Ecological modernisation: new perspectives

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Abstract

“Ecological modernisation” — understood as systematic eco-innovation and its diffusion — has by far the largest potential to achieve environmental improvements. In general, the market logic of modernisation and competition for innovation combined with the market potential of global environmental needs serve as important driving forces behind “ecological modernisation”. In recent times, however, additional factors like rising energy prices or fears from climate change have favoured the rise of this innovation-based approach to environmental policy. The article deals with two special driving forces: first, there is growing evidence for the importance of “smart” environmental regulation. Secondly, the increasingly complex actor constellation of global environmental governance leads to mounting business risks for polluters and thereby exerts pressure for eco-innovation.

Despite these favourable framework conditions, the strategy of “ecological modernisation” nonetheless faces a number of inherent limitations. These include the unavailability of marketable technological solutions for relevant environmental problems like the loss of species, the rebound effect neutralising the incremental environmental improvements through economic growth (the dilemma of the “N-curve”) as well as resistance by “modernisation losers”. Against this background, structural solutions seem indispensable. Here, eco-innovations should be supported by transition management or ecological structural policy.

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1. “Ecological Modernisation”: linking ecology and economy

For more than 20 years, the concept of “ecological modernisation” has been used to describe a technology-based and innovation-oriented approach to environmental policy. “Ecological modernisation” is different from the purely end-of-pipe approaches in that it encompasses all measures taken to foster eco-innovation and to support the diffusion of these innovations. In general, an environmental problem proves politically less difficult to resolve if a marketable solution exists. In contrast, if a solution to an environmental problem requires an intervention in the established patterns of production, consumption, or transport, it is likely to meet resistance.

The term “ecological modernisation” was coined in the early 1980s to provide a formula for the interplay of ecology and economy. The intention was to link the drive for modernisation in the developed market economies and the long-term requirement for an ex ante more environmentally friendly development through innovation in environmental technologies. The concept was first developed in a study for the “Berlin Science Center” [27,28] and adopted by a small community of Berlin social scientists [52,60,14,19] that are sometimes referred to as the “Berlin School” of environmental policy research [38,48]. In the aftermath, the concept of “ecological modernisation” came to exert a strong influence on the environmental debate in Germany. It was most influential in social-democratic circles, but eventually also reached the green party (Bündnis 90/Die Grünen). This political reception of the concept is mirrored in the “red-green” coalition agreement.
of October 1998 where the new German government spelled out a program of “ecological modernisation”. In the environmental science debate, the concept has been in widespread international use since the early 1990s ([57,16,9,59,40,5], see also Ref. [53]).

Today, the broad reception of the idea of ecological modernization is complemented by the development of a number of alternative concepts that bear similar meanings. “Eco-efficient innovation” — the introduction of environment friendly technology which also increases resource productivity — comes closest to this understanding of ecological modernisation. Actually it is a synonym. It has become part of the EU Lisbon strategy for growth and employment. With respect to the latter concept, a “High Level Group” of the EU Commission stated in 2004 that a “promotion of eco-efficient innovations is needed in major investment decisions”, which should in turn lead “to less pollution, less resource-intensive products and more efficiently managed resources” [34]. The German Presidency of the EU (first half of 2007) has introduced the notion of “ecological industrial policy” [8]. It is the headline of its ambitious memorandum for a “New Deal” in eco-efficient innovation as part of the general economic strategy of the EU [13].

Economic advantages and co-benefits have always been essential in this debate. The same holds true for the role of governments supporting both, the “greening” and the acceleration of technical progress. The Heads of European Environment Protection Agencies recently advanced the concept of “good environmental regulation” that can help to reduce costs, create markets, drive innovation, reduce business risk and assist competitive advantage [42]. In sum, the aforementioned concepts all go far beyond the traditional end-of-pipe treatment and adopt a more comprehensive approach that focuses on environmental improvements through resource efficient innovation.

Modernisation, in economic terms, is the systematic, knowledge-based improvement of production processes and products. The urge to modernise is a compulsion inherent in capitalist market economies, and the increasing competition for innovation in industrialised countries has led to the continuous acceleration of technological modernisation. While the problems inherent in this compulsion for innovation have been discussed at length, it is nonetheless possible to influence the direction of technological progress. In fact, exercising such influence is what governance for “ecological modernisation” is all about. The task is therefore to change the direction of technological progress and to put the compulsion for innovation at the service of the environment. The emphasis of this approach lies on the possibility of ecological-economic “win-win” solutions that can be achieved, above all, through cost reduction and competition for innovation.

