

An Innovation System approach to Eco-innovation – Aligning policy rationales

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Abstract

Creating synergies between innovation policies and environmental policies play a central part in integrating sustainability issues into the economic process. It is, however, no easy endeavour. The historic dichotomy between competitiveness and environmental issues still persists and is embodied in policy regimes, economic and other social theories as well as wider societal understandings.

The paper discusses the differences in rationales and instruments underlying respectively environmental and innovation policies. In discussing the differences in policy approaches, the paper argues that there is a schism between (the traditional) environmental policies aiming at addressing reactive behaviour and innovation policies aiming at addressing proactive behaviour, a schism that severely hampers the development of a socially responsible market economy. Understanding and recognizing the differences in rationale between the different policy areas is central for promoting an integration of these.

The paper argues that an essential means to achieve policy integration is to set up a shared consistent framework and a vision for the promotion of eco-innovation. The paper suggests that the national innovation system (NIS) perspective, forming the basis for innovation policy but little applied to environmental issues, may represent such a much needed framework. A framework that may align competitiveness and sustainability issues and hence innovation and environmental policy.

The paper seeks to outline the theoretical framework for a greening of the innovation system. The paper concludes that the NIS perspective departs in important ways from existing environmental policy, noticeably when it comes to the targets and the delimitation and understanding of the (innovation) system involved.

The paper claims that the NIS perspective, based on evolutionary economic thinking, represents a new policy rationale, a rationale first of all giving *knowledge based innovation* and *competitiveness* a pride of place. A strategy for green competitiveness sets new demands on the rationale and competencies of the actors involved, requirements which both the environmental and innovation authorities will have great difficulties in handling.

1. Introduction

The (national) *innovation systems* (NIS) perspective appears by now as a fairly well consolidated frame for national or regional empirical analysis as well as policymaking on innovation. It forms today the basis of much innovation and research policy (OECD, 1999, 2000, European Commission, 2002).

But as yet the perspective has only to a very limited degree entered environmental policy making. An exception is the recent Swedish environment led business strategy (NUTEK, 2003) and to some degree EU's new Environmental Technology Action Plan (ETAP). ETAP sends interesting new policy signals when attempting simultaneously "to tap the full potential of environmental technologies for protecting the environment while contributing to competitiveness and economic growth" (COM 2004 38).

The ETAP creates a topical need to readdress the scope and the means for breaking the historic dichotomy between environmental issues and competitiveness.

From reactive to proactive strategies

Historically, environmental issues have been considered a burden to business, as something that is associated with costs and restrictions and which impairs companies' competitiveness. The first 20 years after the rise of the environmental agenda, i.e. during the 1970s and 1980s, companies had purely reactive strategies to environmental issues, for some companies even obstructive strategies. By the 1990s the environmental agenda was well consolidated in the richer economies and we saw the beginning emergence of proactive environmental strategies. It is important to recognize that green competitiveness goes beyond consumerism. It is associated with the overall need for companies to maintain a good image towards their stakeholders. A range of surveys point to the broad range of incentives companies experience in relationship to their environmental, social and broader ethical work, a factor that is little recognized by policy makers so far (Erhvervsministeriet, 2000, Rutten, 2001, Kemp, Andersen and Butter, 2004). Today, environmental activities are increasingly seen as a potential source of competitive advantage, they offer an element of quality, a source of savings, and part of the social contract with society necessary for the continuity of the company (Rutten, 2001).

Companies are central to the solution of environmental problems because they play a key role in the innovation process. Not only as important developers of knowledge but because they are the ones transforming inventions into value creation on the market.

The innovation concept covers the whole sequence from idea to commercialization on the market. Companies play a central role in the important early stages of the innovation process, when ideas (from customers, suppliers, competitors, research, experimentation ect.), are turned into inventions and technology development.

A green market development, in which environmental considerations form a natural element in companies' strategies and innovation routines, is therefore a crucial means

for achieving a preventive and integrated approach to an environmentally sustainable development. Promoting environmental strategizing among business should therefore have top priority in environmental policy making. This is not the case to day.

