However, the interplay between environmental policy and environmental technology in the case of innovation diffusion is characterized by a wide variety of possible constellations. Theoretically it is possible to distinguish between the following diffusion scenarios, depending on the factors leading to the political and technological innovations:

Technology forcing (A⇒B⇒C⇒D): An innovation in environmental policy in one country forces a technological innovation which is then only diffused internationally if also the political innovation is diffused (e.g.: catalytic converter technology in cars).

Technological priming (B⇒A⇒C⇒D): A new but already existing environmental technology induces a political innovation whose diffusion in turn encourages diffusion of the technology (e.g.: flue gas desulfurization).

Political priming (A⇒B⇒D⇒C): A national environmental policy leads to technological innovations whose diffusion in turn encourages diffusion of the political innovation (e.g.: cadmium substitute [3]).

Technological dominance (B⇒A⇒D⇒C): An innovation in environmental technology is successfully diffused and as a result receives political support both nationally and internationally (e.g.: combined heat and power in industry [4]).

Political dominance (A⇒C⇒B⇒D): The innovation in environmental policy is successfully diffused before a corresponding technology is available; (this scenario is, symptomatically, very rare in ecological modernization).

Autonomous technological development (B⇒D): An innovation in environmental technology is successfully diffused without political influence; (this scenario, beyond incrementally increasing energy efficiency in companies, e.g. coupled production as a purely economically motivated improvement, is clearly also rare).

The above typology does not yet mention the scenario involving a state-supported infrastructure in the R&D sector (OECD, 1999). This is important for a global environmental policy comparison in that a suitable infrastructure can only be assumed in the developed industrialized countries. The intensity, direction, and breadth of state backing for environmental research are of course important variables in this international comparison. However, this applies to every sort of innovation that is the subject of state attention.

What we are discussing here are the specific characteristics in environmental innovations and their diffusion. There is considerable evidence to support the assumption that autonomous emergence and diffusion of innovations in environmental technology is the exception rather than the rule and that such developments usually remain limited to incremental increases in efficiency in companies. The reverse border-line case is innovation in environmental policy where politics clearly exceeds the given technological possibilities.

The limits of ecological modernization (in the narrow sense) are thus defined by the limits of technology. However, these limits are dynamic. They can be extended by research (and by backing for research). For example, research into the development of procedures for reducing CO_2 emissions, if successful, could substantially widen our room for manœuvre in climate politics – even if only in the sense of end-of-pipe measures. The rapid diffusion of suitable political innovations will then be as similarly predictable as the difficulty and slowness of a structural climate policy which de facto places restrictions on established energy markets (coal, oil).

3 The use of cadmium was regulated in Sweden in the early 1980s with their standards for substitutes being adopted by European industry. Not until the early 1990s, however, were these standards made binding by the European Commission (Bätcher/Böhm/Tötsch, 1992).

4 Combined heat and power (CHP) in industry spread largely autonomously, even though regulatory measures were intended to encourage its use in public power stations.

The variants of this interplay between politics and technology in any case are a central theme in research into the diffusion of ecological innovations, especially when it comes to selectively optimizing such innovations.

6 The meaning of ecological lead markets

The question that now arises is how ecological modernization can be structured against the background of globalization. Globalization, we must assume, has long since affected not only the markets but also environmental policy. And at this point we would like to quote once again the well founded hypothesis that national state environmental policy – irrespective of its other inadequacies – does not figure among the globalization losers (Vogel, 1995; Scharpf, 1998; Jänicke, 1998). On the contrary, in the global arena, the pioneering role of the environmentally more progressive nation states has gained a special significance. Pioneer countries in environmental policy again and again create increasingly demanding environmental regulations for certain sub-sectors of their markets which potentially send out a twofold international signal beyond the boundaries of their national market:

1. A national market may be formed for environmentally-friendly technology acting as a basis for subsequent expansion to bigger markets. This best succeeds if the regulation model responsible for creating this market is politically diffused. For example, a tax preference for fuel-saving cars can help suppliers in that country. And the diffusion of this instrument, e.g. throughout the EU, can bring appropriate market expansion. In this case the signal effect affects the demand side outside the domestic market.

