“Designing environmental policy to be innovation friendly”

Final Report

Edited by Yves Tressel (CM International)

Contributions by:
Nicolas Kandel & Laure Thoraval (CM International)
Frans Oosterhuis (Institute for Environmental Studies)
Ben Shaw & Paul Ekins (Policy Studies Institute)

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Preface and acknowledgements

This report is the result of the project “Designing Environmental Policy to be Innovation Friendly” (contract # 07010401/2006/452189/MAR/G1). The objective of this project was to analyse critically ways of making environmental policy as conducive to innovation as possible.

This was done on the basis of an extensive literature review, followed by a critical analysis of a number of recent policy areas. The findings informed the elaboration of a set of operational guidelines designed for policy makers.

The project was carried out by CM International (coordinator) in collaboration with the Institute for Environmental Studies (IVM) and the Policy Studies Institute (PSI). The Commission’s contact person was Christian Hudson, National Expert on Sustainable Development and Economic Analysis of the DG Environment, Unit G.1.

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Executive Summary

The primary objective of environmental policy is to reduce the potentially harmful impact of human, and more specifically, economic activity on the environment. To this end and in view of the ecological challenges mankind faces today, it needs to foster far-reaching changes, both in individual behaviour and consumption patterns, as well as product characteristics, industrial processes and resource use. In other words, in order to address the ecological challenge efficiently and lastingly, environmental policy needs to stimulate and promote innovative approaches wherever it can. Innovation is a key means to reaching environmental objectives and realising sustainable development goals.

There are different policy approaches and different policy instruments available to policy-makers. The type of approach and instrument retained will impact both the nature of innovation and the speed of its diffusion. It is therefore indispensable for policy-makers to clarify right at the outset the type of innovation aimed for in order to elaborate appropriate policy packages.

An innovation emerges, thrives and succeeds (or fails) within a context. This so-called innovation context comprises various elements. There are four main dimensions characterising an innovation context, namely: the state of research and development as well as the existence and nature of remaining technological barriers to be overcome; the ease with which industry takes up the R&D output and transforms it into a marketable and competitive offer; the degree to which an effective market demand for the new product exists or can be created; the existence of an appropriate regulatory framework providing incentives for companies to engage in and adopt innovations.

What is more, each dimension corresponds to different barriers to and drivers of innovation. These barriers need to be addressed in order for innovation to be successful. Scientific and technological barriers are thereby most efficiently addressed by research and development. This can be carried out both by companies and public research institutions, such as research centres and universities. Stimulating relevant R&D is thereby not only a matter of subsidies. In fact, in order to stimulate both the private and public research effort, public policy may provide important organisational and information-related support as well. Also, consistent, stable and clear policy objectives are crucial as they limit
the perceived financial risk in the eyes of potential research actors and/or investment bodies.

At the same time, however, the main barriers to innovation are by no means always scientific-technologic. In fact, once a technological solution to a given problem has been identified, it still needs to be taken up by industry in order to find its way onto the market. This step is far from automatic and frequently constitutes a serious stumbling bloc in the innovation process. The ease with which industry succeeds in turning the R&D output into a marketable and competitive offer is of crucial importance to the success of innovation. In order to stimulate the emergence of a corresponding industrial offer, public policy needs to help bridge the gap between research and industry, stimulate the emergence of the necessary technological infrastructure and distribution channels and simplify regulatory requirements in order not to discourage the uptake of R&D by industry, particularly on behalf of SMEs.

For companies to engage in innovation, i.e. to conduct R&D and develop corresponding industrial offers, they need to expect a future business advantage from it. However, environmental innovations tend to be costly and thus uncompetitive vis-à-vis conventional technologies, at least during the early innovation phase. Public policy has various economic instruments at its disposal, such as market-based instruments, public procurement schemes and the development of small market niches that are particularly receptive to its advent, in order to defend the innovation against this economic disadvantage and help it emerge onto the market. Public policy may thus alter the incentives for innovation by creating markets for new products and processes while limiting those for less environmentally benign ones.

At the same time, the market’s tendency to resist innovations should not be underestimated even after market demand has been raised above the critical level in order for the innovation to become a cost-efficient operation. Even when the offer is competitive, an additional effort may be necessary to help the innovation gain a solid market foothold, be widely diffused and become established by the mainstream. The innovation’s market diffusion can thereby be significantly encouraged by means of demand support schemes as well as largely complementary, information-based approaches, together with public education campaigns.
While it is thus indispensable to take account of the innovation's context specific parameters, there is no “cookery book” or “magic formula” that will ensure that environmental policy automatically leads to specific green innovations. Innovation is an inherently uncertain process, full of surprises and unexpected outcomes. What is more, it is extremely difficult to draw definite conclusions about innovation and policy. Effective policy for innovation depends crucially on the wider context parameters as well as the corresponding innovation barriers. Depending on the contexts, sometimes one type of policy instrument will be more appropriate, sometimes others.

While not all the policy measures that are necessary to overcoming potential innovation barriers fall into the domain of environmental policy making, their complementarity is such that a strong case for integrated policy approaches can be made, comprising environmental and innovation, as well as science and educational policy. Accompanying measures are often indispensable for making environmental policy conducive to innovation. By taking account of this complementarity, the Impact Assessment and Policy Guidelines developed in the context of the present study serve a dual purpose: they constitute a manual for setting up integrated policy approaches at EC level, while at the same time constituting a checklist informing the formulation of recommendations as to key complementary measures to be implemented by national policy makers.

The project's main outputs are:

- **Impact Assessment Guidelines**: A three-paged document designed at raising awareness amongst policy-makers as to the importance of innovation to the success of environmental policy-making, and containing a checklist designed to help policy-makers draft more effective policies, by taking account of their impacts on innovation;

- **Policy Guidelines**: A complementary, more detailed and more illustrative background document, structured along the lines of the three-pager and providing a series of policy guidelines as to the choice and design of innovation-friendly environmental policy.
1. Introduction

Environmental concerns have traditionally been thought to be largely at odds with economic growth and prosperity. It is only the advent of sustainable development - a concept which the Brundtland Report defined in the late eighties as a process that "meets the needs of the present without compromising the ability of future generations to meet their own needs" - that the perception of an inherent antagonism between economic growth, social development and environmental protection gradually evolved. In fact, ample evidence suggests today that, by modifying relative incentive structures and production constraints, environmental regulation can act as a powerful stimulus to innovation and economic growth. Innovation provides thereby the key means by which economic growth and environmental protection are reconciled.

Environmental policy has an impact on innovation and thus it constitutes an indispensable element in the achievement of the Lisbon agenda (2000) which set the objective of “[making] the European Union the most competitive and dynamic knowledge-based economy in the world by 2010”. Acknowledging not only the central role innovation was to play in the realisation of these ambitious goals but also the direct impact environmental policy has upon underlying innovation dynamics, the Lisbon agenda called for regulatory frameworks that were both cost effective and innovation conducive.

Since then, the European Council adopted the Sustainable Development Strategy (Gothenburg, 2001) whose guiding principles were reaffirmed in 2005 and which is largely complementary to the strategic outlines contained in the Lisbon agenda. With the presentation of the “Environmental Technologies Action Plan” (2004), the European Union acknowledged the strategic importance of eco-innovation, with state-of-the-art environmental technologies not only contributing to improved environmental performances, but also potentially making the production process more cost effective while also turning into successful export products.

The common denominator of these different policy initiatives is the clear understanding that innovation has a strategic role to play in the realisation of the objectives of sustainable development.
Against this background, the objective of the present project of which this report summarises the results was to:

✓ Analyse ways of making environmental policy and regulation as innovation friendly as possible;
✓ Elaborate a set of concise and operational guidelines likely to help policy makers within the DG Environment and beyond to make environmental policy as conducive to innovation as possible.

The study thereby comprised the following elements:

✓ An extensive literature review, in order to gain a comprehensive overview of current thinking and recent debates on the impact of environmental policy making on innovation;
✓ Three case studies based on consultation with a variety of innovation stakeholders, in order to
  o Obtain additional information in areas which are either relatively poorly documented or contested,
  o Gain further insights into the behavioural motivations underlying innovation,
  o Illustrate the findings obtained;
✓ An extensive consultation with external experts and policy-makers (within the DG Environment), in order to test, enhance and validate the policy guidelines.

The literature review and the case studies have thereby provided the descriptive input for the analytical transformation of the data available, eventually resulting in the elaboration of the questionnaire of the Impact Assessment Guidelines as well as the Policy Guidelines. Their relevance is, in turn, guaranteed by means of an illustrative complement, adding context specific information that is indispensable to the full appreciation of the policy contexts’ complexity.
Summarising the findings from all three phases of the project, the present report is thereby structured as follows:

- Chapter 2 briefly introduces the meaning of innovation, its different phases as well as the arguably most influential theoretical approaches;
- Chapter 3 places innovation within the context of environmental policy-making and discusses its particularities;
- Chapter 4 introduces the project’s main outputs, i.e. the Impact Assessment Guidelines as well as the Policy Guidelines;
- Chapter 5 contains the various annexes, notably:
  - The project’s main outputs;
  - The summary reports of the case studies;
  - The list of external experts consulted;
  - The database of the literature analysis.
The project's main outputs, i.e. the *Impact Assessment Guidelines* as well as the *Policy Guidelines*, are fully autonomous in that they are stand-alone documents that do not require any additional information.

The present report's main objective is:

- To assemble the different project deliverables (Chapter 5);
- To highlight the context in which the project emerged (Chapter 1 & 4);
- To provide some supplementary information that, albeit not indispensable to the understanding of the project’s main outputs, may facilitate their lecture (Chapter 2 & 3).
2. Introducing innovation

2.1 The meaning of innovation

Innovation is a regular feature of human existence. Innovation thereby refers to the process of making improvements and introducing something new, either in terms of products, processes or services. It comprises both the invention, innovation and diffusion phases. While successful innovation provides added value, in terms of increased profits and market shares as well as a generally improved competitive standing, it also involves risks related to the uncertainties of its outcome. Innovation is a complex, interactive, multi-level process of change.

In the environmental context, innovations commonly refer to measures designed to minimise the environmental impact while also reducing energy and material throughput. A specific feature of environmental technology is the particular mechanism by which the environmental impact is reduced. In the environmental sphere, one commonly distinguishes between three types of innovations:

- Innovations concerning so-called “end-of-pipe” technologies whose objective is to isolate or neutralise polluting substances after their production;
- Innovations concerning “process-integrated” technologies whose objective is to lessen pollution as well as resource and/or energy throughput by means of changes in processes and production methods;
- Innovations concerning products whose environmental impact has been reduced (by means of containing fewer harmful substances, using less energy, producing less waste, etc.).

Moreover, the intensity of innovations may vary. The extent to which an innovation implies changes in material and energy throughput, the skills required as well as underlying organisational routines, corresponding consumption patterns, etc differs greatly. An innovation can thus be “incremental” or “radical”. Incremental, or sustaining, innovation refers to limited changes to already existing products and processes, allowing organisations to continue approaching markets in basically the same way. Radical innovation, by contrast, implies more fundamental changes of the underlying system. Involving larger leaps of understanding, they also tend to imply
more risk due to higher uncertainty about future outcomes. Obviously, these are two extreme types and many innovations will be somewhere in between them. Different kinds of innovation objectives call thereby for different policy approaches.

2.2 Different phases of innovation

The innovation process comprises different phases. The life cycle of innovations can thereby be described using the “s-curve” or diffusion curve. The s-curve maps the extent of market penetration against time. In the early stage of a particular innovation, growth is relatively slow as the new product establishes itself. At some point customers demand sets in and market uptake develops more rapidly. New incremental innovations or changes to the product allow growth to continue. Towards the end of its life cycle growth slows and may even begin to decline.

*Figure 2. Different phases in the innovation cycle*

The progressive acceleration of market uptake is thereby not only due to the fact that the technology is becoming more widely known, but also to improvements and cost reductions occurring in the course of the diffusion process due to economies of scale\(^1\) and learning effects\(^2\).

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\(^1\) Economies of scale refer to the reduction of average cost of production per unit due an increase in volumes produced.

\(^2\)
Again, evidence clearly suggests that different policy approaches, by influencing different parameters, are most effective at particular stages in the innovation cycle. To provide but a very basic example: while the policy of setting up R&D networks might make sense at early invention stages, it is generally far less appropriate during later stages in the innovation cycle.

2.3 Main theories of innovation

Innovation has been studied in a variety of contexts and there exist different conceptualisations of innovation. In the context of environmental policy-making, the arguably most relevant approaches to conceptualising the advent of innovation are the technology push / market pull and the co-evolution approaches. Policy-makers should be aware of their main strands so that they can design environmental policy to promote innovation.

2.3.1 Techno push / market pull approach

Based on an essentially linear conception of the innovation process, the technology push / market pull approach considers innovation as an element that is subject to two distinct, but complementary forces, i.e. technology push and market pull. The underlying dynamics can be graphically depicted as follows:

*Figure 3. Schematic presentation of techno push-market pull dynamic*

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2 The learning curve effect and the closely related experience curve effect express the relationship between experience and efficiency. As organisations get more experienced at a task, they usually become more efficient at them.
The early innovation stages are generally characterised by the technology push logic. The principal drivers for technologies to be explored, developed and brought to the market are business and policy decisions. The technology is pushed onto the market. During the commercialisation and diffusion phases, by contrast, consumer demand progressively develops and pulls the technology onto the market. In fact, both forces are present, at least to some extent, most of the time: while during early R&D stages potential market demand provides an important incentive for technology development to be undertaken, even during the diffusion phase R&D driven technological changes may occur.

During early R&D right to the demonstration stages, public support (financial and other) is relatively important. For technologies of potential public benefit but uncertain market demand this may even be necessary to help the technology from the demonstration to commercialisation and to the diffusion stages. Generally, however, as innovations become increasingly competitive, market demand progressively replaces public support for technologies as the dominant driver for the diffusion of innovation.\(^3\)

### 2.3.2 The co-evolutionary approach

Going beyond the highly useful, but somewhat simplistic conceptualisation of innovation as a result of technology push and market pull factors, the co-evolutionary sub-system approach\(^4\) depicts innovations as being based on the co-evolution between technology, science, users’ needs, policy and society needs and values. In other words, for innovations to become established in the mainstream, they need to be consistent with developments in society across a number of different dimensions: science and technology, economics, politics and infrastructure, as well as culture. The different dimensions interact and mutually influence each other and they have to be aligned for innovation to be successful.

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Despite relatively strong public support, the large-scale diffusion of electric vehicle, for example, is made difficult due to the divergence of the different dimensions impacting innovation. In fact, policy objectives, societal needs, the preferences and the practices of users and the innovative activities of the automobile industry do not converge towards the same trajectory. This misalignment of the subsystems prevents lead markets and strategic niches (e.g. public transport) from diffusing to mass markets.\(^5\)

While environmental policy needs thus to be sensitive to the wider framework conditions which will ultimately condition its very success, its full potential can only be realised when being elaborated in close association with other, largely complementary policy approaches, such as innovation, science and educational policies.

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3. Environmental policy and innovation

Innovation does not occur in a vacuum, but is being shaped by an important number of factors. While innovation is a regular feature of market-oriented economies, its manifestation is largely insensitive to environmental concerns, and appropriate environmental policy is required to modify inherent incentive structures and production constraints. The design of public environmental policy, in turn, impacts innovation in many ways. Interfering either by means of market forces or through direct regulatory action or support, public policy disposes of a large panoply of instruments that may be activated in the pursuit of environmental objectives. At the same time, environmental policy constitutes but one stimulus to innovative activity, the importance of which varies greatly depending not only on the policy instrument chosen (as well as its design and implementation mode), but also on the wider framework parameters.

3.1 Main approaches to stimulating innovation

There are different approaches to stimulating innovation and environmental policy makers should be aware of their respective specificities. One can broadly distinguish between three main approaches, which are highlighted in the following schema at the example of renewable energies.

Figure 5. Different approaches to stimulating innovation
Approach (1) focuses on support provided for R&D activities in order to turn inventions into marketable products whose competitiveness is to be guaranteed due to years of continuous R&D investment and ongoing improvement. Apart from the fact that this kind of R&D project frequently turns out to be rather costly, the approach has the further inconvenient that once the technological solution is competitive, effective market uptake may be limited due to the absence of industrial actors ready to commercialise it.

Approach (2), on the other hand, foresees policy support rather being focused on the development of market demand and thus the acceleration of the corresponding learning curve, by means of the implementation of a variety of market-based instruments, such as guaranteed feed-in tariffs and environmental taxes. This option entails, however, the serious risk of encouraging the diffusion of “second-best” technology solutions, i.e. solutions that would have been likely to be further improved in the absence of public intervention.

Approach (3), in turn, features a more balanced evolutionary model that attempts to establish integrated network systems in which the separation between research and industrial application is partly removed and which allow a specific technology to emerge, develop and diffuse niche by niche. Acknowledging the importance of the existence of an industrial offer for a technology’s eventual market uptake, the approach’s focus is on emerging niches, on the strengths and weaknesses of the incumbent technological regime and on how appropriate niches may be promoted within it (by means of an iterative development process).

Frequently real life conditions are far less clear cut and call for a combination of different approaches in order to successfully stimulate innovation and effectively accompany a given technology throughout the innovation process. The eventual relative preference of one approach over another is thereby directly dependent on the policy objectives and the innovation context at hand.

3.2 Innovation context: barriers and drivers

There exist multiple barriers to as well as drivers of innovation. The eventual success of environmental policy depends to no small extent on a clear understanding of the complex relationships between them. Allowing the identification of innovation barriers, the analysis of the innovation context constitutes a precondition for the elaboration of innovation friendly environmental policy.
For innovations to become established in the mainstream, they need to be in line with all of the innovation context’s different dimensions (which, in turn, correspond with the potential innovation barriers). An innovation context can be described as a function of four distinctive parameters, namely science and technology, the prevalent market and demand structure, the dominant technology application systems, as well as the political and institutional framework. While the relative importance of the corresponding innovation barriers varies from case to case, a failure to address any of them is likely to jeopardise the policy’s overall effectiveness.

The sector specific information gained from an analysis of the innovation context at hand will help inform the elaboration of policy packages and accompanying measures most suited in order to attain the underlying policy objectives.

*Figure 6. Characterising an innovation context*
The innovation context at hand: science and technology

The science and technology parameter plays an obvious role in the analysis of the context within which an innovation is aimed for. The existence and nature of scientific and technological barriers as well as the state of advancement of the research effort, both public and private, will directly impact on the policy options to be retained. Moreover, attention should be paid to the nature of the technological regime, i.e. the degree of appropriability, the nature of knowledge as well its cumulativeness. Another complementary element to be taken into account relates to the relative strength of a given research sector and its chances to successfully compete on the international level. This latter consideration will be weighed against the costs involved in pursuing, and the strategic importance attached to the innovation.

The innovation context at hand: market and demand

The second parameter relates to the predominant market and demand structure. The stage of market development, the solvability of market demand and the size of the potential market have an impact on industry actors’ willingness to invest into specific research paths. What is more, inter-industry links and inter-firm dependencies are such today that simplistic approaches that fail to acknowledge the complexities of the market parameters within which the subject industry operates are virtually condemned to failure. A clear recognition of sector-specific elements, such as competitive pressures (impacting the margins available for investment in innovation activities) and industry structure (influencing the sector’s sensitivity to certain policy instruments), is crucial.

The innovation context at hand: technology application

An innovation’s success frequently depends to no small extent on the existence of collaborative schemes bridging the gap between research and industry. While at times overlooked, the predominant technology application system constitutes thus a third parameter which needs to be taken into account in the analysis of an innovation context. Both the permeability between public and private research efforts and the efficiency of technology transfer schemes affect the likelihood of the existence of a corresponding industrial offer which is often indispensable to an effective technology’s market uptake.
The innovation context at hand: political and institutional framework

The political and institutional framework represents the fourth parameter impacting innovation activity. The existence of a stable political consensus as to the long-term viability of specific innovation objectives, the provision of an adequate infrastructure design as well as the implementation of corresponding regulatory initiatives are elements directly influencing the research actors’ willingness to engage in innovation.
4. Introducing the project’s main output

The key aims of the project’s main outputs can be summarised as follows:

✓ Raise awareness amongst policy-makers as to the important role innovation plays within environmental policy design;

✓ Provide policy-makers with a checklist of issues to be taken into account in order for environmental policy to become more conducive to innovation; this checklist can be seen as an extension of the currently existing “Impact Assessment Guidelines”;

✓ Provide policy-makers with a set of guidelines as to different environmental policy instruments to be used in order to address the specific innovation barriers identified on the basis of the checklist provided.

4.1 Impact Assessment Guidelines

According to the existing “Impact Assessment Guidelines” (SEC(2005) 791), every Extended Impact Assessment is supposed to address a series of questions related to the policy proposal’s impact on a) research and development, b) the dissemination of new production methods, technologies and products, c) intellectual property rights, and d) the promotion of greater resource efficiency.

In practice, however, these items are rarely addressed in a coherent and systematic manner and the innovation aspect is often only insufficiently, if at all, taken into account in the design of policy proposals.

This shortcoming has arguably two reasons:

✓ A tendency on behalf of policy makers to underestimate the importance of innovation in the context of environmental policy making;

✓ A set of existing guidelines that is inadequate, being too general and simplistic, when it comes to assessing a policy proposal’s impact on innovation.

The objective of the complementary, innovation-oriented Impact Assessment Guidelines (Impact Assessment Guidelines) is to address both these issues, while also establishing a link to the background document (Policy Guidelines). As a matter
of fact, the Impact Assessment Guidelines aim to capture the interest of policy-makers for innovation and to incite them to consult the Policy Guidelines that will lay out, practically, how to draft more innovation friendly environmental policy.

4.2 Policy Guidelines

The effectiveness of environmental policy in stimulating innovation depends on a large variety of factors, making it impossible to provide ready-made and context-independent solutions without running the risk of becoming overly simplistic and thus irrelevant. In fact, there is no “cookery book” or “magic formula” that will ensure that environmental policy automatically leads to specific green innovations. Innovation is an inherently uncertain process, full of surprises and unexpected outcomes. The guidelines therefore aim to be at the same time concise and illustrative in order to meet the dual imperative of being operational without being simplistic.

Since innovation does not occur in a vacuum it cannot be adequately understood in isolation from its wider context. Policy approaches designed to stimulate innovation thus need to reflect a context sensitive approach in order to be fully effective. Numerous initiatives in the field of environmental policy design have failed to deliver hoped for results because necessary complementary measures were not put in place.

Moreover, due to the phenomenon of increasing technological interdependency, successful technology development frequently requires corresponding advancements in various related technology areas and a whole panoply of support mechanisms needs to be put in place alongside environmental regulation in order to stimulate R&D activities within rather broadly defined fields of research. In fact, environmental policy maker should create the right conditions for green innovations to emerge and flourish, without knowing exactly in advance what these innovations will look like. Stimulating diversity is essential.

Human resource development, institutional and infrastructure development, boosting of companies’ innovation awareness, and the establishment of networks represent additional elements of a successful innovation strategy to be developed alongside environmental policies. The eventual success and long term sustainability of environmental policy in stimulating innovation requires the elaboration of complementary environmental, research oriented, educational and regional policies.
The *Policy Guidelines* is the background document to the *Impact Assessment Guidelines* of which it is an extension. It provides additional information to policymakers interested in learning more about the different subject areas touched upon.

The document is thereby structured along the lines of the *Impact Assessment Guidelines*. It thus reproduces the 4 main subject areas addressed, namely:

- ✔ Assessing the Importance of Innovation for your Policy;
- ✔ Assessing the Impact of your Current Policy Design on Innovation
- ✔ Stimulating Research and Development Activities;
- ✔ Stimulating the Emergence of an Industrial Offer;
- ✔ Stimulating the Diffusion of Innovation.

*Figure 7. Structuring elements of the Policy Guidelines*

1. Definition of innovation aimed for - Analysis of context
   *Assessing the Importance of Innovation for your Policy*

2. Appropriate incentive structure - Stimulation of innovation on ongoing basis
   *Assessing the Impact of your Current Policy Design on Innovation*

3. Research activities - Elaboration of a prototype
   *Stimulating Research and Development Activities*

4. Technological transfer - Take-up of R&D output by industry
   *Stimulating the Emergence of an Industrial Offer*

5. Market up-take of innovation - Large-scale diffusion
   *Stimulating the Diffusion of Innovation*
5. Annexes

5.1 The Project’s main outputs

5.1.1 Impact Assessment Guidelines

5.1.2 Policy Guidelines

5.2 The summary reports of the case studies

5.2.1 Case Study 1 - The impact of environmental taxes on innovation
   *The example of the Urban Wastewater Treatment Directive*

5.2.2 Case Study 2 - The particularities of systemic innovation
   *The example of recycling*

5.2.3 Case Study 3 - Avoiding technological lock-in
   *The example of the diffusion of renewable energies*

5.3 The list of external experts consulted

5.4 The database of the literature analysis
5.1 The project’s main outputs

5.1.1 Impact Assessment Guidelines
European Commission
DG Environment

“Designing environmental policy to be innovation friendly”

Impact Assessment Guidelines

June 2007
The Importance of Innovation
To the Success of Environmental Policy Making

To achieve your environmental policy goals, you will either have to bring about changes in people's behaviour, or changes in technology. Changes in technology are often less resisted, because there are winners as well as losers and, if the changes fit into the usual replacement cycle of existing technology the costs of change can be small.

Often, technological change is the only way to achieve your policy goals. For others, it will achieve them faster, or more cheaply, allowing you to achieve, politically and practically, more ambitious policy goals. If your policy has targets, it probably will be met by some technological innovation.

But it is easy to get it wrong, and design policy which obstructs or fails to promote technological change. Even market-based instruments have to be designed in the right way, or they may need to be re-designed at a later stage. Your policy will probably need to remove the barriers to innovate, or link to existing policies that already do that.

In the absence of environmental policy that is conducive to innovation, most “eco-innovations” will never emerge. Contrary to “regular” innovations which follow a path dictated by market laws, an initial market rationale for “eco-innovations”, which tend to be costly and thus uncompetitive vis-à-vis conventional technologies, is frequently lacking.

So innovation often needs a boost from policy. A significant reduction of CO2 emissions in cars for example presupposes the introduction of more energy efficient engines and the promotion of alternative fuels, and innovation remains absolutely crucial. The promotion of increased energy efficiency in buildings, yet another key environmental objective, equally hinges on the advent of innovation and its successful market penetration.

And innovation provides synergies between economic growth and environmental protection, creating new markets, business opportunities and exports. Designing policy for innovation is good economically and can reduce business resistance to policy.

This short list of questions, matched by longer answers in the related “Policy Guidelines” document, should help you design your policy to assist innovation by explaining the issues and pointing the way for good design. The questions add to the Commission's Impact Assessment Guidelines, and the third page here helps explain the questions.

Complementary, Innovation-Oriented IA Guidelines
Take 120 seconds to answer these questions:

1. Assessing the Importance of Innovation for your Policy
   • Would innovation contribute to meeting the objectives of your policy proposal?
     ✓ What processes or products could change in a way that supported your policy goal and how?
     ✓ What are the main barriers to and drivers of innovation for these changes to occur?

2. Assessing the Impact of your Current Policy Design on Innovation
   • Does your current policy design promote innovation?
     ✓ Will it affect market competition by making it easier for new companies to sell?
     ✓ Will standards be sufficiently stringent, stable, clear, long-term and set well in advance?
     ✓ Will it avoid “lock-in” of certain technologies by setting performance-based standards, making financial support decrease progressively and treating new technologies like existing ones?

3. Stimulating Research and Development Activities
   • Does your policy tackle blocks to relevant research and development activities?
     ✓ Will it allow easier or cheaper access to public financial resources or private risk capital?
     ✓ Will it stimulate the establishment of coordinated knowledge sharing and research networks?
     ✓ Will it encourage people to look at environmental impacts and potential changes?

4. Stimulating the Emergence of an Industrial Offer
   • Does your policy facilitate the emergence of a commercially viable product?
     ✓ Will it help bridge the gap between research and industry through setting up collaborative/technology transfer schemes and the creation of relevant start-up companies?
     ✓ Will it fill in holes in the necessary technological infrastructure and distribution channels?
     ✓ Will it remove unnecessarily complex regulatory requirements that discourage innovative activity, particularly on behalf of SMEs?

5. Stimulating the Diffusion of Innovation
   • Does your policy encourage the spread of the innovation?
     ✓ Will it off-set the innovation's initial lack of competitiveness and reduce the relative cost compared with existing products or processes?
     ✓ Will it develop small niche markets into which innovations can first be sold?
     ✓ Will it increase belief in innovations through demonstration projects, standardisation or spreading information?