For the majority of companies, the environment is not or only weakly a competitive factor. We are still in a transitional phase where the signals from the markets for eco-innovation and CSR are weak and unclear, though rising. Company environmental strategizing is still primarily directed at environmental regulation, not at the market. One of the greatest barriers to eco-innovation is the false belief that the environment necessarily is a burden and lacking recognition that it could become an asset. This leads companies to under-explore eco-innovation options (Kemp and Andersen, 2004, Kemp, Andersen and Butter, 2004).

This paper investigates the potential of the NIS perspective for aligning innovation and sustainability issues in building strategies for green competitiveness. Such strategies are an important means for placing environmental issues more firmly within the Lisbon process. However, building these strategies depends on creating greater synergies between environmental and innovation policies and that is no easy endeavour. The historic dichotomy between competitiveness and environmental issues still persists and is embodied in policy regimes, economic and other social theories as well as wider societal understandings.

The paper argues that there are important but neglected differences in the rationales and instruments underlying respectively environmental and innovation policies. The NIS perspective, and hence innovation policy, builds on evolutionary economic theory. Environmental policy, on the other hand, has lacked a coherent theoretical framework. It builds on a mixture of neoclassical environmental economics, political science, law and insights from the physical sciences. Social theories can and do guide policy making but it is a factor not much discussed.

Understanding and recognizing the differences in rationale between the different policy areas is central for promoting an integration of these.

The paper argues that an essential means to overcome these differences and achieve greater policy integration is to set up a shared coherent analytical framework and a vision for the promotion of eco-innovation. The national innovation system (NIS) perspective, the paper suggests, may provide just such a framework.

As yet there is little conceptual and empirical clarification of what a greening of (national) innovation systems might entail. Environmental research is only starting to take an interest in the NIS perspective (see Andersen, 1999, Rand Europe, 2000, Hübner et al. 2000, Hübner and Nill, 2001, Kemp and Rotmans (2001), Kemp, R. (2002), Weber and Hemmelskamp (eds.) forthcoming). And hard core innovation researchers on the other hand have only to a very limited degree dealt with sustainability issues (see though Lundvall, 2001).

This paper seeks to outline some key considerations of such a NIS analytical framework and a related three pillar strategy for a greening of the innovation system.

The NIS approach is appealing to policy makers and policy researchers because it seeks to develop a frame for a holistic policy for all key factors and actors influencing on the innovation process. The regulatory regime is given strong emphasis here. However, the broadness and holism of the perspective is also a weakness. The NIS perspective is often misunderstood and referred to in a very broad, general way, also by environmental researchers, taking little account of the micro-theoretical foundations of the NIS approach.

The term “NIS approach” refers here not to a specific methodology, i.e. national empirical analysis of innovation systems, but to a theoretical perspective on innovation. The NIS perspective entails, as this paper points to, a specific theory on the co-evolution of institutions, organizations and technology.

The NIS perspective here reflects the core proponents (noticeably Lundvall and Freeman), but also the author’s considerations as to how the NIS approach could be further developed and applied to eco-innovations (Andersen, 1999, 2002, 2004). The NIS perspective has some limitations, in part related to the broadness of the concept making rigorous analysis at the micro level difficult (Dosi and Malerba, 1996, Andersen, 1999, Miettinen, 2001). This paper joins up with recent trends in innovation theory in synthesizing evolutionary economic and the more strategy oriented knowledge based theory of the firm, also termed industrial dynamics or dynamic capabilities theory, putting more emphasis on economic organization dynamics and firm strategizing (Foray, 1991, Langlois, 1988, 1992, Dosi and Marengo, 1994, Teece and Pisano, 1994, Langlois and Robertson, 1995, Loasby, 1996, Teece, 2000).

The paper presents in section 2 shortly the core features of the NIS approach. In section 3 it seeks to identify and compare key aspects of the rationalities in respectively environmental and innovation policy and discuss conditions of policy integration. In section 4 it moves on to discuss key challenges for a greening of the innovation system as seen from a NIS perspective. This discussion feeds in to the next section outlining a NIS policy framework, consisting of a tree pillar strategy for a greening of the innovation system. Finally section 6 discusses the implications for policy integration.