2. The pioneer market with its ecologically demanding regulations can, however, also send out signal effects to the supply side outside the domestic market. For example, California, with its stricter emission rules compared with the rest of the USA, was able to exert a general influence on the car industry (Vogel, 1995). Similarly, Denmark, in 1994, with its targeted promotion of energy-efficient refrigerators, was able to prompt European suppliers to offer such devices there. In cases like these, competitive companies can advertise their ability to supply such demanding market areas as a sure sign of their quality technology.

Reference is made, in a larger research project carried out for the BMBF by the DIW, FFU, IÖW, and ZEW, to “ecological lead markets”. Lead markets generally are “geographic markets which have the characteristic that product or process innovations, which are designed to fit local demand preferences and local...conditions, can subsequently be introduced successfully in other geographic markets as well and commercialized world-wide without many modifications. In the model of international diffusion of innovations a lead market is the core of the world market where the local users are early adopters of an innovation on an international scale” (Beise, 1999: 4). Empirically lead markets are characterized as follows:

- high per-capita income,
- demanding standards and innovative buyers,
- pressure to solve problems and introduce innovations, and
- flexible, innovation-friendly general conditions for manufacturers and consumers (cf. Meyer-Krahmer, 1997).

Ecological lead markets may be regional or national markets for environmentally (more) suitable technologies. They may be stimulated by higher environmental preferences in that country, by special promotion measures, or by political market intervention. They affect competition in other market regions, trigger appropriate responses and adaptations, and lead to the international diffusion of the new technology. The history of environmental protection is rich in examples for lead markets, from the legally coerced introduction of catalytic converters in cars in the USA, by way of government backing for wind power generation parks in Denmark, right through to the CFC-free refrigerator. Another impressive example is the global diffusion of chlorine-free paper, from the political activities by Greenpeace and the EPA in the USA, by way of the introduction of chlorine-free paper whitener in Scandinavian countries and various Greenpeace campaigns in Germany and Austria, right through to effective political market intervention in south-east Asian countries like Thailand (Mol/Sonnenfeld, 2000).

Compared with general lead markets, ecological lead markets, i.e. those with the specific characteristics of environmental innovations, have a number of important special features:

(1) They offer improvements and solutions for environmental problems which are mostly encountered worldwide or at least in a great many countries. Thus technological solutions to environmental problems enjoy, right from the outset and by their very nature, potentially larger markets.

(2) They can usually be traced back and attributed to political activities. These activities involve the national state promotion of such innovations and the propagation of appropriate new technologies by international organizations (see above).

Their significance also increases with the general trend towards “benchmarking”, i.e. the imitation of and alignment with the measurably best possible solution to each problem. When it comes to the ecological modernization of international markets with a view to establishing really sustainable development, the potential for political influence that this represents could be very considerable

7 The limits of ecological modernization

As previously explained the concept of ecological modernization, in its narrower sense, describes the spectrum of technical, system-compliant solutions to environmental problems. In the technocratic view described here, the concept comes up against its limits where potentially marketable technological standard solutions are not available. The so far unsolved environmental "persistent problems", namely deforestation versus land consumption, bio-diversity and threatened species, soil erosion, final storage for nuclear waste, or the global climate (and the need for CO2 clean-up) all, so far, show up these limits. The modernization approach is thus not a viable option where the risk is acute and immediate defensive action is needed.

On top of this comes the fact that incremental increases in ecological efficiency are still not a causal, sustained solution. They are easily wiped out by subsequent growth processes (e.g. specific emission reductions subsequently neutralized by increasing road traffic). The effects of environmental protection are canceled out again by growth and a reduction in pollution tends to be followed by a resurgence in pollution. These facts were recognized as early as the late 1970s as the "dilemma of the n curve" (Jänicke, 1979: 111). This always happens when a problem has to be combated under growth conditions not as a cause but as a symptom. And this dilemma applies not only to clean-up environmental protection (end-of-pipe treatment) but even to efficiency improvements. For example, Japanese industries, between 1973 and 1985, succeeded in saving energy and raw materials in a remarkable way but the high industrial growth in those days simply canceled out this effect (Jänicke/Binder/Mönch, 1997). The overall growth rate must thus always be accompanied by equivalent progress in (compensatory) technology providing environmental relief.