“Ecological modernisation” may come in the form of incremental improvement (cleaner technology) or radical innovation (clean technology). Improvement affects such different dimensions as material intensity (efficient use of materials), energy intensity (efficient use of energy), transport intensity (efficient logistics), surface intensity (efficient use of space), or risk intensity (regarding plant, substances, products). Innovation describes the initial market introduction of a new technology that may improve some or all phases of a product’s life cycle. The ecological effectiveness of environmental innovation depends on its radicalness but also on the degree of its diffusion. Incremental innovations that remain restricted to niche markets, for instance, will only have a limited effect. With respect to the degree of diffusion, it is crucial to understand the mechanisms underlying the diffusion of environmental innovations, especially when it comes to developing a global strategy for ecological modernisation. Here, the role of lead markets for environmental innovations has become highly important [6,21].

At present, two driving forces of “ecological modernisation” seem most remarkable:

- The role of “smart” government regulation; and
- Growing business risks for polluters in the context of multi-level environmental governance.

In the long run, these two influencing factors may reinforce each other, thereby increasing the already existing dynamics of environmental innovation. While this may increase the long-term potential for creative environmental governance, there are nonetheless important limits to the strategy of “ecological modernisation” that have to be taken into account.

2. Political modernisation: reinventing government

If we think of “ecological modernisation” as the innovation and diffusion of environmental technologies, we have to take account of the political implications of the concept. Here, environmental innovations, if compared with other innovations, have three distinct characteristics:

- First, due to market failure, they typically need political (or at least organised societal) support. This is why “ecological modernisation” is essentially a political concept.
- Second, environmental innovations are an answer to problems that have (or will have in the future) a global dimension. Therefore, they tend to have global market potential based on global environmental needs.
- Third, the global industrial growth itself creates a demand for environmental innovations since many natural resources are scarce and the sink capacity of the earth is limited.

The most important implication is that eco-innovations invariably require political support — a fact that has been confirmed by a number of empirical studies on the determinants of eco-innovations [21,17,33,3]. Typically, there is interplay between environmental policy-making and technological innovators: politicians in favour of technology-based (marketable) solutions co-operate with industrial innovators that seek regulatory support for their respective technologies. The Phillips Company, for example, supports the EU “Energy-using Products” (EUP) Directive because it gives its technology of power-saving light bulbs a strong market position. In the
same vain, Richard Barrington of Sun Microsystems recently appealed to the European Commission: “We want to see standards being set and market opportunities for companies that meet them” (Environment Daily, 27.1.06). McLaughlin has made similar observations with respect to the automotive industry: “(…) a complex interplay has begun between regulation and competition. The regulatory drive (…) has forced companies to compete against each other on environmental criteria” [37,36].

The particular characteristics of eco-innovations also help to explain why a regulatory “race to the bottom” at the expense of the environment has so far not taken place [12,54,29,18]: environmental regulation does not necessarily restrict innovation. Instead, the environmental issue has increasingly become a “motor for economic modernisation” and an important dimension of the competition for innovation [22]. The view that “environmental policy is contributing to the modernisation” of the industry [39] making firms “fitter and more competitive” is not new ([55], see also Ref. [46]) but has taken a long time to establish itself in environmental politics of more advanced OECD countries [1].

While economic globalisation does not restrict environmental innovation, political globalisation has created an arena for political competition, policy innovation and benchmarking. Here, individual (mostly small) countries claim to be pioneers in the area of environmental policy (see Table 1). There are several reasons why certain governments ascribe to themselves such ambitious roles in environmental governance. Beyond domestic motives (see section 3), there are also incentives to be visible in the international policy arena – an incentive that seems to be especially high for smaller OECD countries.