2. The National Innovation system perspective – outlining the framework

The national innovation system (NIS) perspective forms a part of the evolutionary economic theory, aiming to analyze disequilibrium markets. It makes up an alternative economic theory to the predominant neoclassical economic theory. The NIS perspective emerged in the mid 1980’s as an attempt to develop a stronger systems perspective on innovation. The NIS theory seeks to provide an analytical frame for the analysis of the co-evolution of technology, institutions and organizations (Lundvall, 1992 (ed.); Freeman 1987, 1995; Nelson, 1993; Metcalf, 1995). Emphasis is on seeing company innovation in a larger institutional set-up. It is the company and its competitive conditions that form the basis of analysis but the political and other institutional conditions are part of the analysis.

Hence an innovation system is defined as “those elements and relations, which interact in the production, diffusion and use of new and economic useful knowledge” (Lundvall, 1992)¹.

The innovation system analysis is connected to the national level for two reasons. Partly because the nation makes up a natural level for the discussion of policy elements, attributed much importance. Partly because a large part of the structures, understandings and behavioural patterns that characterize the innovation system are specific to the nation state or local regions, i.e. compare notions of “localized learning” and local specificity (Maskell, P. et al. 1998, Foray, 1991). The innovation system theory is, though, increasingly applied to other regions, such as the EU, or industrial sectors or specific technology areas.

A range of important evolutionary economists has contributed to developing the theory and lately noticeably policy institutions such as the OECD and EC play important roles in operationalizing and implementing the frame (Lundvall, 1985, 1988, 1992 (ed.), 2001; Freeman 1987, 1995; Nelson, 1993; Metcalf, 1995; Edquist, 1997, OECD, 2000, 2001a, 2001b, European Commission 2003).

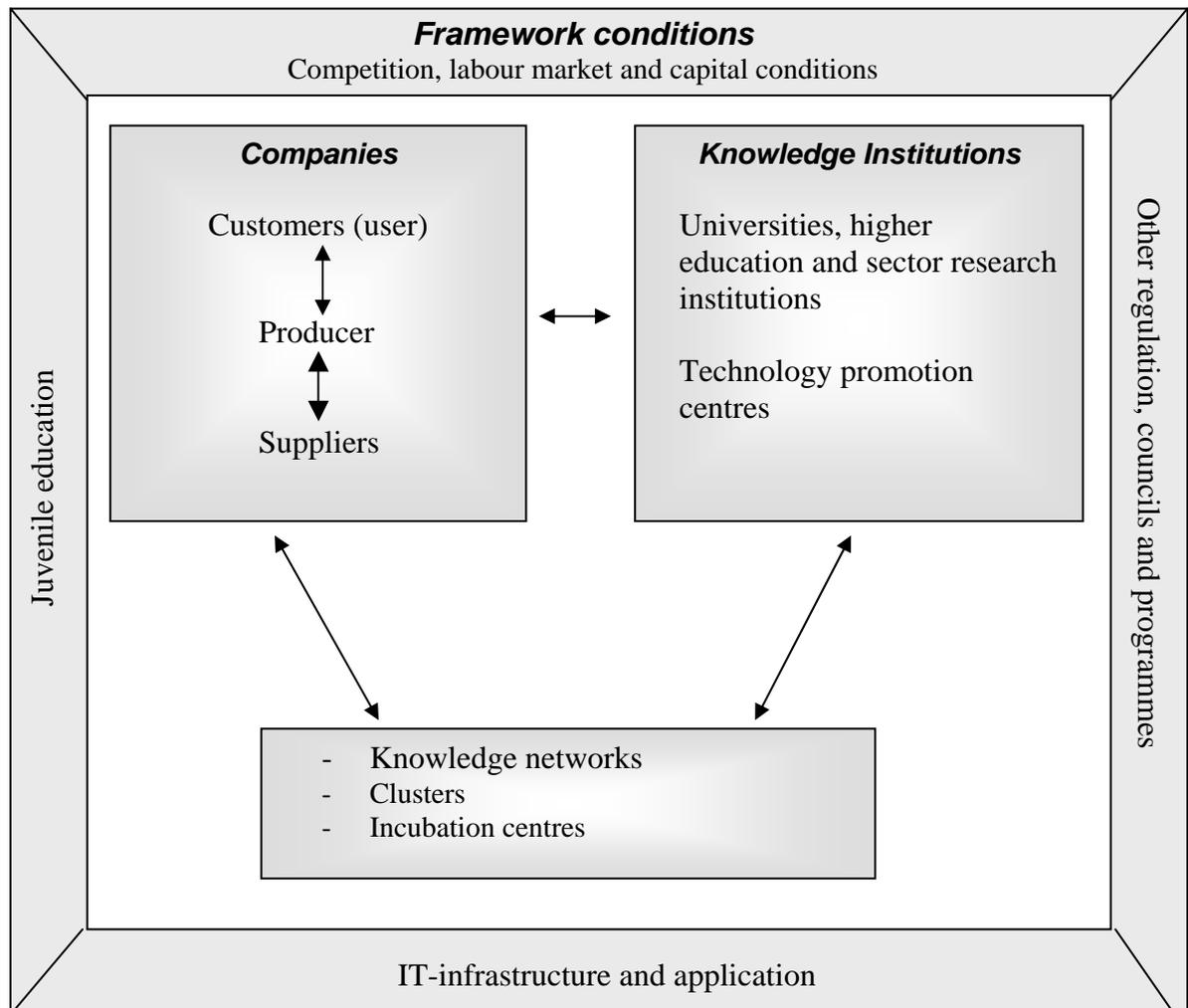
The NIS perspective is closely related to the concept of the knowledge economy, emphasizing the central role of knowledge based competition ((Lundvall, 1992 (ed.); Freeman, 1995; Nelson, 1993; Metcalf, 1995; OECD, 2000). The still more rapid innovation, the mobile capital and the revolution of communication caused by the information technology means changing competitive conditions. Pure cost strategies no longer suffices in the strong global competition. Rather the ability to innovative and seize new market opportunities ahead of others is central. The capacity to learn, i.e. to develop, absorb and apply new knowledge while creatively destructing the old is the key to competitiveness. This goes especially for the affluent, high-cost western economies, which need to find novel parameters to compete on (OECD, 2000).