Additional Comments on the Questions of the Impact Assessment
1. Assessing the Importance of Innovation for your Policy

Innovation is key to the success of environmental policy making. At the same time, it is important to precisely capture the impact innovation may have on the policy outcome and to determine what kind of innovation would provide the ideal fit: incremental or radical, end-of-pipe, process-integrated/organisational or product innovation. The preliminary analysis of the innovation context, with its different barriers and drivers, will invariably influence the choice and design of the policies to be adopted.

2. Assessing the Impact of your current Policy Design on Innovation

The design of environmental policy is of crucial importance. For companies to engage in innovation, i.e. to conduct R&D and develop corresponding industrial offers, they need to expect a future business advantage from it. Environmental policy plays an important role in putting appropriate incentives in place and thus directly shapes the nature and direction of innovation. It needs to be designed carefully in order to continuously drive forward innovation, whilst not creating new barriers to innovation.

3. Stimulating Research and Development Activities

For successful innovation to occur a number of key conditions need to be in place. One of them is the removal of existing scientific and technological barriers. Research and development have an important role to play. Stimulating relevant R&D is thereby not only a matter of subsidies and public policy may provide important organisational, motivational and information-related support as well.

4. Stimulating the Emergence of an Industrial Offer

At the same time the main barriers to innovation are by no means always scientific-technologic. Once a technological solution to a given problem has been identified, it still needs to be taken up by industry in order to find its way onto the market. In other words, the ease with which industry succeeds in turning the R&D output into a marketable and competitive offer is of crucial importance to the success of innovation.

5. Stimulating the Diffusion of Innovation

Environmental innovations tend to be costly and thus uncompetitive vis-à-vis conventional technologies. By internalising environmental externalities, through various economic instruments at its disposal, public policy may defend innovations against this economic disadvantage and help them emerge onto the market. At the same time, the market’s tendency to resist innovations should not be underestimated even after market demand has been raised above the critical level in order for the innovation to become a cost-efficient operation. An additional effort may be necessary to help the innovation gain a solid market foothold, be widely diffused and become established in the mainstream.
5.1.2 Policy Guidelines
European Commission
DG Environment

“Designing environmental policy to be innovation friendly”

Policy Guidelines
Background Document
Introductory remarks regarding the structure of the present document:

This document is the background document to the complementary, innovation-oriented Impact Assessment Guidelines (Impact Assessment Guidelines) of which it is an extension. It provides additional information to policy-makers interested in learning more about the different subject areas touched upon.

The document is structured along the lines of the IA Guidelines. It reproduces the 5 main subject areas addressed, namely:

- Assessing the Importance of Innovation for your Policy;
- Assessing the Impact of your Current Policy Design on Innovation;
- Stimulating Research and Development Activities;
- Stimulating the Emergence of an Industrial Offer;
- Stimulating the Diffusion of Innovation.

Moreover, one sub-chapter is dedicated to each of the sub-questions posed in the IA Guidelines (introduced by “✓”). The structure of each sub-chapter, introducing the key policy elements for the design of innovation-friendly environmental policy, is in turn as follows:

- The role of the issue in promoting/blocking innovation;
- Example(s) of that issue in practice;
- Policy instruments/design features to overcome the potential problem.
0. Introduction

Human, and more specifically, economic activity has a critical impact on the natural environment. The progressive spread of the industrial revolution, steady population increase and the corresponding thirst for economic growth, are putting an ever increasing strain on natural resources and the ecological balance in general. Recent - and not so recent - prognostics, as to the advent of global warming, the loss of biodiversity or drinking water shortages, have repeatedly emphasised the urgency of the situation while also questioning the viability and sustainability of predominant production and consumption patterns.

The objective of environmental policy is to protect the natural environment. To this end it needs to foster far-reaching changes both in individual behaviour and consumption patterns, as well as the characteristics of products and underlying industrial processes and resource use. These changes have to be achieved while also taking account of the social and political imperatives of economic growth and prosperity. With developing countries, such as China and India, catching up rapidly there are few signs indicating that modern society will in the foreseeable future substantially decrease consumption and resource usage. The challenge of environmental policy is thus to provide viable and creative responses to one of the key dilemmas mankind faces today. The dilemma of “meeting the needs of the present without compromising the ability of future generations to meet their own needs”.

Environmental concerns have traditionally been thought to be largely at odds with economic growth and prosperity. It is only with the advent of the concept of sustainable development that the perception of an inherent antagonism between economic growth, social development and environmental protection has gradually changed into a realisation that innovation provides the key means by which economic growth and environmental protection can be reconciled. State-of-the-art environmental technologies may not only contribute to improved environmental performance, but also to making the production process more cost effective while also creating new markets and business opportunities.

Examples of the important role of innovation to the success of environmental policy abound. The promotion of renewable energies depends to a large extent on innovations taking place within the photovoltaics and wind energy sectors, allowing the alternative energy sources to both become more competitive and more easily accessible. A significant reduction of CO2 emissions in cars in turn presupposes the introduction of more energy efficient engines and the promotion of alternative fuels, and innovation remains absolutely crucial. The promotion of increased energy efficiency in buildings, yet another key environmental objective, equally hinges on the advent of innovation and its successful market penetration.

There is equally no shortage of examples of “clean” technologies that have been turned into business opportunities and successfully marketed on national and international markets. It is estimated that Europe currently holds roughly one third of the world market in environmental goods and services. Its companies are particularly strong in sustainable power generation technology and key waste management and recycling technology, where European companies have a global market share of over 40%.

With mounting pressures on the environment, corresponding markets are bound to grow. Fuel cell applications, hybrid vehicles and biofuels, for example, are expected to undergo annual growth rates in the double digit range, though starting from an admittedly relatively small scale. But also more developed markets such as photovoltaics and solar thermal
applications show significant annual growth rates. The dissemination of environmental innovations is a vital step in achieving the European Community’s Lisbon Strategy to become “the most competitive and dynamic knowledge-based economies in the world capable of sustainable economic growth with more and better jobs and greater social cohesion”.

Designing innovation friendly environmental policy is no witch work. Innovation can in fact be stimulated in various ways and the eventual preference of one approach over another depends above all on the underlying policy objectives and the innovation context at hand. The interaction between innovation and policy is highly context specific and very few broad generalisations seem valid. It is essential that, before introducing policy, policy-makers seek to understand the context (technological, market, institutional) within which innovation is to take place. An approach that provides strong support in favour of R&D activities may be the most appropriate if important technological hurdles have yet to be overcome. When, however, interesting technological solutions have already been developed but if market uptake proves to be slow, policies designed to stimulate market demand may be more appropriate.

The following guidelines provide an overview of the main ingredients that have to be assembled in order to design environmental policy that stimulates innovation. As will become clear in the following pages the lack of any one of these ingredients may jeopardise an innovation’s success. Addressing the entire innovation process, the guidelines’ major elements can be graphically depicted as follows:

**Structuring elements of the Policy Guidelines:**

1. Definition of innovation aimed for - Analysis of context
   *Assessing the Importance of Innovation for your Policy*

2. Appropriate incentive structure - Stimulation of innovation on ongoing basis
   *Assessing the Impact of your Current Policy Design on Innovation*

3. Research activities - Elaboration of a prototype
   *Stimulating Research and Development Activities*

4. Technological transfer - Take-up of R&D output by industry
   *Stimulating the Emergence of an Industrial Offer*

5. Market up-take of innovation - Large-scale diffusion
   *Stimulating the Diffusion of Innovation*
1. Assessing the Importance of Innovation for your Policy

Would innovation contribute to meeting the objectives of your policy proposal?

1.1 Defining the type of innovation you’re aiming for

What processes or products could change in a way that supported your policy goal and how?

Before setting out on designing environmental policy, policy-makers should try to clarify the role innovation is likely to play in achieving the objectives underlying the policy proposal. They should ask themselves in what way and to what extent innovation could facilitate the policy’s overall success? Can CO2 emissions from passenger cars, for example, be drastically reduced by means of conventional technologies or does the success of the corresponding policy directive depend on the innovation and large-scale diffusion of alternative, environmentally friendlier technologies, such as more energy efficient engines and alternative fuels? And also: to what extent does the reduction of CO2 emissions require changes in consumer preferences and consumption styles, such as the wide-spread adoption of car pooling schemes or the generalised use of public transport?

By answering this kind of question policy-makers will be able not only to assess the relative importance innovation plays to their policies but also to define whether it is incremental or more radical innovation they should be striving for. Incremental, i.e. piece-meal innovation may be most appropriate in situations in which the further improvement of an already developed technology is likely to yield best results. The primary challenge the photovoltaics sector, for example, faces today is the challenge of innovating to lower cost, i.e. of finding cheaper manufacturing processes while maintaining useful efficiencies. Incremental innovation is most appropriate in this context.

Radical innovation, by contrast, may appear necessary wherever a promising technological solution to an environmental challenge is yet to emerge. Alternative fuels, such as bioethanol and biodiesel, as well as renewable energies, such as photovoltaics and wind energy, are examples of radical innovations. They represent qualitatively new approaches to the environmental challenges posed by CO2 emissions and the lack of sustainability of fossil fuel consumption. They are not only concerned with marginally improving already existing technologies (in order to make them more cost efficient, more user friendly, etc.), but of replacing and/or radically transforming them.

In order to stimulate incremental innovation, public policy needs to set up increasingly stringent standards that form the basis for the choice and design of policy instruments. Complementary measures, such as the financing of R&D and the set-up of technology transfer schemes, tend to be somewhat less important as major technological barriers have already been addressed and financially independent actors capable of pursuing the R&D effort exist. Whenever the policy proposal’s outcome hinges on the advent of radical innovation, far more comprehensive measures are needed.

There exist different policy approaches and different policy instruments and the type of approach and instrument retained will impact both the nature of innovation as well as the
speed of its diffusion. It is indispensable that policy-makers clarify right at the outset the type of innovation they are aiming for in order to elaborate appropriate policy packages.

1.2 Understanding the innovation context

What are the main barriers to and drivers of innovation for these changes to occur?

An innovation emerges, thrives and succeeds (or fails) within a context. This so-called innovation context comprises various dimensions, namely: the state of research and development as well as the existence and nature of remaining technological barriers to be overcome; the ease with which industry takes up the R&D output and transforms it into a marketable and competitive offer; the degree to which an effective market demand for the new product exists or can be created; the existence of an appropriate regulatory framework providing incentives for companies to engage in and adopt innovations.

Each dimension corresponds to different barriers to and drivers of innovation. An innovation’s lack of success can, for example, be due to unresolved technological issues. Such is the case with fuel cells where despite considerable advances, technological issues concerning their reliability and durability are yet to be resolved. An alternative explanation for an innovation’s lack of success may be the absence of a well developed industrial offer. Within the French context, for example, the diffusion of innovation in the wind energy sector has been somewhat slowed down - even before the background of considerable research support - by the presence of only one national industrial actor that manufactures and commercialises wind turbines. The absence of a market that is willing and capable to pay for environmentally friendlier product offers may present yet another barrier to successful innovation. In fact, many eco-innovations are initially rather costly and rely thus to an important extent on public support in order to become competitive vis-à-vis conventional technologies. Last but not least, companies may not be motivated to invest into new and environmentally friendlier production methods without external regulatory pressures. The incentives provided by regulation represent another dimension of the innovation context.

It is essential that policy-makers try to identify the main barriers to successful innovation and its subsequent diffusion within the area their policy proposal is targeting. Is it rather unresolved technological issues (treated under §3)? The lack of a competitive industrial offer (treated under §4)? Weak market demand (treated under §5)? Missing incentives on behalf of companies to adopt cleaner technologies (treated under §2)? There exist various policy approaches to address these issues. The relative importance of these innovation barriers varies from case to case and is essential to gain a clear understanding of their significance and nature when designing environmental policy. A failure to address any of them is likely to jeopardise the policy’s overall effectiveness.

It is also important to identify the “locus” of innovation: Frequently companies operate in, and depend on, large networks that may comprise actors far removed from the industry targeted by a given policy. The technical and economic viability of innovation responses envisaged by policy-makers may depend on the involvement of different industries and sectors along the production chain. For the recycling of waste electrical and electronic equipment to be economically viable and technologically feasible, design, production, collection, transport,
separation, treatment, recycling and controlled disposal need to be involved. It is not enough to impose recycling quotas on producers of electronic appliances while other actors that intervene in the recycling process remain on the sidelines. It is important right at the outset to identify potential systemic aspects of the innovation aimed for.

Characterising an innovation context:

<table>
<thead>
<tr>
<th>Science &amp; Technology</th>
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<tr>
<td>Existence and nature of scientific and technological barriers</td>
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<td>Existence of critical mass of both public and private R&amp;D effort</td>
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<td>Relative positioning vis-à-vis potential international competitors</td>
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<th>Political Framework</th>
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<tr>
<td>Existence of political consensus as to long-term prospective of specific research paths</td>
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<td>Existence of adequate infrastructure design</td>
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<td>Existence and nature of regulatory framework</td>
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<th>Market &amp; Demand</th>
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<td>Stage of market development</td>
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<td>Size of market, present and potential</td>
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<td>Solvability of market demand and relative price elasticity</td>
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<td>Intensity and nature of competitive pressures within industry</td>
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<tr>
<th>Technology Application</th>
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<tr>
<td>Existence and proficiency of technology transfer schemes</td>
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<tr>
<td>Degree of private-public research permeability</td>
</tr>
<tr>
<td>Existence and nature of industrial offer and application uptake (equipment manufacturers)</td>
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2. Assessing the Impact of your Current Policy Design on Innovation

**Does your current policy design promote innovation?**

The design of environmental policy is of crucial importance. For companies to engage in innovation, i.e. to develop alternative and environmentally friendlier products, adopt less polluting production methods and develop corresponding industrial offers, they need to expect a future business advantage from it. Environmental policy plays an important role in putting appropriate incentives into place and directly shapes the nature and direction of innovation. It needs to be designed carefully in order to continuously drive forward innovation, whilst not creating new barriers to innovation.

2.1 Stimulating competition

**Will it affect market competition by making it easier for new companies to sell?**

2.1.1 The role of the issue in promoting/blocking innovation

Market competition stimulates innovation. By providing the prospect of relative competitive advantages due to product differentiation, performance improvement and cost reduction, innovation is a means for companies to try to “escape” competitive pressures. While the design of environmental policy may intensify or impede competition, public policy may also facilitate the entry of new players onto the market and support them in their early efforts to compete with already established actors in more active ways.

2.1.2 Example(s) of that issue in practice

- **Unequal legal requirements impeding competition**: Currently, old chemical substances that have been on the market and have never undergone systematic assessment can be used without many obligations whereas marketing even small amounts of new chemicals requires a lot of testing and data submission. Regulatory practice impedes competition. With the advent of REACH all substances will be treated more or less similarly.

- **Patent policy penalising innovation**: In the US, grantbacks (i.e., the provision of access by the original patentee to a technology that has been improved by another company) have traditionally been illegal. More recently, it has been realised that grantbacks can have procompetitive effects by encouraging a patentee to license its patent in the first place, thereby enabling the licensee’s improvement. Past antitrust rules may have deterred some procompetitive grantbacks, deterring innovations using patented technology.
2.1.3 Policy instruments/design features to overcome the potential problem

The design of environmental policy may affect competition in various ways:

✔ **Removing regulatory bias**: It is crucial to eliminate regulatory bias in favour of established technologies in the form of technology-forcing standards and corresponding support mechanisms that virtually “price out” alternative options marketed by new entrants. Moreover, existing technologies should be subject to the same standards and regulatory requirements than existing ones. At the same time, in order to encourage the creation of and maintain a competitive market, it is important to avoid providing undue subsidies that lead to an overcompensation of initial cost disadvantages of the new technology.

✔ **Defining ambitious, yet reachable standards**: A careful balance needs to be found between ambition and realism, so as to ensure that there are lasting incentives for innovation but also achievable opportunities and sufficient competition. Standards should be set so that a sufficient part of industry believes they are achievable. This part should then become the policy’s main constituency.

✔ **Facilitating market access**: Often environmental innovations have to be marketed on the international scale in order to be viable. By shaping the modalities underlying European-wide market access, EC policy making has an important role to play in the definition of a given technology’s perceived commercial interest. The biofuel experience shows how facilitated market access and the existence of a common market can impact companies’ motivation to engage in innovative activities. There is an equal need to create and maintain a single market in waste.

✔ **Protecting intellectual property**: Companies frequently attempt to protect innovation from competition through intellectual property rights, involving at times practices geared to excluding others from entering the market or from challenging the incumbent monopolist. At the same time, implementing adequate IPR schemes that effectively guarantee the possibilities of protecting innovation from imitation is crucial to reduce the market perception of risk. The conditions of appropriation of innovations directly affect research actors’ willingness to invest in R&D as well as the diffusion of respective outcomes. IPR issues may thus constitute both a barrier to and a driver of competition and innovation, and environmental policy design should take account of this ambivalent role. Both competition and IPR policy foster innovation, but each requires a proper balance with the other to do so.

A series of further complementary measures may be employed in order to facilitate more directly the entry of new players onto the market. Public policy may thus help new actors in obtaining first commercial references (by means of public procurement schemes, e.g.), access to necessary financial resources (by means of low interest loans, e.g.) and other types of assistance (in the fields of recruitment, training and expertise, e.g.).
2.2 Setting up adequate standards

Will standards be sufficiently stringent, stable, clear, long-term and set well in advance?

2.2.1 The role of the issue in promoting/blocking innovation

Innovation implies not only the prospect of new opportunities and financial rewards, but also risk and uncertainty. R&D may require high expenditures over many years before the innovation may be turned into a competitive offer and sold to the market. It is crucial to provide R&D actors and financing bodies with clear and stable policy objectives that are then translated in appropriate standards. More stringent standards will not only produce more radical innovation responses, but also do so at greater speed. Moreover, performance related standards are more efficient than those prescribing a specific technology. The guiding objective underlying the choice and design of the regulatory framework should be to drive R&D continuously forward.

2.2.2 Example(s) of that issue in practice

- **The successful phase-out of Ozone Layer Depleting Substances**: Hailed by the former Secretary-General of the United Nations Kofi Annan as "perhaps the single most successful international agreement to date", the Montreal Protocol on Ozone Layer Depleting Substances is a prime example of clear and stable policy objectives, translated into corresponding policy targets, leading to far-reaching change in consumption patterns, industrial processes and product characteristics. For each group of substances concerned, the treaty provides a timetable for the phase-out and eventual elimination of substances.

- **Stimulating continuous innovation through dynamic standards**: Introduced in Japan in 1999, the most energy-efficient product (the “Top Runner”) becomes the basis for future regulatory standards, taking into account the potential for technological innovation and diffusion. The programme provides for dynamic and therefore ambitious standards and the experience with this set-up has been very positive (even though the programme is more useful for the rapid diffusion of already available technologies and incremental innovations). One interesting distinction between the Japanese Top Runner programme and the corresponding European Automobile Manufacturers’ Association approach (based on voluntary agreements) is that the ACEA sets standards at the industry level, while the Top Runner Programme sets standards at the company level. This latter approach has the advantage that companies are more directly involved. It is remarkable that only about half of the European car manufacturers mentioned the ACEA standard in their annual reports.

2.2.3 Policy instruments/design features to overcome the potential problem

Standards are an important instrument for environmental policy-making. They can be made mandatory, be used as a basis for tax reduction or public procurement or be referred to in eco-labelling criteria or voluntary agreements. The crucial question is how the standard is defined and at what level it is set. They should be:

- **Stringent**: Weak standards result in weak innovation. Compared to the European targets, standards adopted by the United States Corporate Average Fuel Economy programme (CAFE) are not very ambitious (at 9 l/100km for petrol passenger cars and even less for the light-duty truck standards for minivans, pickups and sport utility vehicles). As a result
innovation in the US has been much lower and the average fuel economy of new cars in the US has not improved since the mid 1980s.

✓ **Reachable:** Standards should be both ambitious and realistic so that they represent real incentives to engage. They should be set so that a large part of industry believes they are achievable. This will result in necessary competition.

✓ **Dynamic:** Continuous technological improvements may be realised by taking BATs as the standards' baseline. In order to increase their efficiency they should be set at company, rather than industry level. They should also be updated regularly.

✓ **Performance-based:** Given the absence of strong incentives for continuous output improvement, standards prescribing specific technologies are likely to limit innovation and may even lead to undesirable outcomes. A case in point is the vehicle emission standard referring to the catalytic converter, but excluding the more resource-efficient lean-burn engine due to the low NOx emissions limits that could not be met by this technology. Pushing battery-electric vehicle technology by the Californian Zero Emission Vehicle Mandate in the 1990s is another example of failed technology forcing policy, where regulatory pressure to commercialise this technology was applied before the technology itself was established. Regulatory flexibility towards the means of compliance with standards is crucial.

✓ **Objective:** Standards referring to a specific technology may create the impression that specific stakeholders are discriminated against and thus are more likely to run into opposition. The usefulness of technology-based standards seems greatest when risks are acute, wide consensus about technology trajectory exists, and relevant technology solutions are widely accessible and at relatively low costs.

✓ **Coherent:** The regulatory framework should not allow for too many exceptions as their effectiveness may be seriously undermined as a result. The example of phasing out trichloroethylene in Sweden suggests that imposing chemical substitution by means of a general ban while allowing for numerous exceptions may lead to less environmental innovation while enforcement is more costly.

✓ **Flexible:** It is also important to leave as much room as possible for diversity and unexpected developments. As both the impulse to innovate and the innovation response might originate anywhere along the production chain, policies should try to stimulate the participation of “strangers”, unusual exchanges and interactions.

✓ **Comprehensive:** Whenever an innovation is systemic, comprehensive and transversal standards are most suited. Integrated product policy and extended product responsibility for complex products involving various players along the production line cannot be pursued by a sectorial policy approach. Effective waste management, for example, implies the intervention of different actors, requiring a series of standards on landfilling, emissions from incinerators, waste transport, etc. Voluntary agreements may be useful to avoid conflicting interests between stakeholders (even though they are unlikely to foster (radical) innovation).

✓ **Consistent:** The mere expectation of change in the legal framework may cause companies to modify their strategy. Suppliers of electrical appliances, for example, had begun testing new processing methods, product composition and design features even before the announcement of concrete measures towards tightening recycling related standards. Earlier experience of material bans (CFCs, PCB, etc.) and similar regulation in other sectors (e.g., packaging) prompted the development of new production processes that are more appropriate to recycling even before the advent of legislative changes. The
expectation of regulatory initiatives equally triggered substantial technological and organisational innovation in industries related to end-of-life vehicle sectors.

- **Stable**: Based on long-term visions, standards should take account of both the speed of technological progress and the likely evolution of the environmental issue at stake. Based on concrete targets, they should leave the regulated industry with enough time to develop comprehensive response strategies beyond “end-of-pipe” solutions (e.g., Montreal Protocol).

In order to reduce the perception of risk, standards should be backed up by:

- **Clear and stable objectives**: The demonstration of political aspirations and guidelines at European level in the form of indicative targets for carbon emission reductions and the future share of renewable energies in the electricity sector, for example, has had the effect of sending out clear signals to the research community as to future, medium- to long-term objectives. Uncertainties induced by the framework regulating waste policies for electrical goods, by contrast, have had a detrimental impact on the establishment of adequate collection and sorting schemes, for example.

- **Long-term roadmaps**: Long-term policy objectives are most convincingly articulated through the adoption of coherent policy measures backed up by long-term roadmaps. Currently used in fields of strategic importance in many countries (e.g., the creation of a hydrogen economy in Europe and the USA), they define a vision about a possible future development of a specific part of the economy within clear long-term timeframes. Moreover, instruments may be identified and articulated by which this vision may be achieved. Eventually, the roadmap serves as a controlling device for the effectiveness of the instruments implemented and, if necessary, for a redesign of the political options. Foresight activities constitute a useful mechanism by which to establish roadmaps while also providing useful spaces for learning.

- **Other ways of demonstrating political commitment** include:
  - Awarding corresponding research paths,
  - Acknowledging first-mover entrepreneurs,
  - Officially recognising promising technologies,
  - Public procurement or demand-support schemes,
  - Direct financial support either in form of subsidies or infrastructural investments,
  - Setting up of technical standards/certification,
  - Promotion of the emergence of skill bases through adequate educational policies.

- **Consistency of policy framework**: It is essential to explain and eliminate inherent inconsistencies in order not to increase the perception of uncertainty and risk as to the long-term objectives pursued. Climate Change objectives are, for example, not necessarily in line with current energy pricing and coal subsidies. Equally, the policy drivers relative to the encouragement of biofuels are divers, including concerns over climate change, security of energy supply, and the reform of agriculture. Different and goals and pressures have led to the development of the existing set of somewhat incoherent policy instruments.
2.3 Avoiding technology lock-in

2.3.1 The role of the issue in promoting/blocking innovation

Environmental policies need to be designed carefully in order to stimulate R&D on an ongoing basis and not to discourage further research efforts into alternative, and potentially better, solutions. In other words, public policy has to attempt to remove potential barriers to innovation, whilst not creating new ones. In supporting certain technologies, public policy is favouring these at the detriment of others. There is a tension between public policy needing to help certain technologies gain economies of scale and market diffusion, in order to reduce their costs, and the necessity of not shutting out potentially superior technologies.

2.3.2 Example(s) of that issue in practice

- **The dominant position of private road transport**: One of the most obvious examples of "lock in" to which public policies have contributed is the pervasiveness of private cars and trucks, most of which are powered by internal combustion or diesel engines. The penetration of this transport system has been stimulated by large public investments, especially in road infrastructure. Although much safer and cleaner modes of transport exist, and climate change concerns make it desirable that they are used more widely, their competitive position vis-à-vis the dominant forms of transport that benefits from an intricate system of infrastructure, technology, standards, institutions, economic interests, behavioural habits and social conventions, that has evolved over a long period and continues to be facilitated by an equally complex system of funding and legislation.

- **The long-term effects of poorly designed support programmes**: In an effort to increase energy efficiency in buildings, the Swedish government subsidised in the early 1980s additional wall insulation to reduce heat losses. Some of these buildings were later shown to suffer from moisture problems and poor ventilation performance which have been claimed to cause allergic reactions for the residents. Even though available solutions have since improved, the episode lingers on and still constitutes a psychological barrier when it comes to promoting energy efficiency in buildings.

- **Product standards discriminating against recycled asphalt**: Innovations in the recycling of asphalt were initially up against a series of product related standards that discriminated against recycled asphalt. As the tolerance for the size of the stony particles had been too small for recycled asphalt, technical standards for asphalt had to be modified in order to stimulate market demand for recycled asphalt.

2.3.3 Policy instruments/design features to overcome the potential problem

There exist different approaches to avoid “lock-in”:
The need to remove regulatory bias: It is crucial to eliminate regulatory bias in favour of established technologies. Due to their often recipe-like character, prescribing the use of primary materials, technology-forcing standards form an impediment to innovation in construction and demolition waste recycling. On the other hand, technical standards and quality certification systems are necessary to create market confidence in recycled materials. One way of overcoming this dilemma is the use of exemption guidelines, which create niches for innovations and the base for progressive evolution of the dominant standards. Similarly, existing technologies should be subject to the same standards and regulatory requirements than existing ones. It is also crucial to remove subsidies which prevent effective competition.

The need for clarity: It is important to attach a clear time frame to financial support mechanisms, such as subsidies, feed-in tariffs and public procurement schemes. Moreover, financial support mechanisms should be reviewed regularly. In order to encourage the creation of a competitive market that is a precondition to innovation, it is important to avoid providing undue subsidies that lead to an overcompensation of initial cost disadvantages.

The need for gradual phasing out: Financial support should decrease periodically in order to provide an incentive for companies to continue their search for more cost efficient solutions. It is important to make financial support decrease at a predictable pace and in consultation with stakeholders. The rate of decrease should thereby reflect actual cost digressions achieved. Generation costs of wind energy have, for example, fallen by approximately a factor of ten in Denmark during the 1990s.

The need for adequate tendering: For public procurement decisions, tendering processes should be employed that refer to the functional advantages of a cleaner technology (e.g., low carbon dioxide emission), rather than the technology as such. While being based on Life Cycle Costing calculations, they should be applicable during a limited and period of time only. For example, the tendering specifications for the next two off-shore wind farms to be constructed in Denmark provide price guarantees for a period of 12 years.

The “learning-by-doing” proposition: At the same time, stimulating the diffusion of a specific technology, even when knowing that a more efficient one may well be available in the near future, may under certain conditions be the right diffusion strategy as it allows industrial actors to gain a foothold in promising sectors and to test the technology at a large scale, which in turn may contribute to the acceleration and quality of R&D efforts.

