European Commission
DG Environment

"Designing environmental policy to be innovation friendly"

Policy Guidelines
Background Document

CM International

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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.

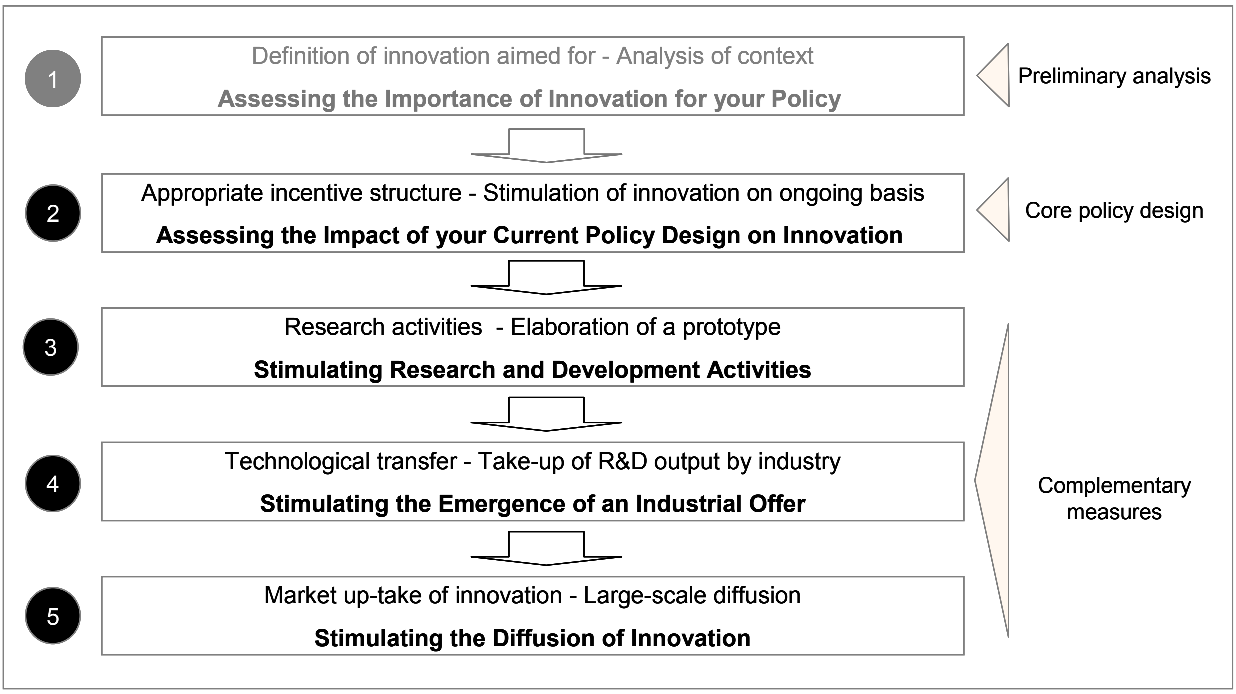
There is equally no shortage of examples of “clean” technologies that have been turned into business opportunities and successfully marketed on national and international markets. It is estimated that Europe currently holds roughly one third of the world market in environmental goods and services. Its 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. 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?

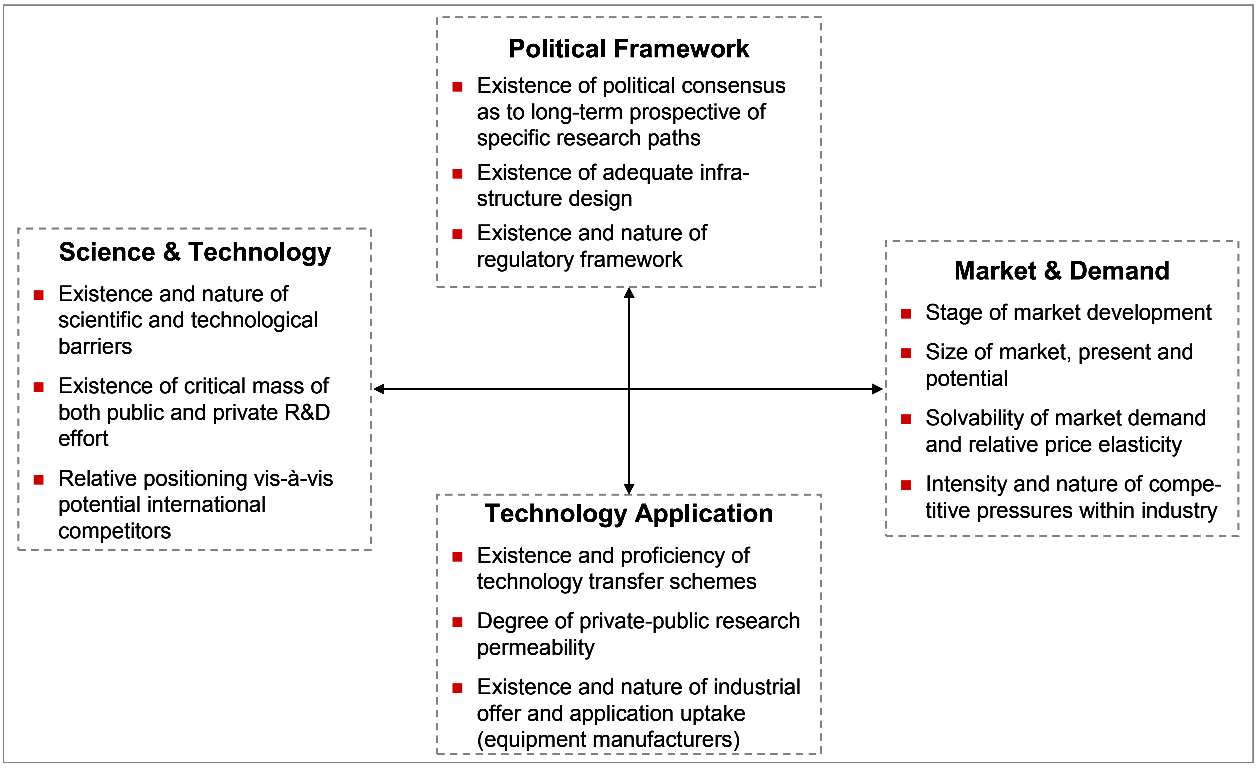
An innovation emerges, thrives and succeeds (or fails) within a context. This so-called innovation context comprises various dimensions, namely: the state of research and development as well as the existence and nature of remaining technological barriers to be overcome; the ease with which industry takes 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:



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***: <u>Weak standards result in weak innovation</u>. 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

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?

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***: <u>Public R&D subsidies are most useful during the early stages of the innovation process</u> 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 <u>targeted at broad technology areas without forcing specific technologies</u>. 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***: <u>FPs play an important role in the advancement of R&D</u>, 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 <u>public-private partnerships</u>, platforms enhance the efficiency of the R&D effort. In order to constitute efficient platforms for mutual learning and knowledge transfer, networks need to <u>comprise different, complementary and mutually enriching expertise areas</u>. 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 <u>physical or virtual</u>, 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 <u>develop the technology during the early innovation stages and to ensure its continued improvement</u> 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 <u>set up a level playing field and guarantee equal market accessibility</u> 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 <u>the sharing of costs involved in grid connection and grid reinforcement</u> (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. <u>The</u>

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.

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