NIS analyses seek to identify those distinct innovation patterns and dynamics, which characterize the different (national) innovation systems. Empirical studies show that national innovation systems vary considerably in their pattern of knowledge production and application (Nelson, 1993, Christensen et al. 1998, OECD, 1999). Despite globalizing markets and an increasing internationalization of policy regimes. These analyses form a basis for formulating strategies for strengthening the national (or regional or sectoral) innovative capacity and competitiveness. In depth, often comparative analysis, seek on the one hand to identify the specific organization of knowledge production on the other hand to identify the central framework conditions for the innovation process (Lundvall, 1992 eds., Freeman 1987, 1993, OECD 2000). The sum of the collected framework conditions and market conditions make up the “selection environment” for the companies. The selection environment determines which companies and technologies survive and come to dominate the market. Hence, it is the selection environment that governs the speed and direction of technological change (Nelson and Winter, 1982).

¹ Innovation is commonly defined in the innovation literature as a novelty leading to value creation on the market.

Figure 1 seeks to illustrate the core elements of the innovation system analytical frame.

Figure 1 The National Innovation System



Source: Andersen, M. M., Risoe National Laboratory, 2004

Key components in the national innovation system are the central knowledge producers in the core. On the one side companies, with emphasis on the interfirm learning between companies in the value chain and the knowledge structure of companies, i.e. the distribution of different industrial sectors and their knowledge intensity. On the other side the public and semi public knowledge institutions providing research and education. Transgressing these two groups are knowledge networks, clusters and incubators that make up important spheres of cooperation between these two groups. The arrows indicate an active interplay in the knowledge production.

The purpose of the NIS approach is not just to shed light on these different elements, but very much to focus on their interaction and synergy effect, as the figure also seeks to illustrate.

In short, the NIS approach makes up a strong system perspective in two ways:

1) Because of its holistic approach, in including the (for companies) surrounding institutional set-up relevant for innovation processes. Many different actors and institutions in society are included in the analysis, only looked upon from an innovation perspective.