3. “Smart Regulation”

(Smart) regulation plays an important role in the political competition for environmental innovation and can be identified as a key driving force behind environmental innovation [2]. This important role ascribed to regulation may come at a surprise since deregulation was the leading economic philosophy during the Reagan and Thatcher era. Ever since, the argument that regulation imposes high costs on firms and stifles innovation and competitiveness has remained popular. From the early 1990s, however, a “revisionist”, pro-regulation view has successfully challenged the traditional neo-classical argumentation by highlighting a positive relationship between environmental regulation and a country’s competitiveness (e.g. [47,55]). The reasons for the revival of a pro-regulation approach are manifold. To begin with, neo-classical proposals (that tend to ignore or underestimate the inherent logic of the policy process) have often proved simplistic and had to be compensated by intensive re-regulation. Also, many of the “soft” or “voluntary” policy instruments have been relatively ineffective, involve high transaction costs and need the organisational capacity of the state and the final guarantee of elected governments [30,44,23,10]. Most importantly, it has become a strong argument that the role of government in the context of multi-level governance is a “functional necessity” and has to be reinvented and strengthened, especially if competition for innovation and environmental protection are at stake.

Environmental regulation may create impediments for companies and industries. But generally it also presents a number of distinct advantages for them:

- Regulation can create or support markets for domestic industries. Here, the most interesting cases are the Japanese “Top-Runner” approach for 21 energy-consuming product groups (see Table 3) and the rapidly diffusing German feed-in tariffs for renewable energy.
- Regulation, often initiated by regulatory trendsetters and leading to global harmonisation, increases the predictability of markets. Anticipation of regulatory trends is therefore a typical behaviour of innovative companies under global conditions of growing complexity and insecurity.
- Regulation (real or threatened) can make things easier for business: in contrast to voluntary approaches, affected companies do not have to worry whether their competitors will enact the same measures.
- Regulation also reduces internal impediments in companies to implement technological change (even energy saving potentials are often being ignored for organisational reasons). Moreover, companies do not have to look for support within the value chain, as their customers simply have to accept the change.

The recent comeback of regulation has even led to the emergence of a theory of “Regulatory Capitalism” [36,31]: “The notion of regulatory capitalism (…) rests on a new division of labour between state and society, on the proliferation of new regulatory agencies, on new technologies and instruments of regulation, and on the legalization of human interactions.

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<th>Governments claiming leadership in environmental policy</th>
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<tr>
<td>“(…) Norway shall be (…) world leading (in) environmental friendly energy” (Minister Enoksen, 2005).</td>
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<td>A Finish government program envisages becoming “one of the most eco-efficient societies” (2005).</td>
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<td>Sweden perceives itself as “a driving force and a model of ecologically sustainable development” (1998).</td>
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<td>“The Netherlands efforts in the EU context play an important role alongside its bilateral and multilateral activities” to promote SD (VROM 2003).</td>
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<tr>
<td>The government of South Korea has the objective to become “a model country of environmental preservation” (Green Vision 21, 1995).</td>
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<tr>
<td>Prime Minister Tony Blair has declared that Britain will “take the lead” in climate policy (2004).</td>
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<tr>
<td>Germany claims to play a “leading role” in climate protection (Coalition Agreement 2005).</td>
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| The Japanese METI (2002) proclaimed Japan as a “recycling oriented economic system (…) in which measures for the environment and conservation of resources are built into every aspect of industrial and economic activity”.

Source: own compilation.
Regulatory capitalism is a technical as much as a political order (...). These regulations are shaping a new global order that reflects the set of problems and solutions that were socially and politically constructed in some dominant countries” (Ref. [36], p. 13, 21–22).

While regulation generally celebrates a comeback, the modes of regulation are changing as the focus is now on “smart” or “good environmental regulation” [15,42]. “Highly sophisticated” regulatory instruments are described as “knowledge-embedded instruments (that) are one of the defining characteristics of the new order” (Ref. [36], p. 22). This is especially plausible if we turn to “ecological modernisation” and innovation. As a result of several projects on “Innovation oriented environmental regulation” [58], we propose the following model of innovation-friendly environmental governance (see Table 2).

The Japanese “Top-Runner” approach is a more recent example of an innovation-friendly regulation pattern (see Table 3). So far, it seems to be the most advanced and sophisticated approach to “ecological modernisation”. Both the demanding, calculable and dialog-oriented policy style and the broad but integrated actor configuration match the framework above (see Table 2). This is especially true for the adopted policy mix that combines tight standards with economic instruments based on the national targets of the Kyoto Protocol (even though critics say that this connection is not strict enough). Most importantly, the “Top-Runner” approach supports innovation as a process by taking into account the different phases from innovation (supported e.g. by awards) to diffusion both into the national (lead) market and the international markets. The success story of the Toyota Prius hybrid car can, to a large degree, be directly explained with this kind of innovation-oriented regulation.