The need to be on the watch-out: As in the case of the private transport example cited above, additional factors favouring “lock-in” situations are important sunk costs of corresponding infrastructure investments, long investment cycles due to products’ long life cycles, the existence of vested interests and the lobbying of political pressure groups and the predominance of certain consumption patterns. Once these barriers are removed and, as a consequence, the new technology comes to prevail, a new bias in favour of the then dominant technology may emerge. Public policy has to be constantly on the guard so that the “lock-in” phenomenon does not prevent innovation.
3. Stimulating Research and Development Activities

**Does your policy tackle blocks to relevant research and development activities?**

Scientific and technological barriers are most efficiently addressed by R&D, carried out both by companies and public research institutions. Stimulating R&D is thereby not only a matter of subsidies. Public policy may provide important organisational and information-related support as well.

### 3.1 Facilitating access to finance

**Will it allow easier or cheaper access to public financial resources or private risk capital?**

#### 3.1.1 The role of the issue in promoting/blocking innovation

Subsidies are an important driver for the emergence of advanced technological solutions. This is particularly true when their development is not only costly, as a result of long development times and significant investments, but also risky in terms of uncertain market prospects, unstable political backing and deficiencies in corresponding intellectual property rights. In the absence of public subsidies basic research efforts into alternative technological solutions that lack a clearly defined market application but which are politically desirable (because of their contribution to the abatement of greenhouse gas emissions, for example), are likely to be chronically under funded and thus at a sub-optimal level. Public policy may also play an important role in facilitating access to private risk capital.

#### 3.1.2 Example(s) of that issue in practice

- **Large-scale R&D programmes in support of wind energy in Europe:** As late as 1996 renewable energy sources still accounted for only 6% of the gross domestic energy consumption in Europe. The main barriers to the widespread use of wind energy were thereby of technological nature. Mainly driven by SMEs, research activities suffered, however, from a chronic lack of finance and critical scale. To overcome this situation, the EC sponsored large-scale research programmes which have had a major impact in advancing the industry's research effort, particularly in developing high-power wind-parks. Since then the wind energy sector has witnessed the emergence of drastically improved products that are marketed today by powerful and financially influential industry players capable of pursuing their own in-house research effort. While of strategic importance during the industry's early phase, publicly financed, large-scale research and demonstration programmes have thus gradually become less important to the future of wind energy.

#### 3.1.3 Policy instruments/design features to overcome the potential problem

- **Timing:** Public R&D subsidies are most useful during the early stages of the innovation process when uncertainty as to the long-term viability of corresponding research paths is particularly high. They may equally apply to R&D programmes designed to adapt already existing innovations to mass market conditions and overcome technological barriers that may jeopardise the innovation's market diffusion and thus its general viability (e.g., technological...
issues impacting the reliability and durability of fuel cells, grid connection/expansion issues related to intermittent and remote power generation, etc.).

✔ **Object of support**: Public support programs should in general rather be targeted at broad technology areas without forcing specific technologies. Radical innovation responses are more likely to emerge as research actors are provided with an additional margin to follow their intuition and pursue the research paths they consider most promising. Research into pollution control technologies, in turn, should only be subsidised when the related research effort involves high expenditures and thus puts the industry at a competitive disadvantage vis-à-vis their foreign counterparts that may be exempt of similar regulatory pressures. Otherwise the “polluter pays principle” should prevail.

✔ **Level of support**: R&D subsidies need to be stable, particularly in order to secure the implication of SMEs, and in line with existing funding mechanisms and frameworks. Moreover, they need to be sufficiently strong. If technological development turns out to be too slow or even fail as a result of insufficient funding, all later effort with regard to the commercialisation and diffusion of the innovation will be largely useless. In order to avoid a pro-subsidisation mentality on behalf of research actors and to direct their research effort towards concrete results, financial support should only be given on a temporary, yet predictable, basis. A step-by-step approach allows to re-evaluate the costs and benefits associated with specific R&D and to avoid the risk of over-subsidising.

✔ **Tendering out R&D**: By tendering out the desired R&D outcomes, financing may only be provided if the presented results correspond with expectations, instead of being based on speculation on whether a given research project may be more successful than alternative ones (as in the case of common tendering procedures for R&D funding).

Access to **private finance** for eco-innovation is often difficult, partly because dossiers involve relatively high risk and uncertainty, partly because investors lack experience in this area. Environmental innovations have only fairly recently caught the attention of the commercial banking sector which remains relatively cautious. Green venture capital funds seem more suitable. Public policy may increase the attractiveness of environmental innovations in the eyes of private risk capital by various means:

✔ **Provision of investment guarantees** in order to reduce financial exposure;

✔ **Provision of technical expertise** needed in order to assess dossier;

✔ **Prospect of valorising R&D output** in the form of start-up creation and incubator support;

✔ **Clear demonstration of public commitment**.
3.2 Providing for integrated research networks

| Will it stimulate the establishment of coordinated knowledge sharing and research networks? |

3.2.1 The role of the issue in promoting/blocking innovation

The (trans-regional/national) coordination of R&D is crucial to overcome the fragmentation and sub-optimal exploitation of respective outcomes. Frequently, technological challenges cannot be effectively addressed by one actor alone, but require the association of different and complementary expertise areas. Networks may also compensate for a lack of economies of scale on behalf of individual members. Moreover, R&D networks imply the centralisation of indispensable, albeit disperse, technological knowledge, facilitated access to information and improved knowledge transfer. R&D networks are particularly important to SMEs.

3.2.2 Example(s) of that issue in practice

- **The establishment of fuel cell research networks in Germany**: Most Länder have set up initiatives for coordinating the R&D effort on fuel cells. Mainly financed by federal governments, they are frequently co-sponsored by industry. Their aim is to promote fuel cell and hydrogen energy technologies by means of coordinating R&D activities, initiating collaborative projects, strengthening the technology transfer into industry, bundling available resources, and providing public relations. In 2004 the Fuel Cell Alliance Germany was established with the aim of integrating most of the federal initiatives within a national framework in an effort to overcome the fragmentation of regional clusters.

- **Optimising information sharing in the Netherlands**: Information sharing and networking are important objectives of the Dutch GAVE initiative to promote the use of biofuels. The parties are kept fully informed of the latest technological and regulatory developments, and exchange knowledge by means of an internet-based knowledge platform, network days and other social activities that are frequently organised.

3.2.3 Policy instruments/design features to overcome the potential problem

- **The role of FPs**: FPs play an important role in the advancement of R&D, not only by providing financial resources but also by coordinating already existing R&D projects, establishing technology platforms and networks, as well as centralising and facilitating the access to relevant information.

- **Network membership**: By mobilising actors from industry, national and regional authorities, and fostering the emergence of public-private partnerships, platforms enhance the efficiency of the R&D effort. In order to constitute efficient platforms for mutual learning and knowledge transfer, networks need to comprise different, complementary and mutually enriching expertise areas. The association of start-ups and SMEs may prove particularly enriching. The close co-operation of manufacturers, adopters, grid operators and governmental authorities is, for example, indispensable to find adequate solutions to grid connection/expansion issues related to intermittent and remote power generation.

- **Physical vs virtual**: Research networks can either be physical or virtual, i.e. made up of geographically close actors (such as in research clusters and science parks) or institutions
that are cooperating over large distances. While larger networks tend to be of the second nature, they require information exchange and contact points, such as internet sites, fairs and the organisation of regular networking events.

✓ **Object of network**: The establishment of networks may serve to develop the technology during the early innovation stages and to ensure its continued improvement by means of ongoing product development. For the continued development of the stationary fuel cell, for example, the formation of R&D networks remains a very important issue. Capable of integrating practical, market-specific considerations into their research effort, private-public initiatives are particularly efficient in the realm of material research, device integration and manufacturing technologies, but less so in the context of basic research.

✓ **Funding**: R&D networks should be funded from commercial as well as public sources, particularly when they involve platforms oriented towards the commercialisation of innovative technologies. The momentum of collaboration and the formation of strong alliances, together with the prospect of financial gains from successful commercialisation, should attract private-sector finance to supplement public support to address remaining R&D challenges.
3.3 Empowering people to “think innovation”

Will it encourage people to look at environmental impacts and potential changes?

3.3.1 The role of the issue in promoting/blocking innovation

An alternative, but largely complementary approach to enhancing companies’ capacity to engage in R&D activities consists in raising environmental awareness within corporations. By being confronted with an assessment of their activity’s environmental impact, best international practices and the logic underlying Life Cycle Impact Assessment and Integrated Product Responsibility, people throughout the company may be encouraged to look at innovation and its possibilities in a new, more pro-active way.

3.3.2 Example(s) of that issue in practice

- **Promotion of EMAS in the Czech context**: The EU’s voluntary instrument to acknowledge organisations that improve their environmental performance on a continuous basis, the Eco-Management and Audit Scheme (EMAS), is promoted in the Czech context by the Business Council for Sustainable Development. The Council has processed numerous projects aiming for cleaner production methods, introducing concepts that are based on the systematic application of preventive approaches and life cycle impact calculations. Environmental consciousness has been raised throughout corporations.

- **Impact of EMAS on the development of CFC-free appliances**: Bosch Siemens Hausgeräte (BSH) decided, as a result of an image campaign of Greenpeace against the company, to abandon the 12 million Euro development of CFC technology and adopt a CFC and Halon free technology. BSH is now the only manufacturer of domestic appliances exporting this environmental sound technology world wide. EMAS encouraged this switch by stimulating a more systematic approach to corporate environmental performance.

3.3.3 Policy instruments/design features to overcome the potential problem

- **Eco-auditing and environmental management**: The introduction of eco-auditing and environmental management systems at firm level (based either on EMAS or on ISO 14001) is a useful means for many companies to become aware of the systemic character of their activities’ environmental impacts. The introduction of Life Cycle Impact Assessment and the propagation of concepts of Integrated Product Responsibility can help render companies’ innovation behaviour more dynamic, by means of breaking down functional barriers within the company and promoting integrative approaches implicating different actors. This widespread involvement increases transparency and the possibility to identify potential areas for environmental improvement. Eco-auditing schemes also stimulate environmental improvement by obliging companies to communicate on their environmental performance.

- **Dynamic regulatory framework**: Continuous technological improvements may be realised by introducing obligations to look for new technological opportunities, even beyond the borders of the own industry. The American Massachusetts Toxics Use Reduction Act (TURA) requires, for example, that firms conduct regularly a systematic analysis of viable production alternatives to substitute hazardous chemical substances. Continuous learning will be the outcome.
✓ **Training for competent key people**: Learning may also be facilitated through access to strategic knowledge on eco-innovation, providing relevant statistics, discussing emerging trends and presenting related business opportunities. In some cases obligatory training and re-training may be feasible to enhance the quality of R&D and positively impact innovation.
4. Stimulating the Emergence of an Industrial Offer

**Does your policy facilitate the emergence of a commercially viable product?**

The main barriers to innovation are by no means always scientific-technologic. Once a technological solution to a given problem has been identified, it still needs to be taken up by industry in order to find its way onto the market. This step frequently constitutes a serious stumbling bloc in the innovation process. The ease with which industry succeeds in turning the R&D output into a marketable and competitive offer is of crucial importance to the success of innovation. In order to stimulate the emergence of a corresponding industrial offer, public policy needs to help bridge the gap between research and industry, stimulate the emergence of the necessary technological infrastructure and distribution channels and simplify regulatory requirements.

**4.1 Setting up technology transfer schemes**

**Will it help bridge the gap between research and industry by setting up collaborative/technology transfer schemes and the creation of relevant start-up companies?**

**4.1.1 The role of the issue in promoting/blocking innovation**

Technology transfer is crucial to the success of innovation. It is rare that technologies are entirely invented by industrial actors themselves. More often, they emerge from research activities carried out by actors who are outside of the company compound. The innovation process is a largely collaborative undertaking and the transfer of R&D output from research to industry is indispensable in order for it to be converted into a marketable product offer. Technology transfer schemes may have an impact on the innovation process itself in that industrial imperatives are more likely to be taken into account by research from the outset.

**4.1.2 Example(s) of that issue in practice**

- **Effective technology transfer in the Grenoble region**: The Grenoble Technology Transfer project identifies, on the ground of the consultation with industry, potential areas of research with strong industrial potential. Research actors are selected on the basis of their expertise areas. R&D outputs will then be fed back into industry, either by means of licensing out the technology or by setting up new companies through incubation. This pro-active identification of research areas that represent a potential interest to industry is an effective means to overcoming the difficulty of finding market applications for non-directed R&D output.

- **French wind energy penalised by the weakness of the industrial offer**: The reason for the French weakness in the field of wind energy is mainly to be found in the 1980s and 1990s. At a time when in other countries, such as Denmark, Germany and Spain, national “champions” started to grow, no serious industrial offer emerged in France. As players, such as Vestas and Gamesa, grew thanks to the development of their internal markets, the French government supported nuclear power instead.

- **Fuel cells advances due to close research-industry collaboration**: GENEPAC, the smallest fuel cell currently available for cars, has been designed, developed and produced
jointly by the car manufacturer PSA Peugeot Citroen and the Commissariat for Atomic
Energy, a French public research centre. From the outset, the project has taken into account
industrial and market-related constraints, associating the CAE’s extensive research
experience with product specifications prepared by PSA Peugeot Citroën.

4.1.3 Policy instruments/design features to overcome the potential problem

Technology transfer may be encouraged by different means:

✔ **Early association of industry needs**: It is important to associate from an early stage
onwards private industry to the research effort. The selection of research centres should be
done on the basis of the needs identified in order to increase the likelihood of successful
research results. Collaborative private-public initiatives derive their strength from their
capacity to take practical, market-specific considerations into account throughout the
innovation process, and should be encouraged whenever possible.

✔ **Promotion of clusters**: The set-up of industry clusters provides an interesting framework
to stimulate private-public collaboration. Clusters refer to groups of companies in spatial
proximity within a particular or related sector that benefit from the common use of public
goods like the infrastructure, a common specialised labour market, advantages from a
market for special services and products, the transfer of knowledge and experience via
moving employees, increased visibility and the important effects of mutual impregnation,
knowledge transfer and collective learning.

✔ **Technology platforms**: So-called technology platforms are an equally interesting
approach to stimulating the emergence of an industrial offer by means of associating relevant
stakeholders, identifying the innovation challenges, developing the necessary research
programme and implementing the results. It is necessary that the key players are engaged in
the platform to bring the technology successfully onto the market. They are also likely to
benefit from the association of SMEs. The leadership should thereby rest with the
stakeholders rather than with public actors. Strong leadership with the credibility to bring
together and mobilise stakeholders is crucial.

✔ **The use of PR events**: A useful approach to technology transfer and the identification of
potentially interesting research-industry partnerships is the promotion of R&D output by
means of public relations events, such as fairs and colloquiums.

✔ **Start-up creation**: Innovation contexts which are marked by the scarcity of relevant
industrial actors that are capable and willing to promote the innovation may require the
creation and development of start-up companies to become the innovation’s future
promoters. **Start-ups are best created within adequate incubators in which mutual
impregnation is intense while the level of permeability between research and industrial
application is high.**
4.2 **Stimulating the emergence of adequate infrastructure design**

Will it fill in holes in the necessary technological infrastructure and distribution channels?

4.2.1 The role of the issue in promoting/blocking innovation

The technological/economic feasibility/viability of innovations frequently depends on the existence of adequate infrastructures. Radical innovation, such as fuel cells, tends to require substantial changes in infrastructure design. Equally, remote power generation is often situated in places that make grid expansion and upgrade a necessity, while the intermittency of renewable power generation may require the adaptation of grid infrastructure to avoid unwanted power fluctuations. The associated investments may be costly and a lack of transparency as to who bears the costs can create a high degree of uncertainty, complicating cost estimates and deterring industrial uptake. In addition, supply chains are at times difficult to set up, not least due to uncooperative attitudes of important intermediary actors interested in retarding the advent of alternative solutions.

4.2.2 Example(s) of that issue in practice

- **Providing non-discriminating grid access**: Even though the EU Directive on promoting electricity from renewable resources holds member states to ensure a fair and a non-discriminating access to the grid at reasonable and transparent prices, the cost-sharing of new installations remains frequently an obstacle. In most member states grid regulations remain adapted to power generation close to existing grid networks. The lack of transparency and principles regarding cost bearing and sharing poses a high degree of uncertainty to cost estimates of corresponding projects. This has a deterring effect on industrial take-up.

- **Vested interests slowing down the bioethanol supply chain**: New supply chains are required in order to direct significant quantities of pure bioethanol into the market, based on a series of specific precautions concerning its storage (due to its volatility) as well as its distribution (which, for example, cannot be done via the conventional pipeline infrastructure). The diffusion of bioethanol is slowed down by the vested interests of car manufacturers and oil companies. Most oil companies tend to be reluctant to support the large-scale diffusion of biofuels as it complicates corresponding distribution processes while also making them more costly. Car manufacturers insist on the negative effects biofuels supposedly have on the longevity of engines and do not exert pressure on oil companies to distribute bioethanol.

4.2.3 Policy instruments/design features to overcome the potential problem

There are different aspects to stimulating the emergence of adequate technological infrastructure and distribution channels:

- **Equal grid access**: The issues of cost transparency and access are often of great concern in the planning of environmentally relevant investments, such as wind energy projects. Public policy needs to set up a level playing field and guarantee equal market accessibility to both conventional and new products. Grid access needs to be regulated to ensure a non-discriminating treatment of electricity generated by renewable energy sources.
Clear cost-bearing standards: Clear standards should be adopted as to the sharing of costs involved in grid connection and grid reinforcement (as is the case in Denmark, Finland, Germany and the Netherlands). Commonly, project developers are responsible for costs of connection, while grid operators cover costs related to grid extension and reinforcement at distribution or transmission level. Costs should be transparent and non-discriminative. The intermittency and unpredictability of renewable power generation can be largely dealt with by grid management.

Need for "brokerage": Where supply chains are difficult to set up due to uncooperative attitude of important intermediary actors, i.e. the car and oil companies in the case of biofuel, political "brokerage" is crucial. Mandatory blending requirements, for example, entail an engagement by the oil industry, if only at the blending and retail sites. Full integration is likely as the attractiveness of the sector grows, so measures to improve the market share will impact the attitude of oil companies and on the quality of the supply chain as well.

Clear long-term objectives: Public policy may also encourage the emergence of adequate infrastructure design in a more indirect way. By adopting clear, long-term objectives, creating favourable market conditions for innovations, and adopting different demand support schemes, the perception of uncertainty and risk on behalf of industry actors is likely to decrease. Recycling of post-consumer plastics and waste electrical and electronic equipment, for example, require large investments in new technology and infrastructure which will only come forward with a more stable market demand for recycled materials.
4.3 Simplifying regulatory requirements

Will it remove unnecessarily complex regulatory requirements that discourage innovative activity, particularly on behalf of SMEs?

4.3.1 The role of the issue in promoting/blocking innovation

If regulatory requirements are too complicated, they have a deterring effect on innovation. SMEs in particular cannot afford burdensome notification and testing processes in terms of both costs and delays. Fewer requirements also imply more rapid innovation responses, more reactivity and more ability to adjust to the right time to market. By decreasing risk and increasing expected return on investment, simplified regulatory requirements contribute to the stimulation of R&D and innovation.

4.3.2 Example(s) of that issue in practice

- **Administrative hurdles complicating the issuing of building permits**: Issuing building permits for renewable energy installations, and wind power in particular, is a complicated and time consuming process, involving large numbers of authorities (at national, regional and local level). In Sweden, for example, a project developer has to face almost the same process twice against both planning and building and environmental legislation, and the intervention of the involved authorities is badly coordinated.

- **Installation of off-shore wind parks slowed down by administrative grey zones**: In France, responsibilities for authorising the installation of off-shore wind parks are badly defined. Theoretically, the submerged part of the structure falls under the responsibility of the “préfet maritime”, whereas the emerged part of it is dealt with by the “préfet”. Consequently, and due to additional administrative hurdles it takes considerable time and effort to obtain but the preliminary authorisations for this kind of projects.

4.3.3 Policy instruments/design features to overcome the potential problem

- **One-stop authorisation agencies**: Regulatory requirements should be kept as simple as possible. One-stop authorisation agencies that will process all necessary administrative matters and provide assistance to applicants are very useful. In the late 1990s, for example, a central, national authority, the Danish Energy Agency, was designated to hear all interested parties and to considerably facilitate the planning process for the installation of new offshore wind farms. Where the set up of a one-stop authority is not feasible, administrative requirements imposed on project planners by different regulating bodies should be coordinated so as to facilitate and speed up their fulfilment.

- **Exceptional treatment**: Public authorities may also facilitate the regulatory process by allocating, in the context of renewable energy installations, zones that are available to projectors with severely reduced permit requirements and reduced lead times.
5. Stimulating the Diffusion of Innovation

**Does your policy encourage the spread of the innovation?**

Environmental innovations tend to be costly and thus uncompetitive vis-à-vis conventional technologies, at least during the early innovation phases. Public policy has various economic instruments at its disposal, in order to defend the innovation against this economic disadvantage and help it emerge onto the market. At the same time, the market’s tendency to resist innovations should not be underestimated even after market demand has been raised above the critical level in order for the innovation to become a profitable operation and an additional effort may be necessary to help the innovation gain a solid market foothold, be widely diffused and become established in the mainstream.

5.1 Improving the innovation’s competitiveness

**Will it off-set the innovation’s initial lack of competitiveness and reduce the relative cost compared with existing products or processes?**

5.1.1 The role of the issue in promoting/blocking innovation

There frequently lacks an initial market rationale for “eco-innovations” which are often uncompetitive vis-à-vis conventional technologies that benefit from accumulated learning and economies of scale. Market based instruments may off-set the innovation’s initial lack of competitiveness and gradually raise market demand above the critical level, by bringing about progressive cost digression and, eventually, a level playing field for the competition between established and new technologies. Market diffusion may also be encouraged through demand support schemes that provide financial incentives for the market to invest in the innovative product. Efficient in “buying down” costs during initial phases, demand-oriented support is a complement to market-based instruments. By creating somewhat artificial market demand, public procurement provides a first basis for the realisation of economies of scale and continued product improvement as a result of market feed-backs and accumulated learning.

5.1.2 Example(s) of that issue in practice

5.1.2.1 Market-based instruments

- **Feed-in tariffs stimulating the German renewable electricity market**: The German Electricity Feed-in Law obligated utilities to purchase electricity produced from renewable energies at fixed prices, based on a percentage value on average consumer prices of electricity. This law proved very beneficial for specifically wind power where the tariffs paid from the utilities, in combination with other supporting schemes, resulted in high accumulated payments. In 2000, it was replaced by the Renewable Electricity Law where the obligation to pay tariffs had been moved from utilities to operators of the grid. In order to increase competition and reduce costs of power from renewable energies, the tariffs paid to new
installations decreased annually. All new renewable energy installations were guaranteed these tariffs during a 20 year period.

- ** Tradable Green Certificates in support of renewables in Sweden:** The underlying principle of tradable certificates is to let market forces determine the additional costs for electricity generated from renewables. The producer receives a certificate for every unit (e.g., kWh) of generated green electricity which can then be sold to distributors or consumers. In Sweden, end-consumers are obliged to purchase a predetermined share of total electricity consumption as green electricity. Producers of green electricity will gain income from both the sales of certificates and sales of electricity on the spot market, contributing to further development, increased competitiveness and accelerated diffusion.

- **Environmental taxes in the context of waste water treatment:** Pricing wastewater treatment has played an important role in the delivery of innovation in the sector in the UK and the Netherlands. Full cost recovery helps wastewater treatment companies to recoup their costs of treatment. The degree to which this price signal is driving action from companies to treat their own wastewater is less clear and the main focus appears to be on end-of-pipe mitigation rather than abatement at source. At current levels environmental taxes largely fail to stimulate radical innovation responses.

### 5.1.2.2 Demand-support schemes

- **Promoting passive housing through low-interest loans:** Passive houses provide for comfortable indoor temperatures without the installation of conventional heating systems due to a combination of technologies, such as generation of solar power, improved insulation, as well as a range of particular construction techniques. The diffusion of the passive housing concept in Germany can be considered as a success story. Buildings which satisfy the requirements of energy use for heating of less than 40 kWh/m2/yr warrant loans covering a maximum of €50,000 per unit at an interest rate set below the capital market level and fixed for 10 years. This scheme provides an attractive investment incentive: it represents a form of a subsidy (as loans are set below the capital market level) while also guaranteeing low economic risks (as loans are based on fixed interest rates).

- **Promoting PV installations by means of investment grants:** In both Germany and Spain investment grants have been employed as powerful tools that have resulted in high penetration of PV installations. In 1991 the German government introduced its 1000 PV roofs programme, where 50% of investment costs were covered. The programme was replaced in 1999 by the ambitious 100 000 PV roofs programme, with a 30% investment support which further decreased to 15% by 2002. Due to the amount of new installations, both investment and operation costs have dropped considerably and allocated subsidies could be reduced.

### 5.1.2.3 Public procurement

- **Public green procurement in Japan:** Japan can be considered to be the international leader in green purchasing of office equipment and electronics, at least partly explaining the advanced position Japanese electronics companies have when it comes to environmental compliance. As far as energy efficiency is concerned, the Green Procurement Law incorporates the standards from the Top Runner Programme which have to be met within 3-12 years: “today’s best model sets tomorrow’s standards”. It has mandatory character.
5.1.3 Policy instruments/design features to overcome the potential problem

**Market based instruments** provide financial incentives for developing new technologies and improve market conditions in order to allow them to enter the market. This can be done by guaranteeing competitive price levels at which goods can be sold onto the market (feed-in tariffs), creating a market in a pollutant (emission trading schemes) or by setting benefits to be gained from reducing emissions (environmental taxes).

- **Feed-in tariffs** are an effective means of attracting investment by means of reducing corresponding risks and stimulating an innovation’s market take-up. They have been successfully implemented in order to promote renewable electricity in Germany, Denmark and Spain. Once implemented, it is crucial that, in order to avoid windfall gains, tariffs decrease in line with the cost digressions achieved due to economies of scale and learning effects and are phased out as early as possible. Should any competitive disadvantages from internalisation of environmental costs be left after scale economies and learning have become effective, these should be compensated by inclusion of the technology’s relevant inputs or outputs into certificate trading or environmental tax schemes. The feed-in tariffs systems may be largely self-financing. As the initial market is small enough to keep the effects of additional costs on electricity prices negligible for end consumers, they can be supported by the public. Along with a growing market, guaranteed tariffs will then be reduced.

- **Emission trading** schemes allow firms capable and willing to reduce emissions below the level imposed by regulation to take economic advantage by selling permits in excess on the market. Tradable permits have a tendency to push abatement beyond the limits imposed by regulation, by providing economic incentives towards ongoing improvement of environmental performance. For corresponding markets to become profitable, trading schemes should be introduced at supra-national level. They need also to be based on steadily decreasing quota allocations that are fixed well in advance in order to avoid uncertainty. The most comprehensive examples of permit-based approaches are the US Acid Rain and Regional Clean Air Incentives Market programmes which were launched in the 1990s and have had considerable success. Emission trading is only useful when dealing with homogeneous, clearly definable output volumes (e.g., CO2). They are likely to be inefficient in the case of electrical goods, for example, due to the broad range of raw materials used and their unequal respective environmental impact.

- **Environmental taxes** are potentially very efficient instruments, though in practice this potential is seldom achieved as they are frequently not high enough to enter the cost calculations of polluting companies as a decisive element. Political resistance is frequently a prime cause. The implementation of a mandatory EU-wide taxation on energy use or carbon dioxide emissions, for example, which many believe to be an ideal tool for carbon mitigation, has proven to be too politically difficult to implement. Political considerations may also lead to the adoption of tax schemes that not only miss their target but whose efficiency is also undermined by exemptions. The implementation of the so-called ecological tax reform in the late 1990s in Germany, for example, did not target the pollutants, notably CO2, in a direct way but outputs associated with CO2 emissions, such as electricity and gasoline. Energy-intensive industries have also been partly exempted for competitiveness reasons. On the contrary, high landfill taxes in the Netherlands have had considerable success. Tax related revenues may subsequently be diverted to finance demonstration projects in order to not only promote alternative approaches but also send a clear message to the market.
**The level of support required:** In order to determine the level of financial support necessary for a new technology to compete successfully with existing alternatives, it is important to know the cost of the new technology in the beginning, the rate of cost digression (learning curve effects) and the installed production capacity on the supply side as well as the willingness to pay (e.g., premium prices) on the demand side. In their “Strategy of Commercialisation” report, the Fuel Cell Alliance Germany, for example, assumed that in the years 2006, 2008, 2010 and 2015 the capacity of total power generation by fuel cells would amount to 15, 93, 320 and 1320 MW respectively. At the same time, the installation cost was assumed to diminish progressively from €4500 via €2600 and €1800 to about €1000 per kW electric capacity. Accordingly, the Alliance calculated the financial support required in order to allow the fuel cell to compete with conventional alternatives to increase to more than €260 million annually in 2010 and decline thereafter to reach zero in 2016.