2) Because of the perception of innovation as a fundamentally social and interactive process. The interplay, coordination, match and mismatch of the different elements in the innovation system are at the corner of the analysis.

The latter perspective is sometimes overlooked, leading to a misuse of the concept. In section 4 we shall look further into the underlying assumptions that need to be considered when developing a strategy for green competitiveness.

Below we shall look into similarities and differences between the NIS perspective and the predominant rationale of environmental policy.

3. Comparing rationales of environmental and innovation policies

Modern innovation policy builds to a large degree on the NIS frame presented above, i.e. on the theoretical framework from evolutionary economic theory. Environmental policy, on the other hand, has lacked a coherent theoretical framework. It builds on a mixture of neoclassical environmental economics, political science, law and insights from the physical sciences. There is accordingly unclarity about the drivers and trends in the societal conditions which environmental policy seeks to address. In fact environmental policy makers (and to some degree environmental researchers) have tended to neglect changes in societal and competitive conditions. Phenomenon such as the changing competitive conditions of the “knowledge economy” (OECD 2000), now widely recognized has been largely ignored in environmental policy making. Societal conditions, such as business and consumer behaviour, have been largely seen as given² and have been treated as a black box by environmental policy makers (Andersen, 2004). There has been no or only minor changes in environmental policy approaches despite the growing number of environmentally proactive companies.

The differences in theoretical background and perspective of the two policy areas give rise to important differences in policy approaches and instruments. Understanding and recognizing the differences in rationale between the different policy areas is central for promoting an integration of these.

Below an overview is given which seeks at a general level to compare key perspectives within environmental and innovation policy. Naturally, there are national differences in the policy approaches and perspectives. And certainly there are changes over time, noticeably in the latter years when we are seeing beginning synergies between innovation and environmental policies as partly reflected in the ETAP. Nevertheless the table illustrates some dominating general differences in perspective that needs to be considered when seeking dialogue and synergies between the two policy areas.

² Such a static assumption of behaviour is the basis for neoclassical economic theory.

Table 1. Key perspectives within environmental and innovation policy

Environmental policy perspectives	Innovation policy perspectives
Starting point/focus: The environment	Business (and knowledge institutions)
Thematic focus: Environmental conditions	Competitiveness Special focus on SMEs
Target: (Urgent and long term) environmental goals	(Long term) high innovative capacity
System focus/delimitation: LCA cradle to grave – products perspective	The National Innovation System – organisation of knowledge production
Regional aspects: Primarily national environmental conditions, but also strong local focus and global perspectives (climate)	National competitiveness in a globalizing economy
Business perspective: Companies with heavy (key focus) or light environmental load Policy sectoral division (eg. transport, agriculture..)	Companies competitive conditions (size, knowledge intensity, clustering ...) Companies role in (eco-) innovation process
Environmental business perspective: Presume business are reactive but want to make them proactive	The environment as a burden (minimize the negative effect of env. regulation on competitiveness) Emerging: Eco-innovation as an asset
Policy means on environment: regulation fiscal measures communicative instruments	“Mould” the market, rectify the systemfailures of the innovation system towards eco-innov.
Tech/business policy instruments: Access to tools (env. monitoring, reporting, management) Labels & BAT, support Clean Tech.	Strategizing Access to knowledge and capital Efficient organ. of knowledge production
Green vision: Healthy, sustainable environment Greening of business and consumers Internalising environmental aspects in the economy	Greening of the innovation system Making eco-innovation the “easy innovation” Green competitiveness
Key limitation: Societal change neglected (black box) Industrial dynamics neglected	Narrow focus on competitiveness Neglect of detrimental effects of technology development

The environmental dimensions on the part of innovation policy reflect the perspectives taken if these policies were to pursue environmental goals per se, i.e. aiming for a strategy for green competitiveness. As it is today, innovation policy generally upholds a defensive strategy of diminishing the harm of environmental regulation towards competitiveness or simply a desinterest.