Similar examples of “smart” regulation that combine strict standards with flexible implementation are obligatory feed-in tariffs for renewable energy, the EU emission trading scheme and the new EU Eco-design Directive. Interestingly, all these examples of innovation-oriented governance are flexible enough to take investment cycles into account. This is a necessary pre-condition for the economic profitability and the acceptability of this mode of environmental governance.

4. Ecological modernisation in a complex world: growing business risks for polluters?

For environmentally intensive industries, the new approach of “smart” regulation presents both a challenge and an opportunity. The increasingly complex actor constellation in multi-level governance causes a higher degree of insecurity for “dirty” industries that face higher pressures to innovate. This seems to be highly relevant for the global process of “ecological modernisation”. In 2005, some 110,000 companies in 138 countries have certified according to the ISO 14001 scheme. This represents a remarkable increase of 71% compared with 2003 (ISO Press Release, 3 August 2006). At the same time, several large multinationals (e.g. GE, BP, Allianz) now seem to acknowledge the benefits of environmental regulation. Here, the statement by Jeffrey Immelt (GE) may be taken as an example: “Stricter environmental standards do not damage the national economy (...). On the contrary, the country could benefit from higher standards if a core competence for environmental goods is developed” (Süddeutsche Zeitung, 30.5.05). Even if we should not overestimate the real environmental impact of this change in attitude, it is still worth to be explained.

There are several new driving forces behind the accelerating trend towards “ecological modernisation”. Here, we can cite the diffusion of environmental knowledge in the context of the “Rio process” or the growing awareness about climate change, reinforced by recent alarmist studies. Another driving force, however, has gained particular importance: companies need a minimum of investment security for the production and marketing of their products [42]. Today, however, they are challenged by two additional business risks: (1) the high price volatility concerning energy and several mineral resources; and (2) the uncertainty about environmental pressures and requirements in the context of increasingly complex

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Table 3

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<tr>
<th>Smart regulation for eco-innovation: the Japanese “Top-Runner” approach</th>
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<tr>
<td>- METI regulation for 21 energy-using products.</td>
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<td>- The “top-runner” regarding energy efficiency becomes the basis of the product standard (weighted average).</td>
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<td>- Efficiency standard becomes mandatory for national producers and importers once the target year is reached.</td>
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<td>- “Name and shame” approach is used as an intermediate instrument.</td>
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<td>- Combined regulations:</td>
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<td>- Green Procurement Law (2001),</td>
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<td>- Green automobile tax,</td>
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<td>- Annual awards for energy efficient products, energy label, support for innovative retailers.</td>
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<td>- The fulfilment of the standards is generally “very positive”: several products have achieved the standard before the target year (air conditioners, cars, computers, videotape recorders).</td>
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<td>- Increased competitiveness of the products confirmed by producers.</td>
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Source: own compilation based on Ref. [41].

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Table 2

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<th>Elements of a “smart” and innovation-friendly framework of environmental regulation</th>
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<td>Instruments are innovation-friendly if they...</td>
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<td>- provide economic incentives,</td>
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<tr>
<td>- act in combination,</td>
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<tr>
<td>- are based on strategic planning and goal formulation,</td>
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<tr>
<td>- support innovation as a process and take account of the different phases of innovation/diffusion.</td>
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| A policy style is innovation-friendly if it is...                                |
| - based on dialog and consensus,                                                 |
| - calculable, reliable, and has continuity,                                     |
| - decisive, proactive, and demanding,                                           |
| - open and flexible,                                                            |
| - management-oriented.                                                          |

| A configuration of actors is innovation-friendly, if...                          |
| - it favours 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.                        |

Source: Jänicke et al. [25].
multi-level and multi-actor governance. Innovation in the direction of eco-efficiency can be the answer to such challenges.

Insecurity as a driving force behind “ecological modernisation” requires some further explanation. There has been an “explosion of complexity” in the actor constellation underlying environmental governance since the early 1970s. Originally, the actor constellation of environmental policy was rather simple (see Fig. 1): government regulated (or at least tried to regulate) the environmental behaviour of polluters through one-sided action of command and control. While there may have occasionally been some pressure from NGOs or the media or bilateral forms of co-operation between government and the target group, the actor constellation remained fairly simple compared with today. Over the last 30 years, however, the actor constellation has been subject to radical changes (see Fig. 2).