**Demand support schemes** are very important instruments in order to help an innovation emerge onto the market. However, they need to be handled with care as they can easily give rise to a pro-subsidisation mentality of the beneficiaries while also favouring “technology lock-in”. They should be employed for a limited period of time to prepare a level playing field for the new technology.

**Public procurement** allows companies, by artificially creating demand, to realise economies of scale and learning effects and to become more competitive vis-à-vis established technologies, and to thus progressively overcome the dilemma of low production volumes and high prices. When applied to relatively high-profile projects, public procurement schemes may also have an important demonstration role, by increasing market awareness for the product, its viability and its functional and/or environmental advantages. The role of local authorities and other agencies using green public procurement procedures to foster the use of biofuels in their captive fleets, for example, is already an important factor in market development in several countries. Using higher blends than private cars, they also serve to demonstrate biofuels’ viability.

The long-term effect of both demand support schemes and public procurement is not unambiguous though as they may actively discourage the ongoing innovation effort by supporting supposedly benign technologies at the detriment of others and they need thus to be handled with care. Tendering procedures should be used that refer to functional advantages, while also attaching clear timeframes that are reviewed regularly.

For additional comments on the dangers associated with the employment of support demand schemes and public procurement, please refer to §2.3 “Avoiding technology lock-in”. 
5.2 Facilitating step-by-step penetration via market niches

Will it develop small niche markets into which innovations can first be sold?

5.2.1 The role of the issue in promoting/blocking innovation

The identification and stimulation of niche markets that are particularly receptive to the innovation’s functional advantages constitutes an interesting and potentially cost efficient alternative to facilitating an innovation’s entry onto the market. While market niches serve as “door opener” for the commercialisation of innovation, their use with premiums paid for specific properties like remote or pollution-free energy supply may allow keeping subsidies at a significantly lower level. They also favour the establishment of a more reiterative innovation process based on continued market feed-back and product development.

5.2.2 Example(s) of that issue in practice

• Creating niche markets to promote stationary fuel cells: While policies based on subsidies for stationary fuel cells tend to be expensive, the need for financial support can be diminished within the context of niche markets in which, on the grounds of their particular characteristics, higher prices can be charged than would otherwise be possible. Niche markets for stationary fuel cells are stand-by emergency power supply (in countries with unreliable grid power supply), pollution-free power supply (mainly in urban areas with excessive power demand) and remote power supply in rural areas.

5.2.3 Policy instruments/design features to overcome the potential problem

Niche market management is based on a number of concepts:

✓ Stimulation of limited markets: Markets need to be particularly sensitive to the functional advantages provided by the innovation in order to accept its relative lack of economic competitiveness and higher prices. The cost digression achieved by supplying the limited market, as a result of economies of scale and learning effects, may then be used to enter the next market niche with lower prices and costs.

✓ Importance of communication: The promotion of technologies within limited market niches requires a corresponding communication effort in order to raise awareness of the innovation and its functional advantages amongst the larger public and thus to prepare its (large-scale) diffusion. The (international) visibility of the market niche should be maximised. Communication should also include the use of eco-labels and quality certification.

✓ Stimulating step-by-step penetration: Niche markets tend to be temporally, regionally and functionally limited, and thus initially of only limited economic attractiveness. This should not discourage the most suited market niches from being selected as they constitute an important testing field for the innovation. If subsequent diffusion is hampered by a lack of suitable niches, more active public policy measures may be necessary, such as public procurement and demand support schemes.
5.3 Influencing underlying consumption patterns

Will it increase belief in innovations through demonstration projects, standardisation or spreading information?

5.3.1 The role of the issue in promoting/blocking innovation

Another, largely complementary means of stimulating market diffusion are approaches that aim at increasing market confidence in the innovation by means of demonstration projects, quality certification/standardisation, and public education campaigns designed at “greening” consumption patterns. They are based on the assumption that individual, consumption-related aspects need to be addressed in order to modify the structure of existing market demand and provide incentives for changes in underlying production processes. A useful policy tool for addressing information problems, informational approaches, such as eco-labelling and certification measures, also increase the pressure on companies to improve their environmental record. Public information and education may enable customers to make well-informed buying decisions in favour of the new technological solution.

5.3.2 Example(s) of that issue in practice

- **Demonstration projects in selective demolition**: In the UK the first demonstration project identifying waste streams and options for selective demolition has been initiated by the Nottingham Trent University. The principal aim of the project is to convince the construction and recycling industries of the feasibility of selective demolition and other recycling activities, while also demonstrating the economic advantages of certain options.

- **The limited success of eco-labelling in the promotion of smart housing**: The effectiveness of communicative policy instruments is rather difficult to assess as the baseline is always unclear. Energy labelling appears to have been effective for electrical appliances such as white goods, but the housing market is fairly different. When purchasing white goods, there may be very similar products with different energy labels and the label may be a decisive selection criterion. When purchasing or renting a house, several other aspects such as distance to work, neighbourhood and architecture, are typically much more important and energy efficiency is merely a small part of the cost calculation. Clients also often focus on minimising investment costs rather than life cycle costs and budgets for new-construction and operation are generally separated.

- **Reassuring the market as to the quality of recyclates**: There is still an important lack of standards, specifications and test methods for both recyclates and products made from recyclates. The certification issue is vital though since stakeholders frequently question the quality of the recycled material. On the manufacturing side, some product designers prefer to use virgin materials with well-known physical properties and are hesitant to use post-consumer recycled materials because of supply and quality concerns. There is frequently also a concern for the presence of hazardous materials and public health.

- **The risks posed to the biofuels sector by long standardisation delays**: Several member states have developed their own quality standards for specific types of biofuel so that the EC gave in 1997 a mandate to the European Committee for Standardisation to develop standards as to the minimum requirements of fatty acid methyl ester – used as biodiesel. While the adoption of a European standard is of strategic importance to stimulate
both industrial and consumer confidence, it took 5 years to develop a standard for just one of the many permutations of biofuel. While it is vital that innovation within the biofuels industry continues to be stimulated in order to lead to better, more efficient fuels, the slow pace of the accreditation process may slow down both the research effort and market uptake.

5.3.3 Policy instruments/design features to overcome the potential problem

- **Demonstration projects** are important to support an innovation’s early development as they demonstrate the workability of a new technology as well as its economic implications. Demonstration activities, including feasibility studies, validation and "scale-up" projects, provide a crucial bridge between lab scale experiments and the commercial application of innovative technologies. Demonstration projects are frequently difficult to initiate by the innovating company alone because of the quantity of financial capital needed and the high risk associated with this investment. Demonstration projects may be financed by means of revenues from environmental taxation. For demonstration projects to be at their most efficient, they need to aim for maximum visibility. In Germany the large-scale implementation of demonstration projects has had a very positive impact on the diffusion of the passive housing concept (providing for comfortable indoor temperatures without the installation of conventional heating systems).

- Useful in order to promote the diffusion of “best available technology” and incremental product improvements, **eco-labels** are a complementary instrument to be used in support of other approaches. Like demand-support schemes, they should be granted for limited time period and tied to criteria that are revised and developed on a regular basis. They are more useful when applied to relatively homogeneous product families where different environmental performance levels may represent an influential element of choice. They may be applied in combination with public procurement schemes. Adequate information sharing via Technology Platforms is essential.

- **Quality certifications** and product standardisation are means to stimulate consumer confidence in technological innovations and to facilitate market acceptance. Owing to the uncertainties and complexities in relation to the environmental benefits of biofuels and fuel cells, for example, developing a system of quality certification is essential to the technologies’ ultimate success (by also tranquilising those potential clients whose scepticism vis-à-vis fuel cells is mainly rooted in their fear of hydrogen). However, it may not be realistic or desirable to establish a certification system too soon in the innovation process if this would present a danger of promoting “technological lock-in” and stifling market development.

- In parallel with technological advances, it is important to start creating social acceptance for new technologies so that missing public preparation is no obstacle during the commercialisation phase. **Public information** and education measures are crucial as they enable well-informed consumer and investment decisions and allow incentive-based instruments to function effectively. The German government, for example, developed a long term strategy for the promotion of alternative fuels, including several awareness raising campaigns to increase public perception and understanding in the agricultural community.

- The current willingness of customers to tolerate economic and/or non-economic sacrifices for environmentally friendly technologies is generally rather low. However, innovations’ success frequently hinges on the active involvement of users and a **public education** effort, in the form of publicity campaigns and/or the adaptation of pedagogic content, is indispensable to overcome the absurdities inherent in short-sighted market demand and a
corresponding lack of Life Cycle Cost calculations (as in the case of the passive housing market in Europe). Life Cycle Analysis is an important means to ensure that maximum resource-use efficiency is achieved throughout the product’s life cycle. While technological innovation is undoubtedly a key factor for achieving better environmental performance, it is important not to put excessive faith in the power of technological change alone. In fact, for environmental challenges to be addressed effectively, a parallel change in the dominant consumption patterns is indispensable. Public education campaigns, and the corresponding mobilisation of pressure groups and public discussion, are crucial in order to reinforce environmental awareness and promote environmentally sound behaviour.
6. References

The above-cited examples are mainly based on the consortium’s in-house knowledge as well as the case studies carried out in the context of the present study.

In addition, they make use of a number of additional case studies that have been sponsored by the European Commission over the last few years.

5.2 The summary reports of the case studies

5.2.1 Case Study 1 - The impact of environmental taxes on innovation

The example of the Urban Wastewater Treatment Directive
Case study 1
Summary report
The impact of environmental taxes on innovation
The example of the Urban Wastewater Treatment Directive

1. The problem addressed

Internalising costs by charging for environmental services and changing prices through use of environmental taxes are key market-based instruments available to policy makers with which to stimulate both innovation and the diffusion of environmentally benign technology. At the same time, however, there exists to date limited empirical work on the impact of this particular instrument on innovation and its relative usefulness is still under debate.

The effectiveness of changing price and the use environmental taxes as drivers of innovation is considered below through the examination of Urban Wastewater Treatment technology.

2. The policies put into place at EC level

Section IV.5.7.3 of European Environmental Bureau provides the following summary of the urban waste water treatment directive 91/271/EEC.

The Directive’s objective is to protect the environment from urban waste water discharges through collection and treatment of such discharges, which according to the WFD has to be achieved by 2015 at the latest. The setting of Emission Limit Values ELVs for organic biodegradable substances, nitrates and phosphates from urban wastewater treatment plants is dependent on the local aquatic environment, i.e. how sensitive it is with regard to eutrophication or whether it is protected for drinking water abstraction. Some countries identified their whole territory as sensitive, some identified parts of their territory, and finally a number of countries do not identify sensitive areas at all, but apply the most stringent ELVs instead. In a tiered approach, Member States have to establish waste water collection for agglomerations with more than 2000 p.e. (population equivalents) by the end of 2005 starting with agglomerations above 150,000 p.e. by the end of 1998.

3. The policies put into place at national level

The European Environmental Agency (2005) reviews the effectiveness of urban wastewater treatment policies in six European Union member states, four EU-15 and 2 new member states. Approaches in these countries include:

- In Denmark full cost recovery legislation was introduced in 1988, with methods detailed for charging for large wastewater discharges included in the legislation. In 1995 a national wastewater tax for industry and sewage treatment plants was introduced along with a water supply tax for households.
- In France full cost recovery for discharges is possible but has not been widely used. However, levies set and collected by river basin agencies for clean-up programmes have provided investment that has been targeted at the most polluting industries. The
Industrial Sector contracts of the early 1970s are seen as very effective but from 1978 were stopped as they were considered to be state aid.

- In the Netherlands economic incentives have been used to provide incentives to polluters to reduce pollution at source, rather than more expensive end-centralised wastewater treatment plants.
- In Spain an initially relatively complex wastewater levy was charged to both households and businesses. This system was simplified in 2003 but it appears to have raised only 1.5% of the sum required to implement the urban waste water treatment directive. This failure has resulted in a joint approach between regions and national level government backed by European Cohesion Funds.

In the UK, companies pay for wastewater treatment to the sewer according to the nature and volume of discharges. These are calculated according to the 'Mogdon formula'. Companies discharging directly to watercourses require a discharge permit from the Environment Agency which is charged for. Householders pay for wastewater treatment according to volume of water supplied for metered properties and rateable value of the property in the absence of a water meter at a property.

There is a division of responsibilities between Defra, the UK environment ministry, which transposes the EU legislation, the Environment Agency which monitors environmental performance and OFWAT, the economic regulator of the water industry, which aims to ensure that investment to meet the regulatory framework’s targets is cost effective. OFWAT conducts periodic five year price reviews. This sets the prices that water companies can charge for water supply and wastewater treatment based on the investment plans of the water companies. Any cost savings companies make between price reviews can be kept by company, which is intended as an incentive to innovate.

4. The innovation barriers at hand

From literature:

- Charging mechanisms for wastewater treatment often do not reveal the full economic costs of pollution to polluters.
- Charges and taxes for wastewater are too low to play any incentive role. If this is the case it seems that taxes are unlikely to be an effective stimulus of innovation.
- Taxes/levies do not provide sufficient information to those creating discharges on what needs to be removed from effluent.
- Provision of centralised treatment services reduces responsibility for taking action at source on pollution.
- Shared responsibilities between municipalities and water basin authorities tends to distort implementation. Denmark has clear responsibilities and successful implementation whereas Spain has a complex structuring of responsibilities between national and regional level. However, there are, of course, other factors accounting for the relative success of the two countries, not least, the very different economic and climatic conditions in each country.
- A focus on the development and provision of centralised wastewater infrastructure overlooks action to address discharges at source. It also results in less cost effective wastewater treatment. The directive appears to enshrines the centralised approach rather than decentralised approaches. Even where company level approaches are
adopted the framing of the policy focuses on treatment rather than reduction of discharges in terms of both quality and quantity.

- Costs of treatment are large and the main cause for delay in implementation of the Urban Waste Water Treatment Directive.
- Large water users may benefit from preferential reduced tariffs from water suppliers. Would this also be the case in wastewater treatment?
- In the UK there is a misalignment of expectations in the supply chain between water companies, discharging companies, economic and environmental regulators and government which limits the ability of the sector to fully exploit the capacity for technological innovation.
- The supply chain, could deliver innovation, is unable to engage in policy debate and development that might allow it to deliver innovation.
- Policy makers do not adequately consider the impact of legislation on water sector and the constraints of corporate strategies.

**From interviews:**

- The Urban Wastewater Treatment Directive is not framed in a way that drives innovation – its targets are not challenging, there is a focus on infrastructure and frameworks for more radical responses to treatment are not created. The approach is incremental and tinkering with approach to wastewater treatment that is over 100 years old.
- Polluter pays charging systems are not always implemented across Europe (although full cost recovery in place in the Netherlands and UK).
- Resource constraints for smaller companies prevents them investing in innovation – innovation is too resource intensive both in terms of staff and financial resources.
- The size of the market in countries such as the Netherlands for wastewater treatment is small (leads to focus on international markets).
- Information on possible responses to legislation and targets and the price changes these may create for companies is poor. Price signals – whether cost recovery or additional taxes - highlights the problem but not the solution. The price signal needs to be accompanied by further information that indicates the range of possible way of reducing discharges.
- A long business cycle of investment, poor availability of capital to invest in treatment along with competing pressures for investment, all reduce ability to innovate, or at least make it a slow process. Timescales of infrastructure replacement are very long. Infrastructure now being replaces which can be 100 years old, or more.
- Risk is a problem in terms of innovation and was repeatedly highlighted by interviewees. Purchasers of technology are very unwilling to risk unproven technologies, so how do new approaches get adopted? Developers of new technologies have the risks associated with high cost of R&D for technologies which may not be able to recoup costs in market.
- One interviewee suggested that the factual basis of policy making is flawed in some areas. Some basic assumptions that policy is based on, such as leakage rates of sewers, are incorrect.
The Urban Wastewater Treatment Directive is 16 years old. Deadline for most targets now past so pressure to innovate not so significant and targets were not very challenging in first place.

Approach based on Best Available Technologies (BAT) does not seem to be a driver of innovation as standards as does not seem to get tighter (in UK). See below for comment on Netherlands where BAT is seen as a driver.

Policy does not make innovation explicit either in EU and national frameworks or more detailed guidance to water companies and companies.

Ease of “flush and pay” approach for companies – even when wastewater costs are very significant proportion of turnover. May be related to the low profile of wastewater treatment infrastructure and problems.

There is a very low awareness of policy frameworks in companies and little, or no interest, from many companies, especially smaller ones, in the policy development process or the overall objectives and spirit of policy. The only issue for most companies is whether meeting they are meeting consent limits and compliant.

Water companies have interests in large long term capital plant which they have to recoup investment from. Derivation of revenues from wastewater treatment reduces incentive for them to engage with companies to reduce their discharges.

Wastewater sector is diverse and scattered making co-operation hard.

In the UK the five year price review mechanism is not aligned with longer term capital investment cycles and life of infrastructure. This reduces the incentive to invest and innovate as costs can’t be recouped over five year price review period (being addressed in next review). Also suggested that the review process may result in cuts to R&D budget in attempts to drive costs down which is counterproductive for innovation in the longer term.

Multiple government department, agencies and regulators can be involved in wastewater. For example environment, planning, trade departments, economic and environmental regulators etc.

5. The effectiveness of adopted policies on innovation

From literature:

European Environmental Agency (2005) -

“Despite three decades of European efforts to introduce and set minimum standard requirements for wastewater treatment, disparities between Member States persist. Implementation shortfalls are found in three of four of the longer established Member States Reviewed.”

Denmark complied fully with the Urban Wastewater treatment Directive and discharges to surface waters have decreased by 90%. However, the approach has been costly.

In France, advanced river basin management, full cost pricing and a water pollution levy has only resulted in modest achievements. Could be improved upon but institutional barriers and lack of political will in some municipalities.

Netherlands is close to compliant with urban waste water treatment directive and economic instruments are used to provide incentives to polluters to reduce pollution at source.
European Environmental Bureau (2005) -

- The Directive has delivered the single biggest improvement in the quality of European rivers and lakes through reduced pollution with organic biodegradable substances. Nevertheless, 40% of European waters still show eutrophication symptoms and up to 50% of this impact can be attributed to urban waste water discharges (EEA 1999).

- The Directive has been often cited as the most expensive European law ever. Indeed waste water collection networks and treatment plants are costly infrastructures, but its human health and environmental benefits are likely to be much higher. Additionally, it is often forgotten that the Directive does not prescribe technical standards, but sets emission limit values, which can be achieved often better and cheaper through decentralised waste water treatment systems and the separate collection of waste water of different qualities.

- Implementation of the Directive has been slow and the Commission launched 34 infringement procedures against Member States between 1994 and 2003 mainly on transposition, reporting, designation of sensitive areas and collection systems (CEC 2004). Whether ELVs are met is subject to an ongoing evaluation by the Commission.

It would seem that this lack of clarity on whether the requirements of legislation are being met likely to be a barrier to innovation as it will not be clear whether further investment is required to be compliant.

Strosser and Speck highlight (from another author’s work) that just the announcement of increased wastewater charges in France created responses from companies in their wastewater practices and also that “pollution charges had promoted a more widespread and rapid adoption of innovations in less water-polluting technologies.”

Specifically in regard to the impact of taxes on wastewater treatment EEA (2005) highlights other authors’ work that indicates that the Dutch system of wastewater taxes has delivered improvements in a cost-effective manner. Through implementation of taxes on a polluter pays basis less capacity has been required in sewerage infrastructure. Companies have been incentivised to engage in a higher level of pre-treatment of their effluents.

It is not stated in EEA (2005) but it is entirely possible that a shift from a focus on large scale end of pipe capital investment at the municipal level to treatment at the company level may create a more dynamic set of relationships in regard to innovation. The smaller scale and diverse requirements of companies discharging effluents would require a more diverse range of suppliers and contractors which could increase the opportunities for and speed of evolution of wastewater technologies.

From interviews:

The interviewees agreed that innovation has happened in the wastewater sector in the Netherlands and the UK. Views on the degree of innovation vary from low to high, but new technologies have been developed, e.g. biological treatment processes such as Anammox, Sharon and integrated membrane technologies and membranes. However, the view seems to be that these are for the most part developments of existing approaches rather than fundamentally new ones and that there is a focus on “black box” end of pipe approaches rather then systemic approaches.

Whether or not these innovations are due to the policy frameworks put in place at the European and member state level was less clear. The impact on innovation of the Urban Wastewater Treatment Directive on innovation was frequently cited as being small. However,
the member states examined have had to transpose the directive into their own legislation. The question this poses is would action have been taken in the absence of the European directive? One interviewee suggested that, while the directive may not have had as much impact on innovation as it could have done, it has changed the terms of the debate. It is now considered unacceptable to discharge untreated wastewater into watercourses. So the existence of the directive has created the basic framework in which innovation can occur.

At the member state level both the Netherlands and the UK are broadly compliant with the directive and money has been invested in wastewater treatment which would not have otherwise been spent.

The Dutch approach adopts a more integrated approach with a wider range of measures than the UK. In the Netherlands, full cost recovery and a focus on collaborative processes and institutional arrangements to drive and deliver policy are used. This seems to have resulted in a level of innovation that is higher than the European average. The UK approach uses fewer instruments and is focused on cost-efficiency but is also based on full cost recovery of waste wastewater treatment costs from polluters. However, the main mechanism to drive investment - five year pricing reviews – appears to be at odds with the longer timescale of investment in the sector. This issue is being addressed in the next price review.

The view from the interviewees suggested that the UK approach is not very conducive to innovation. However, it was also suggested that the UK has implemented the requirements to an equivalent standard of other leading member states in the EU, or at least an above average standard, but this has been done more cost-effectively than elsewhere in Europe. So the innovation has been in terms of cost cutting in existing technologies rather than development of new technologies.

In the Netherlands the opportunities created to sell technologies to international markets was cited as a bigger driver than the national policy frameworks.

One interviewee highlighted the value of European Commission’s technology platforms as useful in identifying what is need in particular sector including water. However, this praise was tempered by the need for these platforms to deliver which needs investment.

6. Lessons to be learned

From literature:

- European environmental policies that suggest or support large scale capital investments to address environmental problems may be hard to implement in an innovative manner due to the scale of investment required and economic/political problems this creates.

- Policies should therefore, whenever possible, focus on creating opportunities for innovation in smaller scale units of operation, for example, the company rather than municipality, which are likely to increase flexibility of response and remove possible institutional barriers.

- The Urban Wastewater Treatment Directive does not specify technical standards, rather it sets emission limit values to be met which allows for flexibility of response to meet these limits.

- Appropriate tax measures can be used to reveal full economic costs of pollution to polluters and incentivise them to adopt cost-effective (at the company and higher levels) pollution reduction or mitigation strategies.

- Decentralised approaches, in the context of clear objectives and responsibilities for action, could conceivably result in more and faster evolution of innovation compared
to centralised large scale end-of-pipe capital investments, which have very long projected lifetimes and are hard to modify once constructed.

- “There is very little information on the effectiveness and impact of existing environmental charges and taxes applied in Europe to the water sector.” (Strosser and Speck).

UK Water Industry Research (2007)\(^6\) -

- The supply chain has innovation to offer but important parts of it are unable to engage in the policy debates which might create frameworks that would allow this innovation to be delivered. Water companies are a key enabler of innovation but they don’t always fulfil this role. There is a latent potential for innovation in the sector.

- There is a need for a ‘system’ to share the costs, risks, benefits and rewards of innovation and mechanisms to promote collaboration. A division of roles across all actors in delivery of water treatment is needed as well as collaborative process for setting targets and priorities. Failures in innovation are often due to fragmented or incomplete division of innovation effort. For example, not all stakeholders being involved in standard setting, user feedback or provision of demonstration sites.

- Better innovation metrics and evidence on innovation are needed to be able to tell if innovation is happening.

- Innovation sharing in the sector and links to academic research are poor. The evidence base on innovation is poor and there is a lack of long-term time series to assess progress.

- Size of company is not a factor in innovation (this seems to contradict the views expressed in some of the interviews).

*From interviews:*

- A focus on decentralised wastewater treatment approaches rather than centralised, large-scale, capital-intensive investment may be both more cost-effective and a stronger driver of innovation.

- Policy development should use mechanisms and processes to obtain the input of the stakeholders who are the pioneers and developers of new technologies rather than just consulting with existing vested interests. This approach is likely to result in more ambitious targets and innovative approaches and better engagement of the actors who can deliver them.

- Both the UK and the Netherlands have implemented approaches that result in full cost recovery from polluters for wastewater treatment. This appears to be a more costs effective approach than subsidised investment used in some of the Cohesion Countries.

- Taxes were cited as an important innovation measure (although there seems to be confusion of the terms charges, taxes and levies which may need to be investigated further) but they need to be accompanied by recycling of tax revenues, maybe only on a temporary basis, to actors who are, or can, innovate and also awareness raising measures that highlight reasons for tax and means to reduce liability to pay it.

\(^6\) The paper refers to the UK situation and the water sector generally, rather than just wastewater.
IPPC is an important driver of performance in this area. However, approaches adopted as a result are still not very innovative. IPPC driving wider uptake of existing approaches rather than new approaches.

In the Netherlands large companies and universities are the main loci of innovation.

Smaller companies find it hard to innovate and tend to rely on innovation being generated by other actors.

In the Netherlands government funds research but there appears to be an unwillingness to support risky projects which might result in higher levels of innovation. Support tends to go to the established players and technologies rather than the more risky emerging companies, technologies and approaches. Additionally, a lack of expert input and understanding of issues facing the sector was highlighted as a problem in the distribution of government support for innovation in this area. A higher level of specialist input might deliver greater rewards.

The Dutch approach to the development and implementation of wastewater treatment policy uses a variety of institutional mechanisms that promote the involvement of a wide range of stakeholders and sharing of innovation. Water management boards promote an integrated approach with input from all stakeholders, which allows issues to be explored and consensus developed on approaches. Also an innovation platform was set up by trade ministry to share innovations. While this may act to reduce an individual company’s competitiveness its overall impact may be to improve the sector's competitiveness, particularly in international markets.

Separated responsibilities for different parts of the wastewater system reduce the potential for innovation. For example, in the Netherlands, local authorities are responsible for the transport of wastewater and water companies for treatment which institutionalises the focus on treatment.

The evidence base for policy making needs further work and assessment of the assumptions that policy is based on need to be tested.

There appears to be a lack of awareness of possible savings to be made by companies emitting wastewater. Focusing on a message of cost reduction rather than compliance may reap rewards.

The UK regulatory approach creates a financial incentive to innovate through the approval mechanism for setting of water company prices and investment plans.

Need to improve awareness of wastewater as an issue with public and companies. Very low profile issue now.

National strategies are needed but these must transfer responsibility to local level for action.

Need a more forgiving environment for experimentation of new approaches and acceptance that some will fail.

Regulatory Impact Assessment needs to be improved. Directives and member state implementation would be difference in area of wastewater treatment if current carbon and climate

7. Conclusions
This research draws on a small number of references from the literature on this topic along with a series of eight interviews of people active in policy making, research or implementation in the area of wastewater treatment. The research focuses on the experience of wastewater
treatment in the UK and the Netherlands, although findings relevant to this study are
highlighted from other countries. Given the limits of the research and the short period in
which it was conducted some caution should be exercised in drawing definitive conclusions
from the work. With this in mind what conclusions can be drawn about the role of tax, and
more generally the use of the price mechanism, in driving innovation in the area of
wastewater treatment technology?

It is clear that innovation has happened in both the UK and the Netherlands, and elsewhere
in Europe, as wastewater is now being treated to a higher standard than it probably would
have been in the absence of European legislation. The innovation that has occurred seems
to focus on development, for the most part of existing techniques in an incremental manner,
that apply to end of pipe wastewater treatment in large wastewater treatment plants. Less
innovation has occurred in terms of decentralised treatment at source although this was
frequently cited as being a more promising locus of innovation.

Pricing wastewater treatment has played an important role in the delivery of innovation in the
sector in the UK and the Netherlands. The importance of pricing of wastewater treatment, in
the form of full cost recovery in both the Netherlands and the UK, is that it creates a revenue
stream for wastewater treatment companies to recoup their costs of treatment. The degree to
which this price signal is driving action from companies to treat their own wastewater is less
clear. EEA (2005) cites a figure of 600 companies undertaking their own treatment but it is
not clear what proportion of companies or overall wastewater discharges this represents. The
main focus appears to still be on end of pipe mitigation rather than abatement at source. This
should not be taken to suggest price is not an important potential driver of innovation, just
that it is not a significant driver at the current levels. In terms of tax, or price mechanisms, as
a driver of change from companies or individuals it seems that they need to be used in
conjunction with other measures to be effective. For example, greater efforts need to be
made to raise awareness as low awareness was reported in companies of policy objectives
and measures and the potential for companies to innovate to reduce their treatment costs.