The overview shows considerable differences in perspective on a range of issues, noticeable when it comes to the targets and the delimitation of the (innovation) system involved. To pick on some of the important ones: There is a major difference between aiming at (urgent) environmental goals and aiming at long term high innovative capacity building. And between focusing on the product life cycle and the organisation of knowledge production in the innovation system respectively. Finally, there is a schism between (the traditional) environmental policies aiming predominantly at addressing reactive behaviour and innovation policies aiming at addressing proactive behaviour.

While some environmental policy makers and researchers in recent years are showing a rising interest towards innovation-friendly policy styles and in a few cases as mentioned even green competitiveness, innovation policy is only changing its perspective somewhat.

Innovation policy and hard core innovation researchers tend to have a narrow focus on competitiveness and have only to a very limited degree dealt with sustainability issues (see though Lundvall, 2001). Focus is on achieving a high innovation rate and develop core competitive competencies (OECD 2000, EC 2002). The question innovation for what? Or attention to possible detrimental effects of innovation is absent.

It is therefore interesting to notice that the European Commission argue for the need to take on a broader innovation concept when pointing to the changing competitive conditions of the knowledge economy. In their communication to the Council³ on the union's future approach to innovation policy they point to the following three types of innovation:

1. *Technological innovation*, primarily stemming from research.
2. *Organisational innovation* or business model innovation, related to innovative ways of organising work in areas such as workforce management, distribution, finance and manufacturing.
3. *Presentation innovation*, covering innovations in design and marketing.

The first one represents the traditional innovation perspective; the two last ones represent a new policy interest within innovation policy. They underline the decreasing role of productivity and the rising role of the more value based parameters for competitiveness. *Presentation innovation* relates to the rising role of branding, image and design for competitiveness, which has important implications for eco-innovation. The identity a product gives, the story associated to it, is as important as its function to many (affluent) consumers. The higher levels of knowledge in society and the rising transparency associated with the information technology revolution, none the least the internet, provides new means for telling more complex stories on

³ COM (2003) 112

companies and products. Hence a companies' image is a lot more sensitive to critique. The importance of the image/brand not the least of the very visible transnational companies, is a key explanation for the rise of corporate social responsibility strategies particularly among the big companies (Zadek, 2001, Zadek et al., 2003).

Much indicates that presentational innovation will be increasingly important for companies especially in the high cost economies. The knowledge economy debate highlights that competitiveness is not merely about strict financial performance but about the ability to survive on the market, which first of all depends on a company's strategies and innovation. This brings new opportunities for proactive CSR and environmental strategies, which policy makers should realize and take advantage of. This is not the case to day, neither within environmental nor innovation policy.

The knowledge economy seems to have the potential for changing into a "socially responsible economy" where high eco-efficiency and responsible behaviour could become an important competitive factor and eventually a global market standard.

These value based issues are so far little discussed in the core NIS research, which maintains a strong focus on knowledge based competition. The environmental agenda may inspire NIS research and innovation policy to take on a broader perspective on competitiveness.

And the NIS approach can help bring the challenges of the knowledge economy into the environmental agenda. There are, thus, rising opportunities and grounds for creating greater synergies between environmental and innovation policy. But major gaps to overcross.

The policy integration picture gets even more complicated by the fact that CSR issues often are situated within ministries dealing with social or labour affairs. But this issue goes beyond this paper.

4. Challenges for a strategy for green competitiveness

In order to come up with NIS based policy recommendations we need to take a closer look at the theory. This section seeks to highlight some NIS inspired key issues on the dynamics of industry and the innovation system, which need to be considered when developing a strategy for green competitiveness. This discussion serves as background for the suggested policy frame in the subsequent section.

Applying core assumptions of innovation system dynamics the following 5 points will be pointed to: Institutional lock-in, innovation as an interactive process, uneven greening, the embeddedness in technological communities and the market representation.

Lock-in

The co-evolution of technology, institutions and organisations make up a fundamental explanation of innovation system dynamics (Lundvall, 1992 (ed.); Freeman 1987, 1995; Nelson, 1993; Metcalf, 1995). A core characteristic of the NIS approach is thus

the explicit focus on institution formation and transformation, noticeably the codification and standardization processes. Institutions are not only background conditioning phenomena for innovation; rather their transformation processes make up core aspects of the innovation process. Special attention is thus given here to how firms simultaneously are conditioned by, transform and create such institutions in order to innovative (Lundvall, 1988). The evolution of technologies, organizations (companies) and institutions should therefore be seen as closely entangled, innovation in one cannot take place without changes in the others.