Globalisation and the need for multi-level and multi-stakeholder approaches to governance have led to a constellation where not only governments and industry but also NGOs act at all levels of the international system. Vertical and horizontal co-operation and co-ordination has become a great challenge [35]. Governments increasingly interact not only with other governments but also with a broad variety of economic and societal actors. Civil society actors — NGOs, scientific organisations, the media — on the other hand, do not only interact with government but often establish a direct relationship with the business community that takes the form of both confrontation and co-operation.

Why has this increasingly complex actor constellation led to additional insecurity and economic risks for polluters? And how can a focus on eco-efficiency contribute to higher economic security?

Multi-level governance provides numerous opportunities to exert pressure against resistant polluters. In the past, companies had only one relevant partner — the national government (see Fig. 1), which could sometimes even be “captured” by the polluting industry. From the late 1980s, as NGOs and the media turned to direct attacks against polluters, companies had to learn that they cannot “hide” behind governments. The Brent Spar conflict is a prominent example for this kind of pressure. The increasing complexity of the actor constellation has made environmental pressures and obligations almost unpredictable and therefore led to increased economic risk and insecurity for polluters. In the short run, powerful polluters may be able to successfully act as veto-players but in the long run this strategy may prove counterproductive. Today, more than before, polluters have to act under different pressures that can be defined as pressure for innovation. This is especially true for competitive product markets.

The pressure for innovation regarding eco-efficient technologies is caused by a large variety of factors that include not only price explosions but also new competing technologies or new headlines. In the highly complex actor constellation of global environmental governance, this pressure for innovation can be exercised from below (local NGOs or consumers), or from above (the EU or international institutions), or from both sides. It can originate from competitors as well as from pioneer countries that initiate new regulatory trends causing “regulatory risk” for polluters [20]. Horizontal pressure through political and/or technological competition has become especially important in this context. This is the mechanism where even powerful (veto)players like the U.S. government are in a weaker position.

5. The post-Rio mode of global environmental governance is essentially knowledge-based

The rise of “smart” regulation and growing business risks for polluters in the context of multi-level environmental governance help to explain the present dynamics of “ecological modernisation”. While this strategy has certainly high potential and is in principal without alternative, it is nonetheless important to recognise the limits of the approach. In this section, we first discuss the weaknesses of purely knowledge-based environmental governance, before we come to address the inherent limits of a technology-based approach to environmental policy (see Section 6).

“Post Rio” global environmental governance is essentially characterised by processes of policy learning and horizontal “lesson-drawing” [49,50]. The creation and diffusion of environmental policy innovations — with “ecological modernisation” at the core — is therefore a predominantly knowledge-based process. While the important role of knowledge in current global environmental governance has generally led to unexpectedly positive results, one has to bear in mind that predominantly knowledge-based policies also encounter inherent limits, in particular with view to policy implementation.

![Fig. 1. Original actor constellation of environmental policy.](image1)

![Fig. 2. Dimensions of modern environmental governance. Source: Jänicke 2003.](image2)
On the one hand, the knowledge-based “Rio process” can be regarded an impressive “success story”. The “Rio model of environmental governance” encompasses the principles of monitored targets, co-operation, participation and policy integration and is thereby the only steering approach that takes into account the increasingly complex actor constellation of global environmental politics [23]. The widespread adoption of “Agenda 21” at all levels of government is highly remarkable since it took place in the absence of legal obligation and/or coercion. While National Strategies for Sustainable Developments (NSSDs) now exist in most countries, a total of 113 countries had initiated at least 6400 local Agenda 21 processes as of 2002 [43]. This spread of knowledge-based policies and the somewhat declining role of power-based strategies is a highly important development. To a certain degree it has changed the political geography: small innovative pioneer countries such as Sweden, the Netherlands, or Denmark exert strong influence on the development of global environmental policy. By offering innovative solutions for global environmental needs, these countries demonstrate that they do not have to be powerful to be influential: if their solutions have a demonstration effect and are widely communicated, they can even exert pressure for change within other countries. Even the US has been forced to adopt a defensive position in the field of climate policy and cannot easily ignore political and technological innovations.