What is needed in the long term therefore is, firstly, a transition from incremental to radical innovations in which ecologically problematic procedures and products are substituted by unproblematic ones (Kemp, 1997: 9). An example is the transition from efficiency improvement in coal-fired power plants to variants of solar energy (so-called backstop technologies). In between lie the border-line cases, a variety of incremental improvements which together represent a radically new quality (e.g. the zero-energy house).

We also need, secondly, structural solutions, i.e. solutions of a non-technical nature, changes in the structure of demand and of industry, and, based on these, an ecological structural policy. Finally we must also tackle the afore-mentioned areas that are difficult to control, namely lifestyle, the level of personal mobility, and residential and accommodation structures, etc. The problem here is not simply that intervention in established interests and behavioral structures needs to go very deep. Unlike the economic-technical variant of ecological modernization we are not dealing here with marketable technical solutions to problems, i.e. new markets for supplies and services with all the usual advantages. There are, for a carefully targeted industrial restructuring away from the environmentally intensive "chimney industries", symptomatically enough, hardly any experience values available. Examples so far, namely the running down of coal mining in the Netherlands or of crude steel works in Luxembourg or the withdrawal from nuclear energy in Italy, were hardly suitable for or capable of diffusion and are unlikely to find imitators. Neither was the real motivation ecological (Binder/Petschow/Jänicke, 2000).

8 Ecological restructuring

Ecological modernization with all its technological innovations is, despite this impressive potential, not enough to ensure long-term environmental stabilization. This is due not only to its inability to cope with all environmental problems but also to the double "*hare and hedgehog-dilemma*" of ecological modernization (in the narrower sense); firstly in the afore-mentioned race between incremental environmental relief and economic growth and secondly in the way that ecological modernization comes up against the limits of the *modernization losers*: If industries and private households save energy, cut their consumption of valuable raw materials, and use environmentally less intensive substitutes, all this will cause losses in the affected industrial sectors (mining, raw materials industry, power generation). However, these in many cases old industries, with established structures of power and influence, often succeed nonetheless in opening up new sales possibilities. For example, the power sector finds new uses for electricity which in turn neutralize the above-mentioned efforts to save energy (e.g. the increasing use of stand-by equipment). In a similar example, the successful environmental protection campaigns against using chlorine have since been canceled out by the expansion of chlorine uses in other areas. So long as any environmentally intensive sector tries in such ways to counteract ecologically desirable decreases in its production, we must go on reckoning with an ecological "n" curve. Ecological modernization is thus severely hampered by the absence of genuine restructuring and by evasive behavior on the part of the modernization losers. Their reaction is of course all too understandable - so long as the adversely affected industries and regions have no alternative perspectives and change takes place in ways that are not economically and socially acceptable.

This is precisely where – strategically speaking – ecological industrial policy should be applied. Its function is above all to make the industrial restructuring which is inextricably connected with ecological modernization socially and economically acceptable. It can promote diversification in other product types or support reductions in capacity where these are economically acceptable. It can also provide social cushioning, retraining, and conversion and reorganization assistance on site. Candidates for such structural policy are, for example, mining, fossil-based and nuclear-based power generation, and many basic and raw material industries. Ecological industrial policy can be recommended especially in those sectors faced by crisis in both ecological and economic terms.

What is needed therefore, parallel to ecological modernization, is to make the restructuring inextricably connected with ecological modernization easier for those affected and to favor innovative investment precisely in the regions affected. The necessities, possibilities, and constraints involved in cushioning ecological modernization by structural policy can be studied by looking at the example of Nordrhein-Westfalen[5]. Here we come up against the limit of the economic-technical modernization concept. Beyond this lies the realm of Sisyphus – the uphill struggle of structural solutions and “persistent problems” – where environmental policy to date has – apart from elements of nature conservation – clearly achieved fewer successes. Here we can expect no assistance from systemic modernization logic, from technological potentials, and from economic-ecological win-win constellations. Here, in many cases, before anything else, we have to remedy the very absence of social and political room for manœuvre. This decisive difference should not be blurred by applying some commonplace concept of ecological modernization. The non-technological, structure-related approaches need a term of their own; “ecological restructuring” would be an apt designation.