This research suggests that the Netherlands has a supporting framework that is more
conducive to innovation in the area of wastewater treatment than the UK. In particular, the
institutional framework created to support delivery of policy and build consensus on
objectives, policies and implementation was highlighted. In the UK however, the focus has
been on delivery of cost-effective implementation of urban wastewater treatment. So while
the UK framework may appear to be less conducive to innovation it has, apparently, driven a
lower cost achievement of standards and implementation of technologies.

Aside from the role of price there seemed to be some interesting lessons or conclusions to
draw for policy makers wanting to stimulate innovation generally:

• First, it was suggested by a number of the interviewees that some of the actors who
  are key innovators are not involved to a large enough degree in policy formation and
  that if they were more innovative approaches might result. It would therefore seem
  sensible to encourage policymakers to actively seek advice and input to policy from
  the “knowledge intensive networks”, as one interviewee put it, which are important
  sources of innovation.

• Second, the potential for decentralised approaches to deliver wastewater treatment at
  lower costs than centralised infrastructure was regularly highlighted, although
  progress in this area seems to be limited or unclear. Decentralised approaches would
  seem, on the basis of the research, to be more compatible with faster rates of
  innovation than centralised infrastructures, although this statement needs further
  testing. This is because of the lower scale of investment required, shorter lifetime of
  plant and the multiple loci of innovation that are potentially created. The long lifespan
  of much wastewater treatment infrastructure is particularly a problem in terms of
innovation and the timescale it operates on. These comments maybe of general applicability to other infrastructures outside the water sector which can be centralised or decentralised, for example, energy generation and waste management.

- Third, the issue of the sector being risk adverse was highlighted. Purchasers only want to buy tried and tested approaches and suppliers are unwilling to develop new approaches if there is not a market for them. However, being risk adverse is a function or the economic and policy framework companies operate in. More ambitious targets and mechanisms to test and pilot new approaches could be used to overcome this barrier.

8. Questionnaire used

Companies

Introduction
1. What role does innovation play in the sector
2. Who are the main actors in this field in your country?
3. What level of performance on innovation is there in your area and country?
4. What are the main barriers to innovation?

Policy framework
5. How has EC and national policy framework impacted on your readiness to engage in innovation? For what reasons?
6. What are the strong / weak points of existing policy frameworks as regards innovation?
7. How would policy frameworks be ideally designed?
8. What are the accompanying measurers needed?

Policy makers
1. What importance was accorded to the issue of innovation in the policy design?
2. How could the weak points (identified previously) be addressed?
3. What are the lessons to be learned?

9. List of interviewees
- Prof Mikael Skou Anderson, NERI, Denmark, author of European Environment Agency report, Effectiveness of urban wastewater treatment policies in selected countries: an EEA pilot study
- Bert Geraats, Grontmij (large consultancy and engineering company), The Netherlands (answers by email)
- Hank Stel, Aqua Industrial Watertreatment BV (small supplier of wastewater treatment technology), The Netherlands
- Bert Palsma, STOWA (Dutch Foundation for Applied Water Research)
John Holt, director Aqua chem. Ltd (small supplier of wastewater treatment chemicals)

Steve Ntifo, Water UK (trade body for UK water industry).

Kevin Ridout, OFWAT (UK economic regulator of water industry).

Hans Mudlamootoo, Defra Water Quality Division.

10. References


5.2.2 Case Study 2 - The particularities of systemic innovation

The example of recycling
Case study 2  
Summary report  

*The particularities of systemic innovation*  
The example of recycling  

1. The problem addressed  
Increased recycling is considered a desirable environmental objective for many reasons. These include: that recycling prevents virgin resources having to be extracted thus avoiding
the impacts on landscape and biodiversity (amongst others) of extraction. Recycling reduces the quantity of waste being sent to landfill and energy recovery thereby reducing emissions to land, air and water. The production of materials from recycling of waste normally requires less energy than production of materials from virgin resources, and compared to energy from waste recycling is normally of greater carbon benefit.

However, for recycling of waste materials to occur activity is required from multiple actors along the production and consumption chain. Waste producers need to separate material for recycling, waste management companies need to collect and separate these wastes and recycling processors need to reprocess the collected materials so they are fit to be used to make new products from. The resulting materials then need to be of comparable standard and price to virgin materials to sell. Producers, ideally, will also consider how they design their products to ensure they are easily recyclable at the end of their life.

The relationship between the various actors is not hugely complicated. However, delivery of recycling is problematic as recycling is competing with other waste management options and these other options tend, in the absence of other interventions, to be cheaper. Waste producers often see dealing with waste as a non-core part of their business because waste management costs tend to be only a few percentage points of turnover.

2. The policies put into place at EC level

The EU Waste Framework Directive provides the basis for waste policy at the European level. It establishes a generic commitment to recycle waste through the waste hierarchy. It also requires member states to have waste management plans in place covering the entirety of their territory. Specific targets for recycling (and other waste management requirements) are created through the series of producer responsibility directives on packaging, end of life vehicles, waste electrical and electronic equipment and batteries. A general but un-quantified commitment to recycle waste oils is indicated by the waste oils directive.

The landfill directive and incineration directive both impact on recycling, either by placing restrictions on waste going to landfill and incineration, or through more stringent emissions requirements, which push up costs, thereby making recycling more economically competitive.

3. The policies put into place at national level

The table below from Green Alliance (2002) highlights the range of waste policy instruments in place in eight countries and states in Europe and the US that, other than the UK, have achieved reasonably high levels of recycling. The study is from 2002 and many of the levels of recycling achieved are now higher. It should be noted that the study is also five years old and hence discussing and analysing the policies, actions and achievements of six or seven years ago. However, the study is still of use as it attempted to understand the reasons behind the increase in recycling levels achieved, sometime very significant and fast increases, notably in the Netherlands and Flanders.
4. The innovation barriers at hand

From literature:

Green Alliance (2002) -

- Price is key to driving up recycling rates. Recycling has to be consistently cheaper than other waste management options for recycling to succeed. Price can be affected by landfill/incineration taxes and variable charging of households for waste collection. Banning material to disposal can also be an effective method of ensuring recyclable material is recycled.
- Rapid gains have been made eg Netherlands increased MSW recycling from 16% to 42% between 1990 and 1995, and Flanders from 30% to 62% between 1994-90. However, many of the areas studies have now reached a plateau. The reasons for this are not given but are likely to include the changing nature of the residual waste stream as higher levels of recycling are achieved (for example, creating a need to focus on organic wastes), householder engagement and increasing cost with diminishing returns.

- Very little market development for recycled materials has taken place, other than in the UK by the Waste and Resources Action Programme (WRAP). The price of waste disposal is instead used to drive market development indirectly. Fluctuating recyclate markets can be a problem. However, as markets grow the incremental increase in material collected is a proportionally smaller part of the total recyclate tonnage, so markets become more stable.

Other regularly cited barriers include:

- Producer responsibility schemes are implemented in ways that dilute individual company's producer responsibility.
- Recycling requires more than collection, sorting and processing infrastructure and requires investment in communication and education.
- There is a lack of clarity in the EU strategic policy framework. The drawn out development of a thematic strategy on recycling and waste prevention and revision of the waste framework directive has created a lack of certainty about future direction of waste policy. For example, this includes issues such as status of waste hierarchy and the relationship between recycling and recovery.
- Different standards of implementation in member states create cross border issues and distortion of single market.
- Poor data availability – especially for commercial and industrial wastes.

OECD (2007) –

Potentially significant barriers and failures in markets for recyclable materials include:

- Search and transaction costs for participants in the recycling market;
- Information failures between purchasers and sellers;
- Consumer perceptions and risk aversion;
- Technological externalities;
- Market power of existing companies in sector may prevent new entrants.

These issues may be best addressed through market policy interventions rather than traditional environmental policy measures.

Crotty (2006), in turn, highlights a low awareness of the end of life vehicles directive in the supply chain companies that are subject to its provision in the UK and also highlights similar findings from other work on the WEEE directive.

From interviews:

- The inconsistency of environmental policy frameworks. For example, objectives and measures being introduced which are removed after a short time before investment can
be recouped. This undermines companies trying to innovate and makes them risk adverse. Or unresolved inconsistency between different policy areas, for example, between, energy from waste, recycling and composting.

- Slow development of policy creating a hiatus in innovation. For example, slow development of waste policy strategies – e.g., thematic strategy at European level and UK waste review has been going on for years. Alternatively the debate on the animal by-products order ran for over three years and then companies allowed doing what they had been previously doing.

- The lack of a single market in waste management and recycling. This undermines regions with higher standards, for example, subsidies for energy for waste variable.

- Financial support for innovation. For example, European Commission framework programmes very complicated to apply for, which excludes or puts off many companies. Research is important, but policy may be a more effective way to create markets and drive action rather than subsidy.

- Lack of data on waste arisings and the impact of policy. This hampers the design and evaluation of policy and any innovation associated with it. Models of innovation are not clear – the drivers of innovation need to be understood by policy-makers.

- Speed of product innovation and lack of producer responsibility. Existing producer responsibility measures only cover a few product areas meaning producers not obliged to consider end of life issues. This means the recycling sectors is always having to react and catch up with product developments. The diversity of products requiring recycling and different types of processing is problematic.

- Waste products end up widely dispersed and the cost of collecting specific waste streams into economic amounts for processing can be prohibitive. For example, Tetrapaks which are very functional as packaging but hard to recycle economically.

- Funding processes and procurement processes (in UK) prompt multimillion multi-year projects that fix technologies in place and reduce space for innovation – need flexibility particularly when policy objectives and framework are evolving quickly.

- Small companies have no awareness of policy, e.g. UK companies not even aware of WEEE. Policy just seen in terms of compliance and red tape.

- Definition of waste a huge barrier to getting new approaches to recycling or reuse of materials off ground.

- Conflicting views of preferred collection system – source separated (Flanders) or commingled (the Netherlands).

- EU policy tends to be diluted towards lowest common denominator objectives in process of negotiation. Legislation may bring up laggards to basic standards but not a driver of innovation beyond that.

- Flanders and Netherlands have small populations so market for new approaches is limited.

- Slow timescale of capital investment.

- Patent system is difficult. Time consuming process and system for checking of novelty of patents is weak. Patents given for non-innovative approaches which reduces the incentive to innovate.

- In Denmark in the 1990s progress was made on increasing recycling, driven by policies including, clear high targets and taxation on incineration and landfill, which provided a clear incentive for action. Much of legislative framework that was driving innovation has
been removed in last five years – including reduced funding for environment agencies and grants, and targets removed except when required by European legislation – has resulted in innovation stopping.

- Much of Danish waste infrastructure is publicly owned and run on a not for profit basis. This appears to have reduced incentive to innovate. Compare this sector to the Danish wind sector which has innovated very successfully and is privately owned.

5. The effectiveness of adopted policies on innovation

*From literature:*

Significant levels of municipal solid waste (MSW) recycling have been achieved:

On packaging CEC (2006) highlights the impact and effectiveness of the packaging directive:

- “Out of the 66 million tonnes of packaging waste [generated in the EU15] around 36 million tonnes or 54% were recycled in 2002.”
- “In 2002, all of the 75 different targets applicable to EU15 have been achieved.”
- “Recycling and recovery of packaging waste have led to positive environmental effects on most parameters. This includes greenhouse gas savings of around 25 million tonnes of CO2 equivalent (around 1 million tonnes as a direct result of the Packaging Directive) and resource savings of around 10 million tonnes of oil equivalent (around 3 million tonnes as a direct result of the Packaging Directive) as a result of recycling and recovery.
of packaging waste compared to a scenario where all packaging waste was sent to landfill or incineration without energy recovery…"

- “Recycling resulting from the Packaging Directive and national programmes and legislation is not significantly more expensive than if the same material had been sent to disposal.”

- “Since packaging recycling has also other environmental benefits, it can be classified with a relatively high degree of certainty among the most cost-efficient options to reduce CO2 emissions and other environmental impacts.”

Green Alliance (2006) -

"Flanders is … is particularly interesting because it already appears to have decoupled household waste growth from economic growth, and has set a target for waste production per capita that would increase the degree of that decoupling. The target is for the amount of residual waste (waste not recycled) produced per capita per year to be reduced to 150kg; most recent figures indicate that current per capita residual waste stands at 159kg (Jan 2004).

The target represents a considerable degree of ambition in a country that has already achieved very high levels of recycling for both household and commercial waste – in 2004, 71 per cent of municipal solid waste went to recycling or composting."

Netherlands MSW recycling at 65 % and Netherlands Government (2004) states: "With regard to efficiency it was stated that no less than about 80% of Dutch waste was collected and processed in compliance with market conditions."

**From interviews:**

- The interviewees gave conflicting views on the level of innovation occurring in recycling sector ranging from a lot to little innovation. This may be partly due to definition of innovation and rather subjective indications of innovation given.

- More innovation happening in collection and sorting than processing (Flanders). Flanders has been sorting since 1991 so focus is now on driving up quality of outputs from collection and conditioning processes.

- Producer responsibility measures (in Flanders) with clear targets driving investment [and innovation] in new approaches.

- Policy can create incentive to innovate – by creating markets that needs to be supplied and restricting disposal options.

6. Lessons to be learned

**From literature:**


“The most important development is the increase in the size of [waste management] companies, which has led to a strong concentration on submarkets like waste incineration, landfill, organic waste processing, glass collection and processing, paper processing and textile processing. The reason for this is that in these areas a small number of players control the entire market. A number of other submarkets are still fragmented, as is the case with the collection of various specific waste streams and vehicle disassembly.
Another major development in the waste market is vertical integration, which means that one single company can offer services throughout the waste chain, from collection to disposal. Ownership or control of the entire chain reduces the financial risk of operating only in submarkets. The collection of household and hazardous waste especially appears to be a major growth market at present for players already operating in other areas of the waste market.”

“Incentives contribute in various ways to achieving the objectives of the National Waste Management Plan. Encouraging the development and transfer of knowledge plays an important part where there are technical obstacles to sound waste management or where the parties concerned are not fully aware of the technical possibilities. Examples are the 2001 government grants schemes for innovative collection techniques and for reuse and recycling. The latter scheme is aimed at supporting the development of markets for secondary plastics and is financed by the business community and government. Incentives are also used as a ‘prod’, a positive stimulus in the form of a financial contribution to activities that result in structural improvements in the management of waste.”

Green Alliance (2002)

- Requires multiple policy interventions to drive innovation in recycling.
- Price is key, but not only, driver.
- Interactive policy making with local government and industry creating shared goals and understanding (Netherlands).
- Communication – tell people what to do and provide feedback.
- Public ownership of waste disposal infrastructure means commercial waste management focuses on recycling (Netherlands).

Crotty (2007), in a study on the impact of the end of life vehicles directive’s impact on supply chains in the UK vehicle manufacturing sector, found that the directive alone was insufficient to instigate greener supply chains. The work focuses on the supply chain of the manufacturing sector but action here does impact on the ability of companies to recycle waste products later in the life cycle.

**From interviews:**

- Policy frameworks are important drivers of innovation provided they give certainty and clarity to companies that may want to innovate. For example, the ban on transfer of waste to landfill in Germany from the Netherlands created new markets for treatment in the Netherlands. High landfill tax in the Netherlands of €80 per tonne makes just about every other waste management option economically attractive (including incineration, which is perhaps growing too much according to some interviewees). The waste hierarchy is also a powerful concept if it can be supported by effective measures.
- There needs to be greater effort to create and maintain a single market in waste. Different standards or approaches to enforcement can result in countries with higher standards being undermined. For example, variation in support for energy from waste creates problems. More standards could be set at European level.
- Focus of policy should be on creating markets rather than subsidising investment/innovation as provides simpler way of driving innovation.
- The desire for innovation needs to be made more explicit in policy and strategy.
• Increased use of producer responsibility is needed to get producers to think about their products waste impacts and create revenue streams for treatment.

• Think about where costs occur in the system and the signal this creates. For example, shifting the costs of waste management from point of disposal to point of purchase (Flanders) may be helpful. Created a funding stream that can be used to deal with specific products and/or general waste streams and also differentiates products on basis of environmental performance at point of purchase.

• Need to align interests of multiple actors for success.

• Strong planning is important.

• There is no single solution for any particular waste stream – Flanders created space for local implementation. A clear regional policy framework was combined with a high level of consultation at local level and also clear financial instruments.

• The market can’t deliver everything. Need to make policy interventions to shape market.

• Enforcement is important otherwise incentives created by policy can be undermined, eg waste leakage to Africa.

• Innovation is occurring but risk is an issue, which reduces willingness to fund new approaches. Also the problem predicting quality of outputs from new approaches will be until pilots have been run.

• Lots of ideas but issue of getting them to market a problem (in UK). Need to create networks of knowledge which include funders and experts to support development of new approaches. Some existing approaches, eg, Knowledge Transfer Networks in UK but problem of getting smaller companies involved and aware.

• Funding programmes for innovation not very accessible (in UK).

• Integrated approach to delivery can help create a framework more supportive to innovation and overcome multiple barriers – eg London Development Agency and food wastes: multiple interventions were made including on training, procurement, collection systems, processing infrastructure, market development, land purchase and planning assistance.

• Demonstrator projects, even very small scale ones, are very valuable catalysts to wider innovation. However, need (simple) mechanisms to subsidise them.

• Markets for recycling small and cost a problem.

• Quality of recyclate is key to successfully selling it.

• In Flanders a mix of instruments was used – economic, communications, producer responsibility and subsidy. Do not expect responses too quickly. Adopted a staged approach to implementation, engage all actors and build up gradually (compare with Germany, which introduced requirement to collect packaging for recycling which flooded market and was very costly, or Denmark which set high recycling targets for municipalities with too short a lead in time). Independent best practice manuals produced by Flemish Technical Institute (used to drive BAT up through reviews every 3-5 years) to support innovation and provide baseline. Prioritisation of operators requiring licensing and ramping-up of BAT took place.

• Dutch packaging covenant approach used to bring stakeholders into process of innovation and make innovation explicit. Phased approach. First covenant targeted front runners, second, on transferring technology to rest of sector. Good independent monitoring important to create buy in
• Need organisational not just technical innovation.
• Vested interests often don’t help in the development of policy that will drive innovation.
• In Denmark most of disposal infrastructure is publicly owned whereas recycling is in private sector. So market can only focus on areas where innovation is wanted.

7. Conclusions

This research draws on a small number of references from the literature on this topic along with a series of eight interviews7 of people active in policy making, research or implementation of recycling. The research mainly focuses on the experience of recycling in the Netherlands and Flanders, although findings relevant to this study are highlighted from other countries and interviews were conducted with people from Denmark and the UK. Given the limits of the research and the short period in which it was conducted some caution should be exercised in drawing definitive conclusions from the work. With this in mind what conclusions can be drawn from the example of waste recycling on how systemic innovation can be stimulated through policy?

Significant levels of recycling have been achieved in some countries and regions in Europe notably the Netherlands and Flanders. This success applies to municipal solid waste and other waste streams such as packaging. However, success is variable and the countries that have succeeded in achieving high levels of recycling have strong, clear and supportive policy frameworks. Policy appears to therefore have had an impact on systemic innovation in waste and recycling. This conclusion on the role of policy is supported by the Danish case where innovation in waste and recycling has halted or slowed since the supportive policy framework was removed in recent years.

A number of barriers to recycling and systemic innovation exist. Consistency of implementation of European policy across states and regions; availability of data to base policy on; the disconnection between production, consumption and disposal; and long timescales of investment/development were all highlighted. Some of these are specific to recycling, but others are of general relevance to policy makers considering interventions to drive systemic innovation.

The issue of regions or member states adopting or enforcing different standards which undermines areas with higher standards (which are likely to be conducive to greater innovation) was regularly highlighted. Consideration may therefore need to be given to how to give better protection to areas that decide to adopt higher standards including better use of enforcement.

Systemic innovation in an area like recycling cannot occur overnight. Examples were given by the interviewees of policy interventions which acted too quickly with counterproductive results. Policy making in an area such as recycling needs to based on a clear understanding of dependencies, capacities, and bottlenecks etc in the system and also an awareness of the timescale of investments that may be made. The staged and gradual approach of Flanders is worth noting in this regard.

The disconnection between product manufacturers and responsibility for end of life waste management of the products was highlighted and the fact that that waste managers have little control over the waste they have to manage. This applies to a number of end of pipe

7 Seven names are listed below as one interviewee asked not to be named in the project outputs.
systems and points to an increased role for producer responsibility measures if waste objectives are to be met.

Changing the relative price of waste management options appears to be central in driving systemic innovation in recycling. Placing restrictions on sending to waste to landfill or incineration – the system that is to be replaced - are also important. However, price alone is not enough: multiple interventions are needed.

Clear allocation of responsibilities is important and Flanders has attempted to increase the level of producer responsibility for waste. Flanders has also in some instances shifted the cost of waste management from point of disposal to purchase which creates a potential powerful signal to encourage recycling.

Conditions for innovation have been created by multiple interventions that act to align the interests of actors along the production and consumption and chain. In the Netherlands a collaborative policy making system with broad stakeholder involvement combines multiple interventions that change the cost of waste disposal, with bans on disposal of recyclable/combustible waste and mandatory or incentivised sorting of household and commercial waste. This has created the market conditions to encourage the supply of recyclates and opportunities for recycling companies – 80 per cent of waste management is dealt with through the market. Where technical barriers are identified which prevent recycling of particular wastes incentives are used to promote knowledge transfer and create funding sources to overcome these technical barriers. Producer responsibility measures for producers act up the production chain and certification ensure the quality of recyclates down the chain. In Flanders a similar approach is used but notable is the covenants approach which institutionalises support for authorities that wish to exceed targets.

8. Questionnaire used

Companies

Introduction
1. What role does innovation play in the sector
2. Who are the main actors in this field in your country?
3. What level of performance on innovation is there in your area and country?
4. What are the main barriers to innovation?

Policy framework
5. How has EC and national policy framework impacted on your readiness to engage in innovation? For what reasons?
6. What are the strong / weak points of existing policy frameworks as regards innovation?
7. How would policy frameworks be ideally designed?
8. What are the accompanying measurers needed?

Policy makers
1. What importance was accorded to the issue of innovation in the policy design?
2. How could the weak points (identified previously) be addressed?
3. What are the lessons to be learned?
9. List of interviewees
   - Danny Willie OVAM, Public Waste Agency of Flanders responsible for waste management and soil remediation in Flanders
   - Christof Delatter, Coordinator INTERAFVAL Association of Flemish Cities and Municipalities
   - Hugh Smith, Programme Manager, London Remade (Organisation developing recycling markets and products in London)
   - Robbert van Duin, Recycling Netwerk / Bureau B&G
   - Mr Mutsaerts, MultiNET bv (Dutch waste management company)
   - Henrik Wejdling, DAKOFA (Danish Waste Management Association)
   - Ruud Richard van Schaik, VAR (Dutch waste management company focusing on collection and anaerobic digestion)

10. References

5.2.3 Case Study 3 - Avoiding technological lock-in

The example of the diffusion of renewable energies
Case study 3

Summary report

*Avoiding technological lock-in*

The example of the diffusion of renewable energies

1. The problem addressed
In supporting certain technologies (by means of feed-in tariffs, public procurement schemes, etc.), public policy runs the risk of favouring certain technologies at the detriment of others. While the diffusion of second best technologies may result thus attractive to market actors, it may be detrimental to the public interest. Environmental policies need therefore be designed in a way so as not only to stimulate market diffusion but also result in ongoing research efforts. The area has been treated by a number of authors (T.J.Foxon, G.C.Unruh, etc.), but existing studies predominantly focus on the characteristics that make different industry contexts prone to lock-in rather than on the impact of policy making itself.

Authors like G.C. Unruh argue that numerous barriers to sustainability arise because today's technological systems and governing institutions were designed and built for permanence and reliability, not change. This is particularly obvious in the case of “carbon lock-in”, that is to say the fossil-fuel based systems which complicate the diffusion of renewable energies.

The question of innovation in the field of wind and photovoltaic energy has been studied as a whole. The case of biofuels, in turn, has been approached more specifically under the perspective of the lock-in danger between the first and the second generation of biofuels.

2. The policies put into place at EC level

There are two main Directives on the subject of renewable energies.

- Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market:

The Directive follows up the White Paper on renewable sources of energy (RES) which confirmed a target of 12% of gross inland energy consumption from renewables for the Community as a whole by 2010, of which electricity would represent 22.1%. It also constitutes an essential part of the package of measures needed to comply with the commitments made by the EU under the 1997 Kyoto Protocol on the reduction of greenhouse gas emissions.

Companies in the EU are currently among the world leaders in developing new technologies connected with electricity from renewable energy source (RES-E). The Directive aims to give a boost to stepping up the contribution of these energies while respecting the principles of the internal market.

The Directive concerns electricity produced from non-fossil renewable energy sources such as wind, solar, geothermal, wave, tidal, hydroelectric, biomass, landfill gas, sewage treatment gas and biogas energies.

Under the Directive, Member States have set up individual RES-E targets. They are free to choose their preferred support mechanism in order to achieve the targets.

The Directive also contains chapters on the necessity of simplifying administrative procedures (i.e. rationalise and speed them up and ensure that the rules are transparent and non-discriminatory) and on the issues of grid connection (it indicates that Member States must ensure that the transport and distribution costs do not in any way discriminate against RES-E).

- Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport:

The Directive sets a minimum percentage of biofuels to replace diesel or petrol for transport purposes in each Member State. It is a question of reducing conventional emissions of CO2
(carbon dioxide), CO (carbon monoxide), NOx (nitrogen oxides), VOC (volatile organic compounds) and other particles which are toxic for health and the environment.

The Directive quotes different types of biofuels: bioethanol: produced by the fermentation of plants rich in sugar/starch; biodiesel: a diesel quality fuel produced from biomass or used frying oils; ETBE: etherised bioethanol… The biofuels can be made available as pure biofuels, blended biofuels or liquids derived from biofuels.

The Member States must ensure that the minimum share of biofuels sold on their markets is 2% by 31 December 2005 at the latest, and 5.75% by December 2010. Any Member State setting lower objectives will have to justify this on the basis of objective criteria.

Another Directive is important in the field of biofuels, as it gives a framework to the economic intervention of national policies: Directive 2003/96/EC restructuring the Community framework for the taxation of energy products and electricity indicates among other things that Member States may apply total or partial exemptions or reductions in the level of taxation to biofuels.

3. The policies put into place at national level

3.1 Wind and PV solar energy

The following table shows the different mechanisms used to support renewable energies in European countries (h: present; x: current):
More precisely, the main measures of the national policies in the countries we have studied are the following:

**Measures destined to support wind energy in Denmark:**

- A spot price, an environmental premium (€ 13/MWh) and an additional compensation for balancing costs (€ 3/MWh) for 20 years is available for new onshore wind farms.

  *NB: The fixed-premium mechanism currently implemented is a variant of the classical feed-in tariff scheme. Under this system, the government sets a fixed premium or an environmental bonus, paid above the normal or spot electricity price to RES-E generators.*

- A tendering procedure has been used for two new large offshore installations. Operators will receive a spot price and initially a settling price as well.

**Measures destined to support photovoltaic solar energy in Germany:**

- The Electricity Feed Law (EFL), implemented in 1991, obligated utilities to purchase electricity produced from renewable energy technologies (RETs) at fixed prices, based on a percentage value on average consumer price of electricity.

- In 2000, EFL was replaced by the *Renewable Electricity Law (REL)* where the obligation to pay tariffs had been moved from utilities to operators of the grid. The prime objective was to double the contribution of RETs, from the levels of 2000, to 2010 (equalling a share of around 6%), in the German electricity sector.

- Specifically for PV energy, from 1990 to 1995, Germany implemented the “1,000 PV roofs” programme that provided subsidies for PV technology adopters. The success of this program paved the way to the “100,000 roofs” program that started in 1999 (loan guarantee and subsidy program).

**Measures destined to support photovoltaic and wind energy in France:**

- A variety of feed-in tariffs.

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Source: EEA Briefing No 2/2004
For individuals, tax credits when acquiring an equipment using a renewable energy source.

Public tendering procedures for big on-shore and off-shore wind projects.

NB: Functioning of the tendering procedure: Government awards power purchase contracts by way of tenders for a certain aggregate volume of eligible RES-electricity to project developers who submit the lowest asking price for a kWh.