This apparent success of the knowledge-based “Rio model” is, however, only one side of the story. On the downside, the enduring power-based resistance of polluters points to the inherent limits of the knowledge-based approach to environmental governance: powerful polluters (often supported by “their” ministries or governments) can resist knowledge-induced change, especially in cases where vested sectoral interests are affected. Power always has the privilege to ignore and not to learn [11]. Powerful actors can be highly innovative and ready to learn. But the pressure to do so is lower compared with actors that do not have much power at their disposal.

The limits of the knowledge-based approach become especially visible if we turn from agenda setting and policy output to policy implementation and outcome. Here, the remarkable success of the Rio process in the areas of agenda setting and policy diffusion stands in sharp contrast to persistent deficits in policy implementation and actual policy outcomes. This discrepancy can be illustrated at the example of National Strategies for Sustainable Development (NSSDs): even though most countries now have an NSSD in place, only 12% have actually moved to the stage of implementation [45]. This is hardly surprising since implementation is the phase of the policy cycle where vested interests — the potential losers of “ecological modernisation” — tend to mobilise powerful resistance. As innovative knowledge often clashes with the interests of traditional polluters, there is a need to reinvent government regulation and find ways to ensure improved implementation. In this context, soft “positive” modes of sectoral “transitions management” [32] do not seem to be sufficient. In addition, the various forms of “negative” pressure for environmental innovation (see Table 4) seem to be a promising driving force. As demonstrated above, the complex actor constellation of global environmental governance offers a huge array of opportunities to exert pressure for environmental innovation — a potential that may be exploited by improved environmental governance and should therefore be subject of future research.

6. Environmental governance beyond technology

While knowledge-based approaches to environmental governance can meet power-based resistance, the strategy of “ecological modernisation” faces additional difficulties. First, the concept encounters inherent limits where (potentially marketable) technological solutions are not available. The “persistent problems” of environmental policy — namely urban sprawl, soil erosion, the loss of biodiversity, the final storage of nuclear waste, or global climate change — all exemplify these limits. Also, the modernisation approach is in general not a viable option when risk is acute and immediate defensive action is needed.

Secondly, incremental increases in environmental efficiency can often not be considered a sustained solution since they tend to be easily wiped out by subsequent growth processes (rebound effect). Reductions in the specific emissions of cars, for instance, can subsequently be neutralised by increasing road traffic — a problem that was early recognised as the “dilemma of the N-curve” [26]. This dilemma affects both end-of-pipe treatment and incremental “ecological modernisation”. With respect to the latter case, we can cite the example of Japanese industries that achieved remarkable savings in the use of energy and raw materials between 1973 and
1985 — achievements that were simply neutralised by the strong industrial growth during this period [24].

The described “dilemma of the N-curve” requires more far-reaching solutions. A first solution lies in the transition from incremental to radical innovations where environmentally intensive production processes and products are substituted by environmentally neutral ones. A well-known example in this respect is the transition from efficiency improvements in coal-fired power plants to variants of solar energy. In between lie the borderline cases — a variety of incremental improvements that together achieve radical improvements (e.g. the zero-energy house). Moreover, structural solutions are needed. These require the development of an “ecological structural policy” that imposes non-technical solutions in form of changes in the structure of supply and demand. This does not only affect the structure of industry but also individual life-styles (e.g. personal mobility, housing). The problem here is not only that structural solutions would deeply affect established interests and behavioural structures. More importantly, structural solutions cannot rely on a strategy of “ecological modernisation” since the existing problems cannot be solved through marketable technological innovations. Against this background, it is hardly surprising that there is so far no empirical evidence for carefully targeted industrial restructuring away from the environmentally intensive industries. Existing examples such as the shutdown of Dutch coal mines, the closure of steel mills in Luxembourg or the nuclear power phase-out in Italy were not environmentally motivated [7].

In sum, “ecological modernisation” is — despite its impressive potential — not sufficient to ensure a long-term stabilisation of the environment. This is not only due to its inability to offer solutions for every type of environmental problem but also to a double “hare and hedgehog-dilemma”: on the one hand, “ecological modernisation” suffers from the aforementioned race between incremental environmental relief and economic growth. On the other hand, “ecological modernisation” meets the resistance of “modernisation losers”: if industries and private households save energy, cut their consumption of valuable raw materials, and use environmentally less intensive substitutes, all this will reduce the profits of the respective industrial sectors (mining, raw materials industry, power generation, etc.). Nevertheless, these “old” industries — with established structures of power and influence — often succeed in opening up new sales opportunities. The energy sector, for instance, finds new uses for electricity, which in turn neutralises the above-mentioned efforts to save energy. Similarly, the successful environmental protection campaigns against the use of chlorine have been overcompensated by the expansion of chlorine use in other areas. As long as environmentally intensive sectors try to counteract ecologically desirable decreases in their production, an “N-curve” can be expected. “Ecological modernisation” is thus severely hampered by the absence of genuine restructuring and by evasive behaviour on the part of the modernisation losers. As long as no alternative economic perspectives are available, their counterproductive reaction is all too understandable and policy changes appear economically and socially unacceptable.