9 Conclusions

A long-term strategy for ecologically sustainable development should first of all as a priority exploit the considerable efficiency potentials in ecological modernization and in this way attempt to gain speed and win acceptance in order to improve its chances when it comes to the more difficult structural solutions. Part of this difficult task is to take account of sufficiency requirements.

The modernization approach can rely on genuine trends which can also be selectively reinforced. In the international competition between the developed industrialized countries to offer innovation and attractive commercial and industrial locations, the environment question has gained substantial significance. This also alters export conditions for threshold countries offering products in the “highly developed” EU or OECD markets. Innovations - and especially environmental innovations – are not only a concern of pioneer companies; they are substantially pushed politically by pioneer countries. Pioneer work in environmental technology can only take place within the framework of a corresponding environmental policy. Pioneer countries in environmental protection have made this quite clear ever since the early 1970s. These are nowadays, notably, mainly small industrialized countries, firmly integrated in the global market, such as the Netherlands, the Scandinavian countries, and in the future probably also countries like South Korea. Although globalization is often viewed with pessimism as weakening the nation state, it must be stated on the other hand that: *never before have nation states, and not least small industrialized countries, had so strong an influence on global developments as in today’s environmental policy* – i.e. quite the opposite story to financial policy, for example. This is true both for national environmental planning and for ecological taxation reform. It is also true above all for the innovation- and competition-oriented environmental strategy of ecological modernization (Jänicke/Weidner, 1997; Andersen/Liefferink, 1997). Of course the large industrialized countries

5 Translator's note: Nordrhein-Westfalen, German Bundesland, North-Rhine-Westphalia, home of traditional heavy industry.

can also play this role. After all, the USA, Japan, and Germany – the leading exporters of environmental technology – were all at different points in time themselves pioneers in questions of environmental policy.

All in all, as we have shown, pessimism may be justified regarding structural solutions beyond technological options; but the possibilities of a global strategy of ecological modernization are still far from being exhausted. We are standing here at the beginning of an accelerating development.

Literature

Abgeordnetenhaus von Berlin: 14. Sitzung (Plenarprotokoll 9/14), Aktuelle Stunde, 1982, S. 750-760.

Andersen, Mikael S./Liefferink, Duncan (Eds.): European Environmental Policy. The Pioneers. Manchester

Bätcher, Karen/Böhm, Eberhard/Tötsch, Walter: Untersuchung über die Auswirkungen geplanter gesetzlicher Beschränkungen auf die Verwendung, Verbreitung und Substitution von Cadmium in Produkten. Karlsruhe 1992. (= Fraunhofer-Institut für Systemtechnik und Innovationsforschung).

Beck, Ulrich: Risikogesellschaft. Auf dem Weg in eine andere Moderne. Frankfurt/M. 1986

Beise, Marian: Lead Markets and the International Allocation of R & D. Paper prepared for the 5. ASEAT Conference "Demand, Markets, Users and Innovation: Sociological and Economic Approaches", Sept. 14-16, Manchester 1999

Binder, Manfred/Jänicke, Martin/Peschow, Ulrich (Eds.): Green Industrial Restructuring. International Case Studies and Theoretical Interpretations. Berlin: Springer 2000.

Blazejczak, Jürgen/Edler, Dietmar/Hemmelskamp, Jens/Jänicke, Martin: Umweltpolitik und Innovation: Politikmuster und Innovationswirkungen im internationalen Vergleich. In: Zeitschrift für Umweltpolitik und Umweltrecht. Jg. 22 (1999), H. 1, S. 1-32.

Brickwedde, F. (Hrsg.): Umwelt und Arbeit - Innovationen als Motor des Strukturwandels. Bramsche: Dietz 1997.

Cohen, Maurice, J.: Science and the Environment: Assessing Cultural Capacity for Ecological Modernization. In: Public Understanding of Science, 7 (1998), S. 149-167.

Conrad, Jobst: Successful Environmental Management in European Companies. Berlin 1996 (= Forschungsstelle für Umweltpolitik/Freie Universität Berlin 1996, FFU-Report 96-3).