3.2 Biofuels

Measures destined to support biofuels in France:

- Since 1992 biofuels have benefited from a partial tax exemption (from the “TIPP”, i.e. the tax on petroleum products), destined to compensate the additional production costs, compared to conventional types of fuels.
- In order to drive distributors to put the totality of the authorised quantities (biodiesel, ETBE and pure bioethanol) on the market, the 2005 Finance Law introduced a new tax called the TGAP (“General Tax on Polluting Activities”): oil suppliers pay an additional tax, unless they introduce a certain percentage of biofuels in their products (the amount of the tax is reduced proportionally to the quantity of biofuel introduced).

4. The case of wind and photovoltaic energy

4.1 The innovation barriers at hand and the potential risk of technological lock-in

From literature and interviews, the following points can be made:

- The risk of lock-in is seen as limited by the interviewees:
  - The different actors, and notably industrials, know that renewable energies are here to stay. There are few risks that the market will disappear. So they have incentives to produce more efficient equipments in order to beat their competitors.
  - Most of the installations have a limited lifetime (around 15 to 20 years for a wind turbine for example), so they will need to be replaced at some point anyway.
- In the case of wind and PV energy, even if there still is a need for some incremental innovation in order to make wind turbines and solar PV panels more powerful and less costly, it can be said that these technologies are more or less mature. The most important question now is how to stimulate large scale diffusion.
- Public acceptance, or the very lack of it, is particularly an obstacle for the diffusion of wind energy. Even if in some countries surveys show strong overall public support for wind power, concrete projects often suffer from the Not-In-My-Backyard syndrome. In Denmark, wind turbines were well accepted in the 1980s when they were installed by local communities. Now that the concentration of the industry sector has produced several big players, people tend to refuse the installation of new turbines near their home because they do not see why they should support companies’ profits.
• Off-shore wind turbines have opponents among the environmentalists because they are said to be dangerous for birds. Consequently, before realising any project, the environmental impact needs to be evaluated. This does not simplify the procedures.

• The administrative barriers are a very significant obstacle to the diffusion of RETs. Acquiring building permits is often a lengthy process, as it deals with complicated regulations. Complex administrative requirements tend to delay the implementation of industrial projects in the field of RETs (wind fields, biomass power plants, etc.) and can discourage industry. These delays can indeed easily jeopardize the profitability of the projects because they make financial projections difficult (as raw materials prices tend to be rather unstable).

• Even if the technologies of wind turbines and PV panels can be considered mature, technical improvements can still be made in the field of grid connection. Indeed the electricity networks in Europe have all been thought of at a time when RET did not exist.

4.2 The effectiveness of adopted policies on (continuous) innovation

At European level -

• The 2001 Directive has played a significant role in giving confidence to the different actors (researchers as well as private investors) because it clearly asserted that there was a large and long-term political consensus on the necessity of fostering renewable energies.

• However, the fact that the national targets indicated in the annex to the Directive were not binding still showed that some countries were not ready to commit themselves to a firm objective. This has changed since March 2007, when the European countries have agreed to make the commitments binding. This has enhanced the confidence of the actors of the field, but they still want to know what the sanctions will be if some countries do not reach their targets.

• The fact that under the Directive, each country is responsible for the choice of the renewable energy technologies it wants to support to reach the national targets is an efficient solution. The various European countries do not have the same natural assets (exposure to wind flows, quantity of sun, possibility to use make hydroelectricity, etc.), so it would have been counterproductive to impose any quota.

• Although the Directive has had a large impact, it can be regretted that it has not yet led to a common supranational policy.

At national level -

General comments:

• The systems of feed-in tariffs or guaranteed buy-back prices have proved very useful in fostering the diffusion of wind and PV energy equipments in Denmark and Germany. By reducing the financial risks for the investors and by guaranteeing an internal market they have led to the emergence and development of private companies.

• Creating economic incentives for private actors to engage in the RET field is an efficient way of promoting the development of a competitive market. Where there is competition
it is more likely to foster innovation because companies want to have the best offers to win market shares. Therefore they invest a lot in R&D. The condition to this virtuous circle is that companies need to be assured that the market is going to expand.

- In Denmark as well as in Germany transparent rules for bearing and sharing the costs of various grid investments have been put in place. It is very important for the promotion of the RETs because it gives a good visibility on the costs of projects.

- Clear messages about the questions at stake in the field of energy are still lacking. In Germany for example, the support for renewables is quite high but there is no public communication about the need for a “transition phase”, during which fossil and renewable need to cohabitate. Consequently the message is blurred.

Specific measures taken in support of continuous innovation:

The main ways of stimulating continuous innovation are to provide producers with decreasing feed-in tariffs and to put a time limit to the guaranteed buy-back. This allows governments to save money, but this can also lead industrials to develop technologies that perform better.

- In Germany, since 2003, new renewable energy installations have been accorded progressively diminishing feed-in tariffs. The rate of degression is based on the empirically derived progress ratios for the different technologies. The tariff guaranteed for the buy-back of solar electricity decreases by 5% each year. According to one of our interviewees, this mechanism stimulates innovations designed at reducing costs. (NB: reducing costs is an obligation in PV industry anyways as prices of materials constantly increase).

In the German case, this mechanism was clearly destined to retain the incentive for manufacturers to systematically reduce production costs and to offer more efficient products every year: “tariffs for new plants need to decrease every year to further technological development and to bring costs down” (source: presentation of a member of the German Ministry for the Environment, Nature Conservation and Nuclear Safety).

- In France, wind energy producers are guaranteed that their electricity will be bought for 15 (on-shore installations) to 20 years (off-shore installations). As for the tariffs, a certain price level is guaranteed during 10 years, followed by a decrease (the amount of which depends on the location of the installation) for the remaining 5 or 10 years.

In the case of energy produced from biomass, one interviewee underlined that the Energy Regulation Commission has lately issued a call for tender guaranteeing more subsidies for projects using more innovative technologies. If the use of this kind of mechanisms was to be systematised, they could stimulate R&D activities on the part of industrials.

- In Denmark, following the two tendering procedures that are currently taking place, subsequent offshore wind farms are to be developed on the basis of market conditions.

5. The case of biofuels

The key challenge is to stimulate the diffusion of the first generation of biofuels without delaying the emergence of the second one. Currently the biofuels that are distributed in France and worldwide belong to what is called the “first generation”. The arrival of a “second generation” is pending but still needs some research before being introduced onto the market.
In the light of the “lock-in” issue, the question is therefore: will the support given to biofuels available today by French policy hinder or delay the emergence of the biofuels of the future?

5.1 The effectiveness of adopted policies on (continuous) innovation

At European level -

- The 2003 Directive on the promotion of biofuels, by setting a minimum percentage of biofuels to replace diesel or petrol, has played the same role as the 2001 Directive in the case of renewable energies. By asserting the commitment of the European Union to promote biofuels in the long run, it has reduced the risk perceived by actors (researchers, cultivators, industrials). Therefore, it provides an incentive both to foster the diffusion of biofuels now while continuing work on future generations.

- At the same time, the Directive is sometimes viewed as weak because it is not mandatory.

- Another flaw of the Directive is that it proves to be in contradiction the earlier Directive 98/70 (Fuel quality standards) that specifies a range of fuel quality parameters for both petrol and diesel for use as road fuels. Amongst others, it sets a maximum threshold of 5% by volume of ethanol in petrol (and 3% for methanol). As ethanol is less energy-dense than petrol, this level is very significantly below the 5.75% target set out in the Biofuels Directive which is defined in terms of energy content. Therefore Directive 98/70 makes it impossible for any Member State to meet the Biofuels Directive’s targets (at least with regard to petrol through the use of low ethanol blends alone). The problem has recently been tackled by the Commission and Directive 98/70 should soon be revised. However, it created a certain amount of uncertainty amongst stakeholders.

- As mentioned earlier, Directive 2003/96/EC sets the rules for the exemption of biofuels and biofuel blends from energy taxes. Member states are allowed to grant a tax exemption for the share of biofuel in a blend. (For example, a blend of 5 percent biofuel and 95 percent petroleum-based fuel receives a tax reduction of 5 percent; a 100 percent biofuel gets a 100 percent exemption from energy tax.) This is necessary as high production costs make biofuels uncompetitive if they are subject to full taxation. However, the tax exemption must not over-compensate actual costs and will be subject to review in light of production costs and market development. Thus, the EU invites its members not to subsidise their biofuel industry excessively and to pay attention to the evolution of technologies. The Directive aims mainly to avoid undue subsidies, but at the same time it creates a framework that obliges biofuel actors to become progressively more competitive. This is a good way to stimulate continuous private R&D.

- There is a need for homogenisation of the support policies across Europe. Otherwise instability will be the outcome that can undermine the efficient implementation of national policies. For example, the tariffs for biofuels are more favourable in Germany than in France. As a result, French producers (whose plants had been subsidised by the French government) have been selling their production to German industry and France has had consequently difficulties reaching its objectives in terms of biofuels diffusion.

At national level -

- The main idea that was expressed by the interviewees is that awaiting the 2nd generation is not the right option. They have underlined that the “learning-by-doing factor” makes it essential to embark on the diffusion of first generation biofuels.
Despite differences between first and second generation biofuels, some parts of the process are identical (especially for bioethanol) and adapting plants will not be a real impediment. If the US and Brazil are more advanced in developing second generation biofuels, it is probably mainly due to their advance with regard to first generation biofuels. “There is no research where there is no industry”, according to one interviewee.

The current legislation creates a market for the first generation. In that perspective, the fiscal mechanisms work well, according to several interviewees, particularly the repressive aspect of it with the tax level being dissuasive.

However, creating a market for the first generation of biofuels is not enough to ensure that innovation will materialise. There needs to be more intensive support for (public) R&D on this subject.

6. Lessons to be learned

The first thing most interviewees have underlined is that the best way to stimulate continuous innovation is to have a growing market with several industrial players. The competition between them and the perspective of lasting growth should be sufficient to lead industrials to invest in R&D and develop better technologies.

Long-term commitments are needed so that industrials can be fairly certain that R&D investments will be profitable. The commitment towards developing renewable energies is difficult to realise at a national level and Europe has a key role to play here.

European as well as national policies should be coherent; otherwise they send mixed messages to the industrials and to the population. For example in Germany, there is at the same time financial support for RET and for coal plants.

A clear time frame should be attached to financial support mechanisms and if possible the support should decrease progressively over time in order to enhance competition and to create an incentive to reduce costs.

Concerning R&D subsidies, a given country cannot support all research areas: “you cannot be a champion in every field”. For example, Denmark has recently chosen to focus on 4 strategic research areas in the field of energy: biofuels of 2nd generation, fuel cells, highly efficient wind turbines, energy efficiency in buildings.

A large stakeholder consultation when fixing tariffs is important, because public authorities can have difficulties in determining the actual production costs of RES-E.

Addressing the problem of administrative barriers should be a priority for national policies. Innovation cannot emerge if there are too many obstacles that delay the implementation of projects. The method that has been implemented in Denmark in the field of energy is an example to follow: around 1997, when another set of planning regulations were developed for offshore wind farms, a central, national authority, the Danish Energy Agency, was designated to hear all interested parties, public and private. This “one-stop shop” method has considerably facilitated the planning process.

Policy makers should always take into account the structure of the market and the kind of company being active upon it. Indeed a vertically integrated company will not react to the legislation put in place the same way as a company which is only present for example at the end of the production process.
7. Questionnaire used

Companies

Introduction
1. What role does innovation play in the sector
2. Who are the main actors in this field in your country?
3. What level of performance on innovation is there in your area and country?
4. What are the main barriers to innovation?

Policy framework
5. How has EC and national policy framework impacted on your readiness to engage in innovation? For what reasons?
6. What are the strong / weak points of existing policy frameworks as regards innovation?
7. How would policy frameworks be ideally designed?
8. What are the accompanying measures needed?

Policy makers

1. What importance was accorded to the issue of innovation in the policy design?
2. How could the weak points (identified previously) be addressed?
3. What are the lessons to be learned?

8. List of interviewees

- Erik Guignard, French Renewable Energies Syndicate
- Bernard Chaud, Direction of economic and international policies, French Ministry for Agriculture
- Daniel Clément, Scientific Director, ADEME (French Environment and Energy Management Agency)
- Project manager in the Renewable Energies department of a big European oil company, in charge of photovoltaic projects
• Project manager in the Renewable Energies department of a big European oil company, in charge of wind and biomass projects
• Person in charge of the group-wide R&D coordination in a big German energy company
• Head of Marketing and New Business Development in a German company producing PV panels
• Nicolai Zarganis, Head of Department “Energy Policy and Energy Efficiency” at the Danish Energy Authority
• Aidan Cronin, International Policy Advisor, VESTAS (leading Danish wind energy company)

9. References
• Policy pathways to promote the development and adoption of cleaning technologies (2006): A Case Study on Electricity from Renewable Energy Sources
• Policy pathways to promote the development and adoption of cleaning technologies (2006): A Case Study on Biofuels
• Inspection des Finances (2005): Rapport sur l’optimisation du dispositif de soutien à la filière biocarburants
• Communication from the European Commission (2005): The support of electricity from renewable energy sources

5.3 The list of external experts consulted

• Frans Berkhout, Institute for Environmental Studies, Netherlands
• Maryse Chappin, Universiteit Utrecht, Netherlands
5.4 The database of the literature analysis
European Commission
DG Environment

“Designing environmental policy to be innovation friendly”