Strategically speaking, this is precisely where “ecological industrial policy” becomes relevant. Since industrial restructuring is inextricably connected with ecological modernisation, “ecological industrial policy” should make the restructuring process socially and economically acceptable. It can promote diversification in product types or provide social cushioning, retraining, and conversion of the work force. Environmental innovations should be as creative as possible to prevent resistance of the losers of “ecological modernisation”. Innovation has also been described as “creative destruction” [51]. Therefore it can also mean heavy conflict with vested interests [4]. Power-based resistance to necessary action — climate protection being the most prominent example — may be countered by conflict strategies targeting the vulnerabilities that have arisen for non-innovative polluters. The softer approach would be a dialog strategy which confronts polluters with questions about: (a) their contribution to long-term environmental problems, (b) the related economic risks, (c) the available options (innovations, diversification, best practice) and (d) the potential government support needed. This could be the basis for strategic sectoral targets, activities and monitoring mechanisms.

7. Conclusion

In the light of the foregoing discussion of the strategy of “ecological modernisation”, I come to the following conclusions:

1. The potential of “ecological modernisation” to radically reduce the environmental burden of industrial growth is without any alternative. The technological potential of “green electricity”, for instance, is estimated to be almost equivalent to the present global power supply [56]. No strategy of “sufficiency” or of changing life-styles could ever have a similar potential.
2. Driving forces behind “ecological modernisation” are the following:
   - The capitalist logic of technological modernisation and the competition for innovation in combination with the market potential of global environmental needs: marketable technological solutions for environmental problems offer a broad spectrum of “win-win-solutions”.
   - “Smart” environmental regulations by pioneer countries, characterised by the interplay of high environmental pressure and high innovation capacity are often motivated by potential competitive advantages. Environmental regulation is often an important prerequisite for both the innovation and diffusion processes.
   - Growing economic insecurity and risks for polluting industries in the context of the increasing complexity of global environmental governance. This increase in business risks makes “ecological modernisation” a more secure strategy for environmentally intensive companies.
3. There are, however, important limits to the process of “ecological modernisation”:
   • Economic growth tends to neutralise environmental improvements if increases in eco-efficiency remain incremental (below the growth rate), if environmental innovations are restricted to niche markets and/or if the “solution” addresses the symptoms, not the causes.
   • “Ecological modernisation” typically meets the resistance of “modernisation losers” that are often powerful enough to limit the scope and effects of environmental policy. “Modernisation losers” may not be strong enough to prevent environmental innovations and knowledge-based policies. But when it comes to policy implementation, power-based resistance remains an important obstacle.

4. As a consequence, governance for “ecological modernisation” has to find new ways to overcome the resistance of powerful polluters. Fears arising from “creative destruction” should be reduced through co-operative transition management. But the carrot will need a stick. Environmental governance must also include structural solutions. A more conflict-oriented approach that increases pressures for environmental innovation under the conditions of growing complexity and insecurity seems possible and indispensable. While growing risks for polluters and the rise of “smart regulation” seem to hold a large potential for improved environmental governance, the exact design of improved strategies requires further research.

5. “Ecological modernisation” as a market-based approach has so far been fairly successful. If compared with structural solutions, it seems to be the easier approach to environmental policy. Having studied processes of “ecological modernisation” in theory and practice for almost 25 years, I do, however, see the danger that we content ourselves with the “low hanging fruits” of marketable “win-win solutions”. At the end of the day, governance for sustainable development cannot succeed if it does not include structural solutions. As the crucial task remains the prevention of long-term environmental disruptions of all kinds, industrial transformation will inevitably clash with vested interests. Governance for sustainable development must therefore, mobilise the will and capacity to win this struggle. This is not going to be easy. Sorry about that.

References