Hajer, Maarten A.: The Politics of Environmental Discourse – Ecological Modernization and the Policy Process. Oxford 1995.

Hauff, Michael v./Solbach, Daniel Perspektiven integrierter Umweltschutztechnologie in der Bundesrepublik Deutschland. In: Zeitschrift für Umweltpolitik und Umweltrecht, Jg.22 (1999), H. 1, S. 67-85.

Hemmelskamp, Jens/Rennings, Klaus/Leone, Fabio (Eds.): Innovation-Oriented Environmental Regulation. Theoretical Approaches and Empirical Analysis. Heidelberg: Physica 2000.

Hemmelskamp: Umweltpolitischer und technischer Fortschritt. Heidelberg: Physica 1999.

Héritier, Adrienne/Mingers, Susanne/Knill, Christoph/Becka, Martin: Die Veränderung von Staatlichkeit in Europa – Ein regulativer Wettbewerb: Deutschland, Großbritannien, Frankreich. Opladen: Leske + Budrich 1994.

Huber, Joseph: Die Regenbogengesellschaft. Ökologie und Sozialpolitik. Frankfurt/M.: Fischer 1985.

Jacob, Klaus/Jänicke, Martin: Ökologische Innovationen in der chemischen Industrie: Umweltentlastung ohne Staat? In: Zeitschrift für Umweltpolitik und Umweltrecht, 21. Jg. 21 (1998), H. 4, S. 519-547.

Jacob, Klaus: Innovationsorientierte Chemikalienpolitik. Politische, soziale und ökonomische Faktoren des verminderten Gebrauchs gefährlicher Stoffe. München: Herbert Utz Verlag 1999.

Jänicke, Martin (Hrsg.): Umweltpolitik der Industrieländer. Entwicklung - Bilanz - Erfolgsbedingungen. Berlin: edition sigma 1996

Jänicke, Martin: Umweltpolitik: Global am Ende oder am Ende global? In: Beck, Ulrich (Hrsg.): Perspektiven der Weltgesellschaft. Frankfurt/M.: Suhrkamp 1998, S. 332-344.

Jänicke, Martin/Binder, Manfred/Mönch, Harald: "Dirty Industries": Patterns of Change in Industrial Countries. In: Environmental and Resource Economics. Vol. 9 (1997), No. 4, pp. 467-491.

Jänicke, Martin/Weidner, Helmut (Eds.) (in coll. with Jörgens, Helge): National Environmental Policies: A Comparative Study of Capacity-Building. Berlin etc.: Springer 1997.

Jänicke, Martin/Weidner, Helmut (Eds.): Successful Environmental Policy – A Critical Evaluation of 24 Cases. Berlin: Edition Sigma 1995.

Jänicke, Martin: Beschäftigungspolitik. In: Natur. H. 4, 1983, S. 58-59 (= "Alternative Regierungserklärung - Die wahre Wende" der Zeitschrift NATUR).

Jänicke, Martin: Über ökologische und politische Modernisierungen. In: Zeitschrift für Umweltpolitik und Umweltrecht. Jg. 16 (1993), H. 2, S. 159-175.

Jänicke, Martin: Umweltpolitische Prävention als ökologische Modernisierung und Strukturpolitik. Berlin 1984 (engl. 1985), 44 S., (= Wissenschaftszentrum Berlin, IIUG dp 84-1).

Jänicke, Martin: Wie das Industriesystem von seinen Mißständen profitiert. Opladen: Westdeutscher Verlag 1979.

Jörgens, Helge: Die Institutionalisierung von Umweltpolitik im internationalen Vergleich. In: Jänicke, Martin (Hrsg.): Umweltpolitik der Industrieländer. Entwicklung – Bilanz – Erfolgsbedingungen. Berlin: Edition Sigma 1996, S. 59-111.

Kemp, René: Environmental Policy and Technical Change. A Comparison of the Technological Impact of Policy Instruments. Cheltenham (UK)/Brookfield (US): E. Elgar 1997.