Data base & Literature Analysis

“The impact of environmental policy on innovation”
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<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Year</th>
<th>Publisher, journal, report n° etc.</th>
<th>Short description</th>
<th>Relevance (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abildtrup J. et al.</td>
<td>Green Roads to Growth</td>
<td>2006</td>
<td>Proceedings of Expert and Policy Maker Forums (held in Copenhagen 1-2 March, 2006)</td>
<td>Explores possible linkages between environmental policy and economic progress. Main conclusions: - Not too much should be expected from environmental policies with respect to broader goals of economic growth and employment. Environmental policies should be designed, in the first place, to protect the environment. - Well designed environmental policies may well become key in creating market conditions that promote innovation that takes society in the direction of cleaner technology. This should be broad based, emphasise economic instruments, should not be too targeted, create market conditions that enable inward investment rather than government subsidy, and support broad-based R&amp;D.</td>
<td>5</td>
</tr>
<tr>
<td>Aggeri, F.</td>
<td>Environmental Policy: A Knowledge-Based Perspective on Cooperative Approaches</td>
<td>2000</td>
<td>In: Research Policy 28 (2000), 699-717 (<a href="http://www.cgs.ensmp.fr/ERI_environnementDD/ERI_environnementdeveloppementdurable21.pdf">http://www.cgs.ensmp.fr/ERI_environnementDD/ERI_environnementdeveloppementdurable21.pdf</a>)</td>
<td>Analyses new cooperative approaches that make use of negotiated instruments such as voluntary agreements, using an interpretation framework that puts the emphasis on collective learning and monitoring devices. This approach is particularly relevant in situations of great uncertainty where a coordinated process of innovation is required to achieve ambitious environmental targets. The implementation of this theoretical approach in the end-of-life vehicles (ELV) case, which has been the subject of several voluntary agreements in Europe, offers a fuller understanding of the characteristics and driving forces of the collective innovation process in action, as well as the obstacles that have still to be overcome.</td>
<td>4</td>
</tr>
<tr>
<td>Ambec, S. Barla, Ph.</td>
<td>A Theoretical Foundation of the Porter Hypothesis</td>
<td>2002</td>
<td>Economics Letters, 75(3), pp. 355-360</td>
<td>Shows that, by reducing agency costs, an environmental regulation may enhance pollution-reducing innovation while at the same time increasing firms’ private benefit.</td>
<td>4</td>
</tr>
<tr>
<td>Anderson, D. et al.</td>
<td>Uncertainties in Responding to Climate Change</td>
<td>2000</td>
<td>Imperial College Centre for Energy- Policy and Technology &amp; the Fabian Society</td>
<td>Presents a simplified model of the form often used to project long-term emissions of CO2 from energy production and use. Considers then three uncertainties in the model’s structures concerning: a) the rate of improvement in energy efficiency and its effect on energy demand; b) the costs of environmental damage; and c) the rate of technological progress and use of technologies for abating CO2 emissions.</td>
<td>2</td>
</tr>
<tr>
<td>Anderson, D.</td>
<td>Innovation and the</td>
<td>2001</td>
<td>Imperial College Centre for</td>
<td>Argues that environmentally beneficial innovations require not only</td>
<td>4</td>
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<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Year</td>
<td>Publisher, journal, report n° etc.</td>
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<tr>
<td>et al.</td>
<td>Environment: Challenges &amp; Policy Options for the UK</td>
<td>2003</td>
<td>'standard' environmental policy instruments, but also direct support for environment-oriented innovation. Main reasons for this are the positive externalities of innovation and the long time lag between the implementation of a standard policy and the market penetration of a new technology.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Arimura, T.</td>
<td>Empirical Analysis that Environmental Policy has on Technological Innovation</td>
<td>2005</td>
<td>ESRI International Collaboration Project on Environmental Issues, Tokyo (<a href="http://www.esri.go.jp/jp/prj-2004_2005/kankyou/kankyou16/06-1-P.pdf">http://www.esri.go.jp/jp/prj-2004_2005/kankyou/kankyou16/06-1-P.pdf</a>)</td>
<td>Assesses the impact of environmental policy on firms in the Japanese context, notably focusing on their engagement in R&amp;D activities and productivity levels. Argues that flexible instruments promote environmental R&amp;D activity, whereas prescriptive instruments largely fail to do so.</td>
<td>3</td>
</tr>
<tr>
<td>Ashford, N.A.</td>
<td>Government and Environmental Innovation in Europe and North America</td>
<td>2005</td>
<td>In: M. Weber and J. Hemmelskamp (eds.), Towards Environmental Innovation Systems. Springer, Berlin/Heidelberg/New York, p. 159-174</td>
<td>Argues that a 'command-and-control' type of environmental policy is needed to achieve the necessary improvements in eco- and energy efficiency. The 'ecological modernization' approach, with its emphasis on cooperation and dialogue, will not be sufficient. Significant industrial transformations occur most often from new firms that displace existing products, processes and technologies.</td>
<td>5</td>
</tr>
<tr>
<td>Becker, F. Englimann, F.</td>
<td>Public Policy, Voluntary Initiatives and Water Benign Process Innovations</td>
<td>2005</td>
<td>In: M. Weber and J. Hemmelskamp (eds.), Towards Environmental Innovation Systems. Springer, Berlin/Heidelberg/New York, p. 137-157</td>
<td>Results from survey suggest that chemical industry's reactions to environmental regulations seem to be by far the most important reason for carrying out both end-of-pipe and production-integrated innovations.</td>
<td>4</td>
</tr>
<tr>
<td>Beise, M. Rennings, K.</td>
<td>Policy-Frameworks for the Development of International Markets for Innovations of a Sustainable Economy:</td>
<td>2003</td>
<td>(<a href="http://www.zew.de/en/forschung/projekte.php3?action=detail&amp;nr=242">http://www.zew.de/en/forschung/projekte.php3?action=detail&amp;nr=242</a>)</td>
<td>The project analysed the conditions for the emergence of lead-markets for innovations of a sustainable development. It has developed policy-recommendations which are able to support the world-wide diffusion of environmental friendly technologies. We understand Lead-markets as regional or national markets, which were stimulated by higher preferences for environmental goods in a given country, specific</td>
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<td>Author(s)</td>
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<tr>
<td>Beise, M.</td>
<td>From Pilot Markets to Lead Markets</td>
<td></td>
<td></td>
<td>supporting measurements, or policy interventions to the market, which are able to influence the competition in other regions effectively, do trigger reactions of adjustment and finally lead to an international diffusion of the new technologies.</td>
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<td>Rennings, K.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beise, M.</td>
<td>Lead Markets of Environmental Innovations: A Framework for Innovation and Environmental Economics</td>
<td>2003</td>
<td>ZEW Discussion Paper No. 03-01 (ftp://ftp.zew.de/pub/zew-docs/dp/dp0301.pdf)</td>
<td>Argues that all lead market factors seem to be at least relevant for environmental innovations. The importance of the Porter effect depends on its relation to global demand and regulatory effects. If national regulation is supported by global demand or regulatory trends, a strong effect can be identified, as was shown in the cases of wind energy in Denmark and Diesel-High-pressure-direct-injection in Germany. If it is not supported, the market remains idiosyncratic, as could be seen in the failure of the the Golf Ecomatic.</td>
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<tr>
<td>Rennings, K.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beise, M.</td>
<td>National Environmental Policy and the Global Success of Next Generation Automobiles</td>
<td>2004</td>
<td>(<a href="http://www.rieb.kobe-u.ac.jp/academic/ra/dp/English/dp154.PDF">http://www.rieb.kobe-u.ac.jp/academic/ra/dp/English/dp154.PDF</a>)</td>
<td>Analyses the impact national regulatory policy approaches have on the innovation performance and product outcomes with regard to the automobile sector. Concludes that due to the high costs of fuel cell vehicles and the lack of strict regulation supporting this radical innovation, incremental innovations such as new versions of conventional combustion engines and hybrid cars have the best chances of becoming globally successful.</td>
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<td>Rennings, K.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beise, M.</td>
<td>Lead Markets and Regulation: A Framework for Analyzing the International Diffusion of Environmental Innovation</td>
<td>2005</td>
<td>Ecological Economics 52/1, pp 5-17</td>
<td>Extending the lead market model to environmental innovations and taking account of the peculiarities of such innovations, in particular, the public good character of environmental benefits and the role of regulations, demonstrates that when supported by global demand or regulatory trends, strict regulation results in the creation of lead markets.</td>
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<td>Rennings, K.</td>
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</tr>
<tr>
<td>Beise, M.</td>
<td>Lead Markets of Environmental Innovations: A Framework for Innovation and Environmental Economics</td>
<td>2005</td>
<td>Centre for European Economic Research ftp://ftp.zew.de/pub/zew-docs/dp/dp0301.pdf</td>
<td>Questions whether environmental regulations can create lead markets, enabling firms to export innovations that are induced by local market conditions and national regulations. Two case-studies are analysed: the emergence and international diffusion of wind energy generation and fuel efficient technologies for passenger cars.</td>
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<td>Rennings, K.</td>
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<td>Author(s)</td>
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<td>Publisher, journal, report n° etc.</td>
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<td>-----------</td>
</tr>
<tr>
<td>Berkhout, F.</td>
<td>Technological Regimes, Environmental Performance and Innovation Systems: Tracing the Links</td>
<td>2005</td>
<td>In: M. Weber and J. Hemmelskamp (eds.), Towards Environmental Innovation Systems. Springer, Berlin/New York, p. 57-80.</td>
<td>Challenges the view that there is a ‘natural’ tendency for environmental technology to develop from abatement (end-of-pipe) to ‘integrated’ (clean) technologies. Argues, at the example of two cases (pulp and paper and PVC production), that attempts to explain technological changes with major environmental performance impacts by means of a simple pressure-response model are not justified. There are many non-environmental factors leading to such changes.</td>
<td>5</td>
</tr>
<tr>
<td>Berkhout, F.</td>
<td>Innovation in the Chemicals Sector and the New European Chemicals Regulation</td>
<td>2003</td>
<td>SPRU, University of Sussex (Report for WWF-UK)</td>
<td>Concludes that many of the main provisions of REACH will tend to promote innovation, both within the EU chemicals sector and more widely. Contains a critical analysis of some earlier studies on the impact and costs of REACH.</td>
<td>5</td>
</tr>
<tr>
<td>Bernauer, T.</td>
<td>Explaining Green Innovation - Ten Years after Porter’s Win-Win Proposition: How to Study the Effects of Regulation on Corporate Environmental Innovation?</td>
<td>2006</td>
<td>Center for Comparative and International Studies</td>
<td>The Porter hypothesis has spurred a substantial amount of research on the influence of environmental regulation on innovation, but the results have so far remained inconclusive. This article discusses the key problems in extant research and outlines a comprehensive analytical framework for studying the effects of environmental regulation on innovation alongside firm-internal conditions and external market forces. This framework also takes into account varying opportunities for direct customer benefits across areas of environmental innovation.</td>
<td>5</td>
</tr>
<tr>
<td>Boekholt, P.</td>
<td>Innovation Policy and Sustainable Development: Can Innovation Incentives Make a Difference?</td>
<td>2002</td>
<td>IWT-Studies, Contributions to a Six Countries Programme Conference, (February 28 - March 1, 2002, Brussels) (<a href="http://www.iwt.be/download/publicaties/observatorium/obs40.pdf">http://www.iwt.be/download/publicaties/observatorium/obs40.pdf</a>)</td>
<td>Concludes that environmental policies have demonstrated some effectiveness in changing behaviour in addressing focussed technological challenges. States that the challenge now is to extend these more targeted approaches towards a systemic change process affecting the broader business community. The contributors write that further policy innovations in the field of policy integration will be needed. The study is based on country case studies that demonstrate the wide variety of initiatives that are developed to stimulate innovation for environmental sustainability, depending on different development paths and different institutional settings.</td>
<td>5</td>
</tr>
<tr>
<td>Brunnermeier, S.</td>
<td>The Determinants of Environmental Innovation</td>
<td>2003</td>
<td>Journal of Environmental Economics and</td>
<td>Provides new evidence on the determinants of environmental innovation. Employs panel data models to study how environmental innovation by</td>
<td>4</td>
</tr>
<tr>
<td><strong>Author(s)</strong></td>
<td><strong>Title</strong></td>
<td><strong>Year</strong></td>
<td><strong>Publisher, journal, report n° etc.</strong></td>
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<td>in US Manufacturing Industries</td>
<td>Management, vol. 45, p 278-293</td>
<td></td>
<td>US manufacturing industries responded to changes in pollution abatement expenditures and regulatory enforcement during the period 1983 through 1992. Conclusions: environmental innovation (as measured by the number of successful environmental patent applications granted to the industry) responded to increases in pollution abatement expenditures, however, increased monitoring and enforcement activities related to existing regulations did not provide any additional incentive to innovate. Also provides some empirical evidence that environmental innovation is more likely to occur in industries that are internationally competitive.</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Buen, J.</td>
<td>Danish and Norwegian Wind Industry: The Relationship Between Policy Instruments, Innovation and Diffusion</td>
<td>2006</td>
<td>Energy Policy 34 (18), p. 3887-3897</td>
<td>Compares the role of policy instruments in stimulating long-term technological change in Danish and Norwegian wind industry, concluding that Denmark’s broad portfolio of policies has been well adapted to the different stages in the development of its wind industry. This has contributed to a high degree of innovation, successful establishment in niche markets, high degree of diffusion of domestic and international mass markets, and—in recent years—an increasingly successful replacement of senescent technology.</td>
<td>5</td>
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<tr>
<td>Burtraw, D.</td>
<td>Innovation under the Tradeable Sulphur Dioxide Emission Permits Programme in the US Electricity Sector</td>
<td>2000</td>
<td>OECD proceedings Innovation and the Environment, OECD, Paris (<a href="http://www.rff.org/documents/RFF-OP-00-38.pdf">http://www.rff.org/documents/RFF-OP-00-38.pdf</a>)</td>
<td>Provides a survey and assessment of the SO2 allowance trading program with a focus on the role of innovation. After 10 years the cost of compliance has fallen dramatically compared with most expectations and innovation accounts for a large portion of these cost savings, but in an unusual way. Innovation under the SO2 allowance trading program involves organizational innovation at the firm, market and regulatory level and process innovation by electricity generators and upstream fuel suppliers.</td>
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<td>CBI</td>
<td>Green Taxes: Rhetoric</td>
<td>2002</td>
<td>In: Business Environment,</td>
<td>Critically assesses the appropriateness of environmental taxes put into</td>
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<td>Author(s)</td>
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<td>De Vries, F. Withagen, C.</td>
<td>Innovation and Environmental Stringency: The Case of Sulphur Dioxide Abatement</td>
<td>2005</td>
<td>Discussion Paper no. 2005-18, CentER, Tilburg University</td>
<td>The ‘incentive to innovate’ is measured by means of patent applications. For measuring strictness of environmental policy, three different approaches are used. Two of these do not reveal a positive significant effect of stringency on innovation. In the theoretically preferred model, however (in which the underlying idea is that high emission levels trigger strict environmental policy) a positive relationship between stringency and innovation is obtained.</td>
<td>4</td>
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<tr>
<td>Egmond, C. Jonkers, R. Kok, G.</td>
<td>One size fits all? Policy instruments should fit the segments of target groups</td>
<td>2006</td>
<td>Energy Policy 34 (18), pp. 3464-3474</td>
<td>With regard to technical innovations in the field of energy-efficiency, analyses early market and mainstream decision-making behaviours, and how the active ingredients in policy instruments specifically target the characteristics of the two markets. Argues that mainstream instruments should intervene as early as possible in the decision-making process and emphasize communication about advantages such as comfort and quality in addition to money and energy savings. Energy conservation should be presented as a solution to an actual problem. Early market actors are highly internally motivated, implying that early market interventions need to be challenging and facilitating.</td>
<td>4</td>
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<tr>
<td>Elzenga, H. Ros, J.</td>
<td>MEI-Energie: RIVM’s Energiebesparingsmodel (MEI Energy: RIVM’s energy savings model)</td>
<td>2004</td>
<td>In: Kwartaalschrift Economie 1 (2), p. 168-189</td>
<td>Presents a model which calculates past and future energy savings in industry, based on the diffusion of energy conservation technology. The model simulates company behaviour and pays specific attention to the role of policy instruments. Voluntary agreements and regulations appear to be more effective than financial instruments (such as taxes and subsidies) for the implementation of investments with long payback time. Improvement of the empirical underpinnings of the model is complicated by a lack of data and reliable long term monitoring.</td>
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<td>Fischer, C. Parry, I. Pizer, W.</td>
<td>Instrument Choice for Environmental Protection When Technological Innovation is Endogenous</td>
<td>1998</td>
<td>Resources for the Future (<a href="http://www.rff.org/Documents/RFF-DP-99-04.pdf">http://www.rff.org/Documents/RFF-DP-99-04.pdf</a>)</td>
<td>Presents an analytical and numerical comparison of the welfare impacts of alternative instruments for environmental protection in the presence of endogenous technological innovation. The authors analyze emissions taxes and both auctioned and free (grandfathered) emissions permits. They find that under different sets of circumstances each of the three policies may induce a significantly higher welfare gain than the other two policies. In particular, the relative ranking of policy instruments can crucially depend on the ability of adopting firms to imitate the innovation, the costs of innovation, the slope and level of the marginal environmental benefit function, and the number of firms producing emissions.</td>
<td>3</td>
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<tr>
<td>Fleischer, M.</td>
<td>Regulation and innovation in the chemical industry: A comparison of the EU, Japan and the USA</td>
<td>2003</td>
<td>In: Surface Coatings International Part B - Coatings Transactions, Volume 86, Number 1, 1 March 2003, pp. 21-29(9)</td>
<td>Summarizes regulation and innovation in the chemical industry by comparing the EU, Japan and the USA and focusing on three important policy issues related to innovation: a) the structural differences between the notification systems for new chemical substances; b) the evaluation of the innovative performance of the chemical industries; c) the determination of whether the differences observed can be attributed in part to the structural differences of the regulatory systems.</td>
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<tr>
<td>Foxon, T.J.</td>
<td>Technological and Institutional ‘Lock-In’ as a Barrier to Sustainable Innovation’</td>
<td>2002</td>
<td>International Summer School on Innovation for Sustainable Development: Institutions, Incentives and Economic Policy (<a href="http://www.iccept.ic.ac.uk/publications/public.html">http://www.iccept.ic.ac.uk/publications/public.html</a>)</td>
<td>Examines the role of technological and institutional ‘lock-in’ as a barrier to more sustainable innovation, before suggesting appropriate policy responses designed to overcome innovation obstacles.</td>
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<tr>
<td>Foxon, T.J.</td>
<td>Inducing Innovation for a Low-Carbon Future: Drivers, Barriers and</td>
<td>2003</td>
<td>The Carbon Trust (<a href="http://www.thecarbontrust.co.uk/Publications/publication">http://www.thecarbontrust.co.uk/Publications/publication</a>)</td>
<td>Reviews and analyses the latest academic and policy thinking on the drivers of, and barriers to, innovation, and asks how significant innovation towards a low carbon future could be stimulated through</td>
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<td>Policies</td>
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<td>detail.htm?productid=CT-2003-07&amp;metaNoCache=1</td>
<td>policy incentives. Argues that, to put an end to the “carbon lock-in”, information about future demands and future technological possibilities needs to be exchanged between users and producers. This means that non market transactions, including forms of co-operation and exchange of qualitative information, may be needed together with market transactions, to stimulate radical innovation.</td>
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<tr>
<td>Foxon, T.J. et al.</td>
<td>Innovation Systems and Policy-Making Processes for the Transition to Sustainability</td>
<td>2004</td>
<td>Environmental Policy and Management Group, Imperial College London (<a href="http://web.fu-berlin.de/ffu/akumwelt/bc2003/proceedings/096%20-%20112%20foxon.pdf">http://web.fu-berlin.de/ffu/akumwelt/bc2003/proceedings/096%20-%20112%20foxon.pdf</a>)</td>
<td>Describes initial results from a research project investigating the interaction between the policy-making process and the innovation process. The project is undertaking theoretical and empirical analyses of the interactions between policy-making processes and innovation systems in two case study areas - low carbon innovation in the UK and alternative technologies for energy sources in vehicles at the EU policy level.</td>
<td>3</td>
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<tr>
<td>Foxon, T.J. et al.</td>
<td>Transforming Policy Processes to Promote Sustainable Innovation: Some Guiding Principles</td>
<td>2005</td>
<td>Environmental Policy and Management Group, Imperial College London (<a href="http://www.reapsystems.co.uk/images/stories/si_policy_guidance_final_version.pdf">http://www.reapsystems.co.uk/images/stories/si_policy_guidance_final_version.pdf</a>)</td>
<td>Proposes five guiding principles to inform strategic thinking about the policy goals, processes, measures and instruments appropriate for a Sustainable Innovation policy regime: - Stimulate the development of a sustainable innovation policy regime that brings together appropriate strands of current innovation and environmental policy and regulatory regimes; - Apply systems thinking and practice, engaging with the complexity and systemic interactions of innovation systems and policy-making; - Advance the procedural and institutional basis for the delivery of sustainable innovation policy; - Develop an integrated mix of policy processes, measures and</td>
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<td>Foxon, T.J.</td>
<td>Applying Systems Thinking and Practice for Promoting Sustainable Innovation</td>
<td>2006</td>
<td>Ibid. (<a href="http://www.sussex.ac.uk/Units/spru/events/ocs/viewpaper.php?id=233">http://www.sussex.ac.uk/Units/spru/events/ocs/viewpaper.php?id=233</a>)</td>
<td>Instruments that cohere to promote sustainable innovation; - Incorporate policy learning as an integral part of sustainable innovation policy process.</td>
<td>-</td>
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<tr>
<td>Foxon, T.J. Pearson, P.J.</td>
<td>Towards Improved Policy Processes for Promoting Innovation in Renewable Electricity Technologies in the UK</td>
<td>2007</td>
<td>Energy Policy 35 (3), p. 1539-1550</td>
<td>Based on the 2005 paper setting out 5 guiding principles, this paper describes these principles and examines the first and second in more detail. In particular, it argues for the concept of 'systems failure' as a rationale for public policy interventions, rather than the narrower economic concept of 'market failure'.</td>
<td>3</td>
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<tr>
<td>Giljum, S. et al.</td>
<td>Environment and Innovation: New Environmental Concepts and Technologies and Their Implications for Shaping</td>
<td>2006</td>
<td>Report for the European Parliament by SERI (Sustainable Europe Research Institute), UNI-MERIT (United Nations University), and FFRC</td>
<td>Discusses six emerging environmental concepts (ecological footprint, cradle-to-cradle, dematerialization, eco-sufficiency, transition management and vulnerability) in terms of their potential for further use and the differences between responses in the EU and in other countries. Also discusses six emerging environmental technologies (white biotechnology, hydrogen based transportation fuels, small-scale wastewater treatment systems, energy producing greenhouses, solar</td>
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<td>Giessel, F. Van der Veen, G.</td>
<td>Policy Instruments for Sustainable Innovation</td>
<td>2004</td>
<td>(<a href="http://www2.vrom.nl/docs/internationaal/RegionalResearch03.pdf">http://www2.vrom.nl/docs/internationaal/RegionalResearch03.pdf</a>)</td>
<td>Provides an overview of the various financial and economic instruments available and assesses their respective usefulness in order to support innovation in the area of sustainability.</td>
<td>5</td>
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<tr>
<td>Gottberg, A. Morris, J. Pollard, S. Mark-Herbert, C. Cook, M.</td>
<td>Producer Responsibility, Waste Minimisation and the WEEE Directive: Case studies in Eco-Design from the European Lighting Sector</td>
<td>2006</td>
<td>Science of the Total Environment 359 (1-3), pp. 38-56</td>
<td>Shows, on the ground of several case studies, that the principle of extended producer responsibility (EPR) has had little effect on product development so far, as most producers have been able to pass on incremental costs associated with EPR to customers with negligible effects on sales. Demonstrates that other drivers, such as bans on hazardous substances, product declarations and supply chain pressures, were often more effective promoters of eco-design. Advocates a mix of policy rather than reliance on economic instruments alone.</td>
<td>4</td>
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<tr>
<td>Greaves, C. (ed.)</td>
<td>Regulation and innovation in the recycling industry</td>
<td>2000</td>
<td>ESTO Project Report (<a href="http://ftp.jrc.es/eur19623en.pdf">http://ftp.jrc.es/eur19623en.pdf</a>)</td>
<td>Analyses the impact of legislation on innovation and development in the recycling sector. Shows that anticipation of regulation is a stimulus for recycling, that perceptions of quality have limited the demand for recycled materials, and that standards for secondary raw materials and quality certification schemes can stimulate confidence and, thus, market demand.</td>
<td>5</td>
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<tr>
<td>Green Alliance</td>
<td>Next Steps for Energy Taxation: A Survey of Business Views</td>
<td>2002</td>
<td>(<a href="http://green-alliance.org.uk/uploadedFiles/Publications/NextStepsForEnergyTaxation.pdf">http://green-alliance.org.uk/uploadedFiles/Publications/NextStepsForEnergyTaxation.pdf</a>)</td>
<td>The UK is committed to using economic instruments to protect the environment, and has a range of measures in place, including the Climate Change Levy and a voluntary emissions trading scheme, which aim to reduce the carbon intensity of the UK economy. Based on a survey of 24 businesses, assesses progress toward this goal and discusses how economic instruments could be further developed to set business on the path to innovation, increased competitiveness and a low-carbon future.</td>
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<tr>
<td>Gross, R. Foxon, T.J.</td>
<td>Policy Support for Innovation to Secure Improvements in Resource Productivity</td>
<td>2003</td>
<td>Environmental Policy and Management Group, Imperial College London</td>
<td>Presents the case for direct policy support for environmental innovation, aimed at improving resource productivity, as a complement to standard regulatory or market-based instruments of environmental policy. Argues that more widespread adoption of such policy instruments is needed, together with systematic analysis and assessment of their effectiveness in stimulating environmental innovation in different industries and at different stages of the innovation cycle.</td>
<td>4</td>
</tr>
<tr>
<td>Gunningham, N.</td>
<td>Leaders and Laggards: Next Generation Environmental Legislation</td>
<td>2002</td>
<td>Greenleaf</td>
<td>Argues that command and control regulation has made a substantial contribution in many areas of environmental policy, particularly in relation to laggards, and will continue to do so. However, 'the low hanging fruit' has largely been picked, and, in an increasingly complex, diverse and interdependent society, command and control is a blunt tool. A variety of other options including voluntary mechanisms, regulatory flexibility and informational regulation, are examined. Such strategies are most likely to succeed if they are underpinned by direct regulation.</td>
<td>4</td>
</tr>
<tr>
<td>Hafkesbrink, J. Halstrick, M.</td>
<td>Estimated innovation effects of Environmental Policy Instruments on the Substance Flows of Used and Scrap Electrical Goods</td>
<td>2000</td>
<td>In: Klemmer, P.: Innovation and the Environment (<a href="http://www.aroew.de/deutsch/downloads/Innovation_WE">http://www.aroew.de/deutsch/downloads/Innovation_WE</a> EE.pdf)</td>
<td>Analyses the efficiency with which the principle of closed substance flow systems has been realised in the German context with regard to used and scrap electrical appliances. Highlights the impact the announcement of the Electrical Scrap Ordinance had on R&amp;D activity with regard to material flow management, product design and production processes (front end versus end of life): energy efficiency, ease of dismantling, and resource use during production process.</td>
<td>5</td>
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<tr>
<td>Hansen, O. Søndergard, B.</td>
<td>Environmental Innovations in Small- and Medium-Sized Enterprises</td>
<td>2002</td>
<td>Technology Analysis and Strategic Management, vol. 1, n°1, p 37-56</td>
<td>Focuses on the adoption and diffusion of environmental innovations amongst SMEs. Research suggests that whilst SMEs possess high flexibility, their innovative capacity may be limited to incremental changes within their existing technology system and network. Based on the findings of 20 case studies an analytical framework is suggested, whereby the environmental innovative capability of SMEs is conceived as the result of an interplay between the competencies, the network relations and the strategic orientation of the company. This indicates that policy to support SME's adoption of environmental innovations has to take an integrated form, i.e. addressing and developing competence,</td>
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<tr>
<td>Hemmelskamp, J.</td>
<td>The Impact of Wind Energy Policy on Innovation</td>
<td>1999</td>
<td>Environmental Experts</td>
<td>Some countries of the EU have witnessed an amazing surge in the development of wind power generation over recent years. Looks at how national governments, through their environmental policy, are playing a crucial role in influencing the development of wind energy.</td>
<td>4</td>
</tr>
<tr>
<td>Hemmelskamp, J.</td>
<td>Environmental Policy Instruments and their Effects on Innovation</td>
<td>1997</td>
<td>European Planning Studies, 2, 177-194</td>
<td>Analyses the impact of requirements, levies, permits, liability laws, and the EC- eco-audit regulation with respect to the generation of environmentally benign innovations. Most theoretical studies come to the conclusion that direct requirements provide little incentives for dynamic effects and that emission taxes and permits are better instruments to promote innovations. However, the empirical studies show that the dynamic effects of environmental policy instruments in practice partly differ from the ideal instruments analysed in theoretical studies.</td>
<td>5</td>
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<tr>
<td>Hemmelskamp, J.</td>
<td>Environmental Taxes and Standards: An Empirical Analysis of the Impact on Innovation</td>
<td>2000</td>
<td>ZEW Economic Studies 10, p.1-10 (<a href="http://web.fu-berlin.de/ffu/jacob/Hemmelskamp.PDF">http://web.fu-berlin.de/ffu/jacob/Hemmelskamp.PDF</a>)</td>
<td>Argues that the ideal environmental policy is based on policy-mix combining the relative advantages of the different instruments available. Defends a framework approach that stresses policy coherence, the integration of various policies and interlinkages with innovation systems.</td>
<td>4</td>
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<tr>
<td>Hemmelskamp, J. Bradford, D. Kottmann, H. Marsanich, A. Gouldson, A.</td>
<td>The Impact of the EU Eco-Audit Regulation on Innovation in Europe</td>
<td>2000</td>
<td>IPTS report (n°8/2000)</td>
<td>Examines the relationship between the EC Eco-Management and Audit Scheme (EMAS) and innovation. Covers the following issues: - How EMAS can promote a steady improvement in environmental performance at company level; - Investigation of the different ways in which the regulation may be implemented, and the impact this has had on innovations to date, in particular on technological innovations; - An assessment of the links with other management regulations, such as ISO 14001 and ISO 9001 (Quality Management) to ascertain whether companies combine relevant evaluations to achieve efficiencies of cost and effort.</td>
<td>3</td>
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<tr>
<td>Hemmelskamp, J. Leone, F.</td>
<td>Innovation-oriented Environmental</td>
<td>2000</td>
<td>Physica Verlag, Heidelberg/New York</td>
<td>Contains the papers of a conference held in Potsdam, May 1999. To a large extent, these papers are based on the German ‘Innovation Impacts' study of 1999. The study was commissioned by the German Federal Environmental Foundation (DBU) and carried out by the authors of this report. The aim of the study was to provide an overview of the current state of research and development in the field of innovation-oriented environmental management.</td>
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<td>Rennings, K. (ed.)</td>
<td>Regulation: Theoretical Approaches and Empirical Analysis</td>
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<td>of Environmental Policy (FIU) project, and on the IPTS framework project on ‘The Impact of Regulation on Innovation in European Industry’.</td>
<td></td>
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<tr>
<td>Hemmelskamp, J. Brockmann, K.L.</td>
<td>Environmental Labels – The German Blue Angel</td>
<td>1997</td>
<td>Futures, 1, 67-76</td>
<td>Argues that a credible environmental label can only be established if it is issued by a neutral or state organisation on the basis of scientifically derived criteria. This holds true for the German ‘Blue Angel’. A case study of emulsion lacquer paints labelled with the Blue Angel indicates that an environmental label can support a product's market penetration effectively, even if this is accompanied by rising prices. Nevertheless, it is quite clear from survey data, that in general households' willingness to pay higher prices for an environmentally friendly product is unlikely to be strongly pronounced. In the case study there was a scope for demand expansion at an even higher price level because the individual consumer can expect a personal positive advantage by utilizing the labelled product.</td>
<td>3</td>
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<tr>
<td>Huppes, G. (in collaboration with Simonis, U.)</td>
<td>Environmental Policy Instruments in a New Era</td>
<td>2001</td>
<td>Wissenschaftszentrum Berlin für Sozialforschung gGmbH (<a href="http://bibliothek.wz-berlin.de/pdf/2001/ii01-404.pdf">http://bibliothek.wz-berlin.de/pdf/2001/ii01-404.pdf</a>)</td>
<td>Gives a classification and an evaluation of policy instruments. Underlines that one basic problem in discussions on policy instruments is that both their functioning and their effects are context dependent. This implies that in decisions on policy instrumentation, binding society for a long time, also long term changes in context are to be taken into account. Some main lines of development are discussed, with implications for instrument choice. Within these mouldable boundaries, some practical guidelines are given for policy development at a case level.</td>
<td>5</td>
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<tr>
<td>Institute for European Environmental Policy</td>
<td>Policy Instruments and Innovation. A Kick Off Presentation for the Policy Instruments Breakout Session</td>
<td>2006</td>
<td>POPA-CTADA, International Workshop, 2006, Brussels (<a href="http://ec.europa.eu/environment/envanco/pdf/popa_dact_long.pdf">http://ec.europa.eu/environment/envanco/pdf/popa_dact_long.pdf</a>)</td>
<td>Draws a list of the policy instruments available and analyses which policy instruments relate to which innovation barrier/determinant. Studies whether some specific instruments are particularly useful at different points in the innovation cycle.</td>
<td>5</td>
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<tr>
<td>Jacobsson, S. Johnson, A.</td>
<td>The Diffusion of Renewable Energy Technology: An Analytical Framework</td>
<td>2000</td>
<td>Energy Policy, 28(2000), pp. 625-640</td>
<td>Demonstrates that the idea that there are no commercially interesting technologies in the field of renewable energies is no longer entirely correct - in the 1990s there has been a double-digit growth rate in the market for some renewable energy technologies. The consequent</td>
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<tr>
<td>Jänicke, M.</td>
<td>Ecological Modernization: Innovation and Diffusion of Policy and Technology</td>
<td>2000</td>
<td>Forschungsstelle für Umweltpolitik (Freie Universität Berlin)</td>
<td>alteration in the energy system, is, however, a slow, painful and highly uncertain process. This process needs to be studied using an innovation system perspective where the focus is on networks, institutions and firms’ perceptions, competencies and strategies.</td>
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<td>Jänicke, M.</td>
<td>Governing Environmental Flows: The Need to Reinvent the Nation State</td>
<td>2005</td>
<td>Environmental Policy Research Centre (<a href="http://web.fu-berlin.de/ffu/download/rep_2005_03.pdf">http://web.fu-berlin.de/ffu/download/rep_2005_03.pdf</a>)</td>
<td>Gives an analysis of the possibilities and limits of the concept of ecological modernization. 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, so a more complex policy pattern is 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.</td>
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<tr>
<td>Jänicke, M.</td>
<td>Global Environmental Change and the Nation State: Lead Markets for Environmental Innovations</td>
<td>2001</td>
<td>In: Biermann, F. &amp; Brohm, R. &amp; Dingwerth, K. (eds.): Global Environmental Change and the Nation State, Potsdam 2002, pp. 139-148</td>
<td>Discusses the role of the nation state in stimulating lead markets for green innovations. It is often feared that the nation state loses its capacity for action because of economic and political globalization. This article rejects this hypothesis. It argues that empirical research on actual environmental policies reveals that it is most often nation states that pioneer new approaches, push for advances in environmental policy, and serve as regional starting points for new ‘green’ technologies. The innovation and diffusion of environmental technologies and their support through national environmental policies bear the potential of a far-reaching ecological modernization.</td>
<td>2</td>
</tr>
<tr>
<td>Jänicke, M.</td>
<td>The Diffusion of Environmental Policy Innovation</td>
<td>2001</td>
<td>Wissenschaftszentrum Berlin für Sozialforschung (<a href="http://skylla.wz-berlin.de/pdf/2001/ii01-302.pdf">http://skylla.wz-berlin.de/pdf/2001/ii01-302.pdf</a>)</td>
<td>Emphasises the importance of the diffusion of environmental innovations between countries for the global development of environmental policy. The key determinants of policy diffusion include: a) national factors; b) the dynamics of the international system; and c) aspects of the specific</td>
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<td>Author(s)</td>
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<tr>
<td>Jaffe, A. Palmer, K.</td>
<td>Environmental Regulation and Innovation: A Panel Data Study</td>
<td>1997</td>
<td>Review of Economics and Statistics 79, pp. 610-619</td>
<td>In answer to Porter’s hypothesis, examines the stylized facts regarding environmental expenditures and innovation in a panel of manufacturing industries. Finds that lagged environmental compliance expenditures have significant positive effect on R&amp;D expenditures, but finds little evidence, however, that industries’ inventive output (as measured by patent applications) is related to compliance costs.</td>
<td>4</td>
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<tr>
<td>Jaffe, A.B. Newell, R. Stavins, R.</td>
<td>Environmental Policy and Technological Change</td>
<td>2002</td>
<td>Environmental and Resource Economics 22, p. 41-69.</td>
<td>Distinguishes two major strands of thought regarding the determinants of innovative activity: the ‘induced innovation’ and the ‘evolutionary’ approach. Argues that only the second approach allows for ‘win-win’ solutions à la Porter. Addresses market failures that need to be removed for technology diffusion. Discusses the incentives for technology diffusion from different environmental policy instruments, concluding that market-based instruments are more effective than command-and-control instruments in encouraging cost-effective adoption and diffusion of new technologies.</td>
<td>4</td>
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<tr>
<td>Jaffe, A.B. Newell, R.G. Stavins, R.N.</td>
<td>A tale of two market failures: technology and environmental policy</td>
<td>2005</td>
<td>Ecological Economics, vol. 54, p 164-174</td>
<td>Market failures associated with environmental pollution interact with market failures associated with the innovation and diffusion of new technologies. These combined market failures provide a strong rationale for a portfolio of public policies that foster emissions reduction as well as the development and adoption of environmentally beneficial technology. In the presence of weak or nonexistent environmental policies, investments in the development and diffusion of new environmentally beneficial technologies are very likely to be less than would be socially desirable.</td>
<td>5</td>
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<tr>
<td>Jaffe, A.B. Newell, R.G.</td>
<td>The Effects of Economic and Policy Incentives on</td>
<td>2006</td>
<td>Energy Economics 28 (5-6), pp. 563-578</td>
<td>The ability to estimate the likely effects of potential climate change policies on energy use and greenhouse gas (GHG) emissions requires</td>
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<td>Stavins, R.N.</td>
<td>Carbon Mitigation Technologies</td>
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<td>an improved understanding of the relationship between different policy alternatives and energy-saving and GHG-reducing changes in technology. A particularly important aspect is thereby the conceptual and empirical modelling of how the various stages of technological change are interrelated, how they unfold over time in response to market forces, and the differential impact of various policies (for example, R&amp;D subsidies, environmental taxes, information programs).</td>
<td>1</td>
</tr>
<tr>
<td>Jakemann, G. et al.</td>
<td>Induced Innovations and Climate Change Policy</td>
<td>2004</td>
<td>Energy Economics 26, p.937-960</td>
<td>Assesses the potential macroeconomic impacts of the Kyoto Protocol, given the recent negotiated developments. In addition, given attempts to model endogenous technical change in general equilibrium models, a new methodology for incorporating the induced innovations hypothesis into a general equilibrium model is described and implemented. It is found that incorporation of the hypothesis reduces abatement costs.</td>
<td>3</td>
</tr>
<tr>
<td>Johnstone, N. Labonne, J.</td>
<td>Environmental Policy, Management and R&amp;D</td>
<td>2006</td>
<td>OECD Economic Studies N°42, 2006/1</td>
<td>Shows that environmental policy stringency increases the likelihood to invest in environmental R&amp;D, as does the use of more flexible environmental policy instruments.</td>
<td>5</td>
</tr>
<tr>
<td>Johnstone, N. Hascic, I.</td>
<td>Renewable Energy Policies and Technological Innovation: Empirical evidence based on patent counts</td>
<td>2007</td>
<td>OECD, Working Party on National Environmental Policies</td>
<td>Examines the effects of public policies on innovation in the area of renewable energies in a cross-section of OECD countries over the period 1978-2003, using patent counts as the most suitable proxy for innovation. Indicates that public policy has had a very significant influence on the development of new technologies in the area of renewable energy. Instrument choice also matters. With respect to patent activity in renewable energy overall, taxes, obligations and tradable certificates are the only statistically significant policy instruments.</td>
<td>4</td>
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<tr>
<td>Johnstone, N.</td>
<td>The Firm, the Environment and Public (final report of the OECD’s)</td>
<td>2001</td>
<td>OECD Publishing, Paris</td>
<td>Drawing on case studies, existing literature and national policy reports, assesses the links between firm-level commercial motivations and environmental management and performance. Advocates the use of</td>
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<td>Johnstone, N.</td>
<td>The Environmental Performance of Public Procurement</td>
<td>2003</td>
<td>OECD Publishing, Paris</td>
<td>Assesses the performance level of &quot;greener public purchasing&quot; (GPP) policies in order to increase the recycled content of products or achieve specified levels of energy efficiency in capital equipment. It is the outcome of a Workshop on &quot;Greener Public Purchasing&quot;, held at the Austrian Ministry of the Environment in Vienna in October 2001.</td>
<td>3</td>
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<tr>
<td>Johnstone, N.</td>
<td>Environmental Policy, Technological Innovation and Patent Activity: Initial Empirical Results and Project</td>
<td>2005</td>
<td>OECD, Working Group on National Environmental Policy, (ENV/EPOC/WPNEP(2005) 3, 26 May 2005)</td>
<td>Uses patents (in solar, water and wind energy technology) as a measure of environmental innovation. Concludes that public policy appears to be the dominant influence on patent activity, rather than economic factors. Obligations/quotas, price guarantees and tax preferences have the most important influence. Public subsidies for R&amp;D play a less important role.</td>
<td>4</td>
</tr>
<tr>
<td>Jordan, A. et al.</td>
<td>“New” Instruments of Environmental Governance? National Experiences and Prospects</td>
<td>2003</td>
<td>Frank Cass &amp; Co. Ltd.</td>
<td>Many highly industrialised countries are rapidly adopting ‘new’ environmental policy instruments (NEPIs) such as eco-taxes, tradable permits, voluntary agreements and eco-labels. This apparently profound shift has prompted widespread claims that NEPIs have eclipsed regulation as the preferred tool of environmental policy by providing a genuinely systematic analysis of the policy and politics surrounding the adoption and use of the main NEPIs in a variety of industrialised countries. The contributors of this book assess the claim that NEPIs have supplanted regulation, heralding a new era of environmental governance in which the state plays a secondary role in sustainability policymaking.</td>
<td>4</td>
</tr>
<tr>
<td>Kemp, R.</td>
<td>Technology and Environmental Policy : Innovation Effects of Past Policies</td>
<td>2002</td>
<td>OECD (<a href="http://www.oecd.org/dataoecd/">http://www.oecd.org/dataoecd/</a> 25/1/2106491.pdf)</td>
<td>Looking at the innovation and technology adoption effects of past environmental policies, finds few examples of environmental policies stimulating innovation. Argues that in order to be effective policy instruments need to be fine tuned to the circumstances in which socio-</td>
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<tr>
<td>Kemp, R. Andersen, M Butter, M.</td>
<td>An Innovation-System Approach to Eco-Innovation</td>
<td>2004</td>
<td>Background report about strategies for eco-innovation (<a href="http://web.fu-berlin.de/ffu/akumwelt/bc2004/download/andersen_f.pdf">http://web.fu-berlin.de/ffu/akumwelt/bc2004/download/andersen_f.pdf</a>)</td>
<td>Stressing that the creation of synergies between innovation policies and environmental policies plays a central part in integrating sustainability issues into the economic process, discusses the differences in rationales and instruments underlying the respective environmental and innovation policy approaches.</td>
<td>5</td>
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<tr>
<td>Kemp, R. Rennings, K.</td>
<td>Blueprints for an Integration of Science, Technology and Environmental Policy</td>
<td>2004</td>
<td>Strata-Project DG Research (<a href="http://www.insme.org/documenti/blueprint.pdf">http://www.insme.org/documenti/blueprint.pdf</a>)</td>
<td>Argues that various kinds of environmental innovation, i.e. improved knowledge and technological options, can be induced by science and technology policy. Capacity building in the field of environmental innovation can be stimulated by S&amp;T policies and can be extremely helpful for environmental policy. Examines the relationship between S&amp;T and environmental policies considering the complexity of factors influencing innovation and environmental decisions in firms.</td>
<td>5</td>
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<tr>
<td>Kivimaa, P.</td>
<td>Is There a Role for Environmental Policies in Supporting Innovation? Comparing Experiences From Products and Production Technologies</td>
<td>2006</td>
<td>Proceedings of Innovation Pressure Conference (15-17th March 2006, Tampere, Finland) (<a href="http://www.proact2006.fi/apter_images/302_Ref_B178_P_Kivimaa.pdf">http://www.proact2006.fi/apter_images/302_Ref_B178_P_Kivimaa.pdf</a>)</td>
<td>Explores to what extent environmental considerations of product development and innovations in paper and packaging derive from the influence of environmental policy. Argues that a) technology push, through searches for specific technical improvements and through public R&amp;D funding, was important both for the emergence of environmentally sounder technological innovations improving the production processes and product innovations; b) the role of market pull, in the early stages, was more important for environmentally improved products than for production-side technologies; and c) regulatory push and pull had more direct effects in the case of production-side innovations.</td>
<td>4</td>
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<tr>
<td>Koch, L. Ashford, N.A.</td>
<td>Rethinking the Role of Information in Chemicals Policy: implications for TSCA and REACH</td>
<td>2006</td>
<td>Journal of Cleaner Production 14 (1), pp. 31-46</td>
<td>Analyses the role of different kinds of information for minimizing or eliminating the risks due to the production, use, and disposal of chemical substances and contrasts it with present and planned (informational) regulation in the US and the EU, respectively. Argue that informational tools can be made more technology inducing – and thus more oriented towards environmental innovations – than they are under current practices, with or without complementary regulatory mechanisms, although a combination of approaches may yield the best results.</td>
<td>4</td>
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<tr>
<td>Krozer, Y.</td>
<td>Milieu en innovatie (Environment and</td>
<td>2002</td>
<td>PhD Thesis, Groningen University</td>
<td>Investigates the extent to which environmental innovations can be introduced at socially acceptable costs, and what policies are needed to</td>
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<td>Lange, I. Bellas, A.</td>
<td>Policy Innovation Impacts on Scrubber Electricity Usage</td>
<td>2006</td>
<td>National Centre for Environmental Economics (April 2006)</td>
<td>By analyzing changes in scrubbers’ use of electricity (also known as parasitic load) in relation to regulatory policy regimes, the paper shows that restructured electricity markets have led to a considerable (30-45%) decrease in parasitic load. Conversely, the change to a cap-and-trade system for sulphur dioxide has not led to a decrease.</td>
<td>2</td>
</tr>
<tr>
<td>Lanjouw, J.O. Mody, A.</td>
<td>Innovation and the international diffusion of environmentally responsive technology</td>
<td>1996</td>
<td>Research Policy 25 (4), p. 549-571</td>
<td>Presents new evidence on environmental innovation and diffusion over the 1970s and 1980s. In the US, Japan, and Germany, the share of environmental patents in all patents was higher than the corresponding share of pollution abatement expenditure in GDP. Across these three countries and over time, innovation responded to pollution abatement expenditure, an indicator of the severity of environmental regulations.</td>
<td>3</td>
</tr>
<tr>
<td>Mahdi, S. Nightingale, P. Berkhout, F.</td>
<td>A Review of the Impact of Regulation on the Chemical Industry</td>
<td>2002</td>
<td>SPRU, University of Sussex (final report to the Royal Commission on Environmental Pollution, Nov 2002)</td>
<td>Explores the claim that health, safety and environment (HS&amp;E) regulation in the EU has reduced the capacity of the European chemicals industry to innovate. Concludes that there is no consensus about whether regulation inhibits or stimulates innovation in industry; in most cases it is likely to do both. Empirical evidence is scarce and there are theoretical and methodological difficulties. EU dominance in the chemicals industry, founded on high levels of innovation, has increased in the 1990s. The historically lower rates of innovation in the EU are likely to be caused mainly by other factors than HS&amp;E regulation.</td>
<td>4</td>
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<tr>
<td>Mazzanti, M. Zoboli, R.</td>
<td>The Drivers of Environmental Innovation in Local Manufacturing Systems</td>
<td>2005</td>
<td>Economia Politica, n°3, 12/2005</td>
<td>Local and regional industrial concentrations frequently imply the existence of accrued environmental pressures, partially offset by a relatively high innovation propensity of industry clusters. Making use of the empirical findings from the industrial zone of Emilia Romagna, assesses the stimulating forces for environmental innovation in manufacturing firms.</td>
<td>2</td>
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<tr>
<td>Mazzanti, M.</td>
<td>Examining the Factors</td>
<td>2006</td>
<td>Fondazione Enrico Mattei</td>
<td>Environmental innovation is being spurred by both exogenous driving</td>
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<td>Zoboli, R.</td>
<td>Influencing Environmental Innovation</td>
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<td>forces, like public policy intervention, and/or endogenous factors associated with firm market and management strategies. Provides a micro-economic analysis of the forces stimulating innovation at the firm level, while also highlighting the effects of environmental policy pressures and regulation costs.</td>
<td></td>
</tr>
<tr>
<td>Mazzanti, M. Zoboli, R.</td>
<td>Economic Instruments and Induced Innovation</td>
<td>2006</td>
<td>Ecological Economics 58 (2006), 318-337</td>
<td>Analyses the mechanisms by which economic instruments based on the &quot;producer responsibility principle&quot; can influence innovation dynamics. The EU policy on End-of-Life-Vehicles is used as a representative case study of &quot;multiple-industry PRP instrument&quot; dynamic efficiency shortcomings.</td>
<td>3</td>
</tr>
<tr>
<td>McDonald, A. Schrattenholzer, L.</td>
<td>Learning rates for energy technologies</td>
<td>2001</td>
<td>Energy Policy 29, p. 255-261.</td>
<td>Assembles data on experience accumulation and cost reduction for a number of energy technologies (including wind and solar PV), estimates learning rates for the resulting 26 data sets and evaluates their usefulness for applications in long-term energy models.</td>
<td>2</td>
</tr>
<tr>
<td>Meyer, N.</td>
<td>Implications of Danish Regulatory Policies for Technologies Supporting Sustainable Energy Developments</td>
<td>1997</td>
<td>Paper presented at the Workshop &quot;Regulation and Innovative Activities&quot;, Vienna, 1997, p24. -25.2</td>
<td>The goal of the official Danish energy plans is to establish a sustainable energy development. The Danish government has established test stations to secure a high quality of the new technologies and to certify the new products. Extensive development and demonstration programmes have been sponsored by government money in the fields of biogas and wind power, followed up by government investment subsidies. Regulations by the EU Commission have been counterproductive in several cases, and the present liberalisation of the electricity market is raising serious questions for a sustainable development. The above points are discussed in the paper.</td>
<td>3</td>
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<tr>
<td>Montalvo, C.</td>
<td>Environmental Policy and Technological Innovation: Why Do Firms Adopt or Reject New Technologies?</td>
<td>2002</td>
<td>Edward Elgar, Cheltenham</td>
<td>Distinguishes three types of factors determining a firm’s willingness to invest in cleaner technology: its attitude (determined by perceived risks), social pressures (including regulation), and control (the technological and organisational capabilities of the firm). The findings (based on a study of the ‘maquiladoras’ firms located near the Mexico-US border) suggest that the third factor has the biggest influence, which would imply that reinforcing the cleaner technology knowledge base in enterprises should be the main policy priority.</td>
<td>4</td>
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<tr>
<td>Müller, E.</td>
<td>Environmental Labelling.</td>
<td>2002</td>
<td>Blauer Engel</td>
<td>Discusses the role of environmental labelling in the overall toolbox of</td>
<td>4</td>
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<tr>
<td>Norberg-Bohm, V.</td>
<td>Stimulating ‘Green’ Technological Innovation: An Analysis of Alternative Policy Mechanisms</td>
<td>1999</td>
<td>Policy Sciences, 32, pp. 13-38</td>
<td>Explores how to design public policy mechanisms to stimulate rather than impede pollution-preventing technological innovation. Concludes that thanks to the US environmental policy system firms are likely to undertake technological innovation for the environment in situations with clear short-term economic benefits. However, it has been unable to drive technological innovation in industries where the pay-off is more long-term or uncertain.</td>
<td>3</td>
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<tr>
<td>Oberndörfer, U. Rennings, K.</td>
<td>The Impacts of the European Emission Trading Scheme on Competitiveness and Employment in Europe</td>
<td>2006</td>
<td>Centre for European Economic Research (report commissioned by WWF) (<a href="http://www.wwf.fi/wwf/www/uploads/pdf/clearingthemist_fullreport_june2006.pdf">http://www.wwf.fi/wwf/www/uploads/pdf/clearingthemist_fullreport_june2006.pdf</a>)</td>
<td>Analyses the future impact of EU ETS on innovation and competitiveness of European companies, demonstrating the positive aspects of the trading scheme approach as opposed to other instruments, such as Command and Control regulation. Grandfathering, rather than auctioning, of emission allowances might be needed though in order to disentangle the European companies’ full innovation potential.</td>
<td>5</td>
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<td>OECD</td>
<td>Voluntary Approaches for Environmental Policy</td>
<td>2003</td>
<td>OECD Publishing, Paris (<a href="http://www.foundationpartnership.org/pdf/oecd.PDF">http://www.foundationpartnership.org/pdf/oecd.PDF</a>)</td>
<td>Assesses the environmental effectiveness, economic efficiency and administrative costs related to voluntary approaches used in isolation or as part of “policy mixes”. Case studies include: Pollution Control Agreements in Japan, Industrial Energy Efficiency in Denmark, Elimination of Toxics programme in Canada.</td>
<td>5</td>
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<td>Oosterhuis, F. (ed.)</td>
<td>Innovation Dynamics Induced by Environmental Policy</td>
<td>2006</td>
<td>European Commission – DG Environment (final report ENV.G.1/FRA/2004/0081)</td>
<td>Using specific case studies, analyses how different environmental policy instruments induce innovation and provides an assessment of the dynamics of this innovation. Also provides an analysis of the extent to which market-driven innovation can reduce the environmental impacts of products and processes.</td>
<td>5</td>
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<tr>
<td>Parliamentary Office of Science and Technology (UK)</td>
<td>Environmental Policy and Innovation</td>
<td>2004</td>
<td>Postnote 212 (January 2004) (<a href="http://www.parliament.uk/documents/upload/POSTpn212.pdf">http://www.parliament.uk/documents/upload/POSTpn212.pdf</a>)</td>
<td>Discusses the relative effectiveness of different policy tools in the UK context, such as environmental taxes, trading systems and voluntary agreements. Raises doubts over their impact on companies’ international competitiveness.</td>
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<td>Parry, I.</td>
<td>On the Implications of Technological Innovation for Environmental Policies</td>
<td>2006</td>
<td>Resources for the Future (<a href="http://www.rff.org/Documents/RFF-DP-01-44.pdf">http://www.rff.org/Documents/RFF-DP-01-44.pdf</a>)</td>
<td>Assesses the economic efficiency of different environmental policy approaches. Defends emission taxes over emission permits on the grounds of innovation incentives. Also advocates the setting of more stringent regulation targets than necessary to internalise pollution externalities.</td>
<td>5</td>
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<tr>
<td>Parto, S.</td>
<td>Industrial Innovation and Environmental Regulation - Developing Workable Solutions</td>
<td>2006</td>
<td>United Nations University Press (<a href="http://www.intech.unu.edu/research/past_research/2004_2005/2000_164.php">http://www.intech.unu.edu/research/past_research/2004_2005/2000_164.php</a>)</td>
<td>Combines theoretical and conceptual analysis with empirical case studies of particular firms and industries in both industrialised and developing countries, focusing on the way in which environmental regulations interact with trade and innovation policies – and with the characteristics of particular industrial sectors and firms – to influence innovation outcomes.</td>
<td>4</td>
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<tr>
<td>Pearson, P.</td>
<td>Finding the Right Policy Mix for Sustainable Innovation</td>
<td>2004</td>
<td>Economic and Social Research Council (<a href="http://www.sustainabletechnologies.ac.uk/Projects/policy.htm">http://www.sustainabletechnologies.ac.uk/Projects/policy.htm</a>)</td>
<td>Working in two case study areas (low carbon technologies and waste minimisation), analyses how a better mix of policy instruments could work to promote more sustainable technologies. By analysing the successes and failures of policy approaches both in the UK and in other countries, intends to assist the development of an effective policy mix in the UK and EU.</td>
<td>4</td>
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<tr>
<td>Pickman, H.A.</td>
<td>The Effect of Environmental Regulation on Environmental Innovation</td>
<td>1998</td>
<td>Business Strategy and the Environment 7 (4), p. 223-233</td>
<td>The author conducts an empirical study of the US manufacturing industry's environmental patent activities and environmental regulation as measured by pollution abatement and control expenditure (PACE) data. She finds a statistically significant positive relationship between environmental regulation and innovation when estimated by ordinary least squares.</td>
<td>3</td>
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<td>Pontoglio, S.</td>
<td>EU Emission Trading Scheme: Potential Effects on Innovation</td>
<td>2006</td>
<td>OIKOS – Foundation for Economy and Ecology (<a href="http://www.oikos-stiftung.unisg.ch/academy2006/Paper_Pontoglio.pdf">http://www.oikos-stiftung.unisg.ch/academy2006/Paper_Pontoglio.pdf</a>)</td>
<td>Argues that the most important design element influencing dynamic efficiency with regard to emission trading schemes are allocation rules and principles (directly impacting the relative incentive structure for investing in alternative technology solutions) as well as its overall target and stringency.</td>
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<td>POPA - CTDA</td>
<td>Policy pathways to promote the development</td>
<td>2004</td>
<td><a href="http://www.popa-ctda.net/uploads/media/POPA">http://www.popa-ctda.net/uploads/media/POPA</a>_</td>
<td>Industry sector background study.</td>
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<td>Author(s)</td>
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<td>Popp, D.</td>
<td>International innovation and diffusion of air pollution control technologies</td>
<td>2006</td>
<td>Journal of Environmental Economics and Management 51 (1), pp 46-71</td>
<td>Examines innovation and diffusion of air pollution equipment, using patent data. Concludes that investors respond to domestic, but not to foreign regulatory pressures. The results suggest that transfers of environmental technologies across borders will be slowed by the need for domestic R&amp;D to adapt these technologies to local markets.</td>
<td>3</td>
</tr>
<tr>
<td>Porter, M. Van der Linde, C.</td>
<td>Toward a New Conception of the Environment-Competitiveness Relationship</td>
<td>1995</td>
<td>Journal of Economic Perspectives, vol. 9, n° 4, pp 97-118</td>
<td>Argues that accepting a fixed trade-off between environmental regulation and competitiveness unnecessarily raises costs and slows down environmental progress. Studies finding high environmental compliance costs have traditionally focused on static cost impacts, ignoring any offsetting productivity benefits from innovation. They typically overestimated compliance costs, neglected innovation offsets, and disregarded the affected industry's initial competitiveness. Rather than simply adding to cost, environmental standards can trigger innovation offsets, allowing companies to improve resource productivity.</td>
<td>5</td>
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<tr>
<td>Rennings, K. et al.</td>
<td>Environmental Policy Tools and Firm-Level Management Practices in Germany</td>
<td>2004</td>
<td>(<a href="http://www.oecd.org/dataoecd/26/17/31685533.pdf">http://www.oecd.org/dataoecd/26/17/31685533.pdf</a>)</td>
<td>Explores the relationship between environmental policy tools and both organisational and process innovation in manufacturing firms in Germany. Notes the importance of regulatory instruments, such as input bans and technology-based standards, while also underlining the growing importance of market-based means, such as the more recently introduced eco-taxes.</td>
<td>3</td>
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<tr>
<td>Rennings, K. et al.</td>
<td>Instruments for Supporting Environmental Innovations - Status Quo</td>
<td>2007</td>
<td>Project sponsored by the Umweltbundesamt Dtl. (<a href="http://www.zew.de/de/forschung/projekte.php3?action=">http://www.zew.de/de/forschung/projekte.php3?action=</a></td>
<td>Provides an overview of the most important policy instruments used to stimulate environmental innovation in Germany and assesses their respective efficiency. Also provides a discussion of “best practice” cases abroad. Publication of Project report announced for 2007.</td>
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<tr>
<td>Rennings, K. et al</td>
<td>The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance</td>
<td>2006</td>
<td>Ecological Economics 57 (1), pp. 45-59</td>
<td>Environmental modernization of the economy includes the implementation of environmental policies which connect environmental management to technical environmental innovations and improved economic performance. Some of the most important instruments in this respect are standards for environmental management systems such as the EU Environmental Management and Auditing Scheme (EMAS). Investigates the effects of different characteristics of EMAS on technical environmental innovations and economic performance.</td>
<td>3</td>
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<tr>
<td>Requate, T.</td>
<td>Dynamic incentives by environmental policy instruments – a survey</td>
<td>2005</td>
<td>Ecological Economics 54 (2-3), p. 175-195</td>
<td>Concludes that under competitive conditions market-based instruments usually perform better than command and control with regard to both adoption and development of advanced abatement technology. Also demonstrates that taxes may provide stronger long term incentives than tradable permits if the regulator is myopic. If the government can anticipate new technology or is able to react on it optimally, regulatory policies by virtue of administered prices (taxes) and policies by setting quantities (issuing tradable permits) are (almost) equivalent.</td>
<td>5</td>
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<tr>
<td>Requate, T. Unhold, W.</td>
<td>Environmental Policy Incentive to Adopt Advanced Abatement Technology</td>
<td>2003</td>
<td>European Economic Review, vol. 47, pp 125-146</td>
<td>Investigates the case where the regulator makes long-term commitments to policy levels and does not anticipate arrival of new technology, showing that taxes provide stronger incentives than permits, auctioned and free permits offer identical incentives, and standards may give stronger incentives than permits.</td>
<td>3</td>
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<tr>
<td>Rousseau, S. Proost, S.</td>
<td>Comparing Environmental Policy Instruments in the</td>
<td>2005</td>
<td>Environmental and Resource Economics, vol. 32, Number 3 /</td>
<td>Aims to include rule making, implementation, monitoring and enforcement costs into the cost comparison of policy instruments. Uses a simple partial equilibrium model and apply it to the textile industry. The model includes discrete abatement functions and costly</td>
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<td>Sartorius, C.</td>
<td>Presence of Imperfect Compliance – A Case Study</td>
<td>November, 2005, pp 335-347</td>
<td>Monitoring and enforcement. The case study uses individual firm data to simulate the differences in abatement costs and compliance decisions between firms. The articles compare combinations of regulatory instruments (emission taxes, emission standards and technology standards) and enforcement instruments (criminal fines, civil fines and transaction offers). It shows that the inclusion of information, monitoring and enforcement costs indeed alters the relative cost efficiency of the different instruments.</td>
<td>3</td>
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<td>Nill, J.</td>
<td>Innovation Policy Towards Sustainability – the Preparation, Use, Creation and Maintenance of “Time Windows”</td>
<td>2004</td>
<td>Paper for the international conference ‘Innovation, Sustainability and Policy’, 23-25 May 2004, Kloster Seeon (Germany) (<a href="http://www.tu-berlin.de/fak3/ifet/ensys/downloads/publications/sarto_2004_seeon_paper.pdf">http://www.tu-berlin.de/fak3/ifet/ensys/downloads/publications/sarto_2004_seeon_paper.pdf</a>)</td>
<td>The process of innovation is adequately described as an alternation of periods of stability (= lock-in, i.e. the barrier to market entry faced by innovation) and periods of instability. The authors denote the latter periods as ‘windows of opportunity’ or “time windows” as they allow policy makers to pursue the corresponding technological transitions with much less effort – in money as well as in power terms. In this paper, the authors distinguish several ways in which policy makers can make use of windows of opportunity in a time-strategic way, i.e. time strategies of window preparation, use, creation and maintenance. The paper further elaborates on this four-fold distinction of time strategies in innovation policies towards sustainability by providing a variety of illustrative examples and pointing to some implications for policy instrumentation.</td>
<td>3</td>
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<tr>
<td>Sartorius, C.</td>
<td>Time Strategies, Innovation and Environmental Policy</td>
<td>2005</td>
<td>Cheltenham: Edward Elgar</td>
<td>Argues that resistance to technological change is subject to substantial temporal variation and that it is economically and politically sensible to identify periods of time in which resistance is weakest and to exploit these ‘windows of opportunity’ whenever and wherever they occur. Also highlights how time strategies for innovation policy can involve the preparation and creation of ‘windows’ which do not yet exist. Contains case studies on a.o. CFC phase out, the lean burn engine versus the catalytic converter, ecological alternatives to chemical pesticides and the zero emission vehicle mandate in California.</td>
<td>3</td>
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<tr>
<td>Zundel, S. (eds.)</td>
<td>Pollution Regulation and its Effects on Technological</td>
<td>2002</td>
<td>Journal of Environmental Law 14 (2), p. 143-160.</td>
<td>Shows that regulation (gradually tightening of emission limit values) has had an observable impact on the diffusion of technology in the Finnish pulp and paper industry, particularly with respect to end-of-pipe technology.</td>
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<tr>
<td>Strasser, K.</td>
<td>Cleaner Technology, Pollution Prevention, and Environmental Regulation</td>
<td>1997</td>
<td>Fordham Environmental Law Journal 9 (1), p. 1-106</td>
<td>Argues that, in addition to pollution control, pollution prevention is crucial for the future of environmental protection. Traditional environmental regulation has often discouraged innovation and diffusion of cleaner technology. The author states that the extent to which a business is likely to develop or embrace new technologies in response to regulatory stimuli is a reasonably knowable and predictable process, and therefore regulators can craft environmental policies that will be consciously supportive of environmental technology. A change in regulatory culture is needed, as well as a multimedia and sector-oriented approach.</td>
<td>3</td>
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<tr>
<td>Taylor, M.R.</td>
<td>Effect of government actions on technological innovation for SO2 control</td>
<td>2003</td>
<td>Environmental Science and Technology 37 (20), pp. 4527-4534</td>
<td>Examines relationship between government actions and innovation in environmental control technology relationships with regard to sulphur dioxide control technology for U.S. coal-fired power plants. The results indicate that government regulation appears to be a greater stimulus to inventive activity than government-sponsored research support alone, and that the anticipation of regulation also spurs inventive activity. Regulatory stringency focuses this activity along particular technical pathways and is a key factor in creating markets for environmental technologies. The important role of government in fostering knowledge transfer via technical conferences and other measures is also seen as an important factor in promoting environmental technology innovation.</td>
<td>3</td>
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<tr>
<td>Trautmann, T. Hoffmann, V.</td>
<td>The Role of Industry and Uncertainty in Regulatory Pressure and Environmental Strategy</td>
<td>2006</td>
<td><a href="http://www.sustec.ethz.ch/news/AoM_BP_2006">http://www.sustec.ethz.ch/news/AoM_BP_2006</a></td>
<td>Drawing from the literature on environmental uncertainty, institutional theory, and the resource-based view of the firm, proposes that a) the level of perceived state uncertainty, and b) the impact of regulatory pressure on environmental strategies are industry-specific. Further proposes that a high impact from regulatory pressure on environmental strategy is associated with a high level of perceived state uncertainty.</td>
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<tr>
<td>Trautmann, T. Rogge, K.</td>
<td>Innovation Impact of the European CO2 Emission Trading Scheme</td>
<td>2006</td>
<td>PhD Project, Eidgenössische Technische Hochschule Zürich (<a href="http://www.sustec.ethz.ch/research/PhDProjects/InnoImpETS">http://www.sustec.ethz.ch/research/PhDProjects/InnoImpETS</a>)</td>
<td>Agrees that a flexible instrument such as the EU ETS represents a more efficient climate policy instrument than regulations setting standards. However, to induce innovation, further factors are crucial: price and allocation of CO2 allowances must incentivize the companies to invest in climate protection innovations and companies need to have a certain level of planning reliability to take the risk of investing.</td>
<td>3</td>
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<tr>
<td>Tucker, A.</td>
<td>Identifying Priorities for Environmental Product Policy</td>
<td>2006</td>
<td>Journal of Industrial Ecology Summer 2006, Vol. 10, No. 3: 1-4 (<a href="http://www.mitpressjournals.org/doi/pdf/10.1162/jiec.2006.10.3.1">http://www.mitpressjournals.org/doi/pdf/10.1162/jiec.2006.10.3.1</a>)</td>
<td>A limited number of activities and product groups related to Mobility: automobile and air transport; Food: meat and dairy, followed by other types of food; and the home plus related energy use: buildings, and heating-, cooling-, and other energy using appliances; cause 70 to 80% of the total environmental impacts in society. Important reductions in environmental impacts thus can be reached by policies that target this limited group of product categories.</td>
<td>2</td>
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<tr>
<td>Van Humbeek, P. Dries, I. Larosse, J.</td>
<td>Linking Innovation Policy and Sustainable Development in Flanders</td>
<td>2004</td>
<td>IWT (nr. 50) IWT-Observatory, Brussels (<a href="http://www.iwt.be/downloads/publicaties/observatorium/obs50.pdf">http://www.iwt.be/downloads/publicaties/observatorium/obs50.pdf</a>)</td>
<td>Argues that the present governance of both sustainable development and innovation policy is still dominated by a sectoral logic of institutional behaviour and policy development that is a bottleneck for integrated policy development. Sustainable development has not achieved an integrated governance structure that can implement the planning framework. Sustainable development and innovation have been largely strangers to each other until recently.</td>
<td>2</td>
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<tr>
<td>Van Soest, D.P.</td>
<td>The Impact of Environmental Policy Instruments on the Timing of Adoption of Energy-Saving Technologies</td>
<td>2005</td>
<td>Resource and Energy Economics 27 (3), pp. 235-247</td>
<td>One of the main considerations in designing environmental policy is the impact of policy instruments on the timing of firms’ investment decisions with respect to energy-saving technologies. Analyses the impact of environmental taxes and quotas on the timing of adoption when (i) the rate at which new, improved energy-efficient technologies become available, is uncertain, and (ii) the investment decision is (at least partially) irreversible. Concludes that neither policy instrument is</td>
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<td>Vasanthakumar, N.</td>
<td>Environmental Regulations and Innovation Activities: A View Point</td>
<td>2001</td>
<td>International journal of environmental studies, 2001, vol. 58, n°6, pp. 741-8 (<a href="http://cat.inist.fr/?aModele=afficheN&amp;cpsidt=13390544">http://cat.inist.fr/?aModele=afficheN&amp;cpsidt=13390544</a>)</td>
<td>Explores the impact of environmental regulations on innovative activity, using state-level and company level data on patents, new product introductions, emissions, and penalties. A significant effect of environmental regulations on corporate innovative activity is found. In addition, excellence in environmental performance appears to have an indirect effect on innovation performance of companies.</td>
<td>4</td>
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<tr>
<td>Wolf, O. et al.</td>
<td>The Impact of Regulation on Innovation of European Industry</td>
<td>2001</td>
<td>IPTS report EUR 20390 EN (<a href="http://susproc.jrc.es/pages/2.htm">http://susproc.jrc.es/pages/2.htm</a>)</td>
<td>Proposes a thorough methodology recognising the complexity of the innovation-regulation relationship, by mainly focusing on: a) methodological issues; b) an analysis of the impact of SMR on innovation processes in Europe; and c) an analysis of the impact of environmental regulation on three key industries: chemicals, recycling and the end-of-life vehicle sector.</td>
<td>5</td>
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<tr>
<td>Zoboli, R. et al.</td>
<td>Regulation and Innovation in the area of end-of-life vehicles</td>
<td>2000</td>
<td>IPTS report (<a href="http://ftp.jrc.es/eur19598en.pdf">http://ftp.jrc.es/eur19598en.pdf</a>)</td>
<td>Analyses the impacts of National and European initiatives to increase the recovery of scrap cars on innovation in the automotive, industrial chain. Provides information on the dismantling industry, standards and voluntary agreements in EU Member States, the USA and Japan. The results show that policy development and targets have been effective in stimulating organisational and technological innovation in leading countries. But, also, that the choice of specific policy instruments, e.g. free take back of scrap cars, does not always provide the expected results, considering the complexity of the ELV system.</td>
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