Kern, Kristine/Jörgens, Helge/Jänicke, Martin: Die Diffusion umweltpolitischer Innovationen. Ein Beitrag zur Globalisierung von Umweltpolitik. Berlin 1999 (= Forschungsstelle für Umweltpolitik/Freie Universität Berlin, FFU-Report 99-11).

Kern, Kristine: Die Diffusion von Umweltinnovationen. Umweltpolitische Innovationen im Mehrebenensystem der USA. Opladen: Leske + Budrich 2000.

Klemmer, Paul/Lehr, Ulrike/Löbbe, Klaus: Umweltinnovationen. Anreize und Hemmnisse. Berlin: Analytica 1999.

Luhmann, Niklas: Ökologische Kommunikation. Kann die moderne Gesellschaft sich auf ökologische Gefährdungen einstellen? Opladen: Westdeutscher Verlag 1986.

Meyer-Krahmer, F.: Innovation und Nachhaltigkeit im Zeichen der Globalisierung. In: Ökologisch Wirtschaften. 1/1997, S. 20-22.

Ministry of Environment: Our Environment. Stockholm 1996.

Mol, Arthur P. J./Sonnenfeld, David A. (Eds.): Ecological Modernisation Around the World. Perspectives and Critical Debates. London/Portland (Or.): Frank Cass 2000.

Mol, Arthur P. J./Spaargaren, Gert: Ecological Modernisation Theory in Debate: A Review. In: Mol, A. P. J./Sonnenfeld, D. A. (Eds.): Ecological Modernisation Around the World. London/Portland (Or.): Frank Cass 2000, S. 17-49

Murphy, Joseph/Gouldson, Andrew: Environmental Policy and Industrial Innovation: Integrating Environment and Economy through Ecological Modernisation. In: GEOFORUM. Vol. 31 (2000), S. 33-44.

New York: Manchester University Press 1997.

OECD: Managing National Innovation Systems. Paris: OECD 1999.

OECD: Technology and Environment. Towards Policy Integration (Ms). Paris: OECD 1999(a).

Porter, Michael E./van der Linde, Claas: Green and Competitive: Ending the Stalemate. In: Harvard Business Review. September/October 1995, S. 12-134.

Prittwitz, Volker v. (Hrsg.): Umweltpolitik als Modernisierungsprozeß. Politikwissenschaftliche Forschung und Lehre in der Bundesrepublik Deutschland. Opladen: Leske + Budrich 1993.

Richardson, Jeremy J. (Ed.): Policy Styles in Western Europe. London: Allen and Unwin 1982.

Rose, Richard: Lesson-Drawing in Public Policy. A Guide to Learning across Time and Space. Chatham (NJ): Chatham House 1993.

Scharpf, Fritz W.: Die Problemlösungsfähigkeit der Mehrebenenpolitik in Europa. In: Kohler-Koch, Beate (Hrsg.): Regieren in entgrenzten Räumen. Sonderheft 29 der PVS. Opladen: Westdeutscher Verlag 1998.

Simonis, Udo E.: Ökologische Orientierung der Ökonomie. In: Jänicke, M./Simonis, U. E./Weigmann, G. (Hrsg.): Wissen für die Umwelt. Berlin: De Gruyter 1985.

Sturm, Andreas/Wackernagel, Mathis/Müller, Kaspar: The Winners and Losers in Global Competition. Why Eco-Efficiency Reinforces Competitiveness. A Study of 44 Nations. Chur/Zürich: Rüegger 2000.

Tatenhove, Jan van/Arts, Bas/Leroy, Pieter (Eds.): Political Modernisation and the Environment. The Renewal of Environmental Policy Arrangements. Dortrecht/Boston/London: Kluwer 2000.

Vogel, David: Trading Up. Consumer and Environmental Regulation in a Global Economy. Cambridge (MA): Harvard University Press 1995.

Wallace, David: Environmental Policy and Industrial Innovation. Strategies in Europe, the USA and Japan. London: Earthscan 1995.

Weale, Albert: The New Politics of Pollution. Manchester/New York: Manchester University Press 1992.

Zimmermann, Klaus/Hartje, Volkmar/Ryll, Andreas: Ökologische Modernisierung der Produktion. Strukturen und Trends. Berlin: Edition Sigma 1990.