This means that we need to inquire further into the evolving patterns in environmental behaviour and strategizing, none the least when it comes to the degree of proactivity of company behaviour in understanding the greening of innovation systems. The co-evolution of technology, institutions and organizations in the 35 years environmental issues have been on the international political agenda, have led to distinct patterns in the institutional set up and lock-in related to eco-innovation in various (national) innovation systems. The long period of command and control policymaking has led to *reactive* behavioural patterns among companies, but also among investors, researchers, consumers and other actors in the innovation system. The lock-in is based on the perception that the environment and the economy are opposites and that taking care of the environment is the responsibility of the government. Realizing eco-business opportunities is to a large degree not on the business or research agenda, prohibiting more proactive environmental strategies (Kemp and Andersen, 2004). There are sunk costs to these established strategies and routines meaning that the “easy innovation” and hence the direction of technological change (Nelson and Winter, 1982) currently still to a large degree is not very proactive when it comes to eco-innovation. This means that the environmental early movers are faced with high costs and risks (Andersen, 1999).

The specific formal and informal institutional setting and strategic maturity in various countries are necessary to consider when seeking to design an innovation system which facilitates a widespread uptake of proactive environmental strategies and eco-efficiency heuristics.

It is important to recognise the lock-in and take specific measures to overcome it before a kick-off of a green market development can take place.

The co-evolution discussion is very fundamental in NIS theory and is being elaborated on in the other points made below.

Innovation as an interactive process

The NIS perspective emphasizes the essential role of knowledge based competition. But knowledge is much more than research. Innovation is fundamentally an interactive process springing from multiple sources of knowledge (OECD 2000, Lundvall, 2002, EC 2003). This perspective departs very much from the classic linear approach to innovation, which sees innovation as the end-stage of a process driven mainly by scientific advances in basic research.

The for NIS theory central concept of *interactive learning* especially refers to the knowledge sharing between professional users and producers in the value chain (B2B) (Lundvall, 1985, 1988, 1992). On a market the tendency for firm activities to centre

around specialized knowledge or “similar capabilities” to achieve productivity and innovation gains increases the coordination need (Richardson, 1972). Hence knowledge is distributed in the value chain among the specialized knowledge producers who need to coordinate and collaborate with each other for efficient innovation (Lundvall, 1988, 1992). The point about this argument is that interfirm learning is an ongoing and fundamental part of market mechanisms, which to a high degree shapes the market development and the direction of technological change.

The importance of interactive learning is supported by empirical findings, which show that firms to a large extent draw their knowledge from other firms. And that there are important sector specific differences in the learning patterns (e.g. Allen, 1977; Conway, 1995, Hippel, 1978, 1988; Scherer, 1982; Pavitt, 1984; Dodgson, 1993). Modern innovation system research hence relies much on analysis from the industrial cluster literature and the studies on innovation networks and interfirm cooperation (OECD 2001a, 2001b, 2001c).

The NIS approach is often associated with an emphasis on the learning relation between companies and the surrounding knowledge institutions (and the need for government to support this learning partnership). But it is important to stress that interfirm learning is attributed an even higher importance to the innovation process.

The innovation system research highlights how *the organization of knowledge production* is becoming still more complex in the knowledge economy (OECD 2000). The rising pace of innovation means that there is an increasing use of multiple knowledge sources, feedback and parallel sequences in the stages of the innovation process (OECD, 2000).

The view on innovation as a fundamentally interactive process changes the perception of the role of the company. It now makes little sense to talk about “the polluter” such as underlying the polluter pays principle and much of environmental regulation. It is not the singly company that should be addressed but the innovation system. I.e. populations of interdependent companies and the other key actors in the innovation system such as the investors and knowledge institutions. The evolutionary nature of innovation should be recognized. It is the sum of decentralized processes of discovery (Dosi, 1991), in which companies however, play a key role. It is therefore necessary to consider the company’s role in (eco-)innovation within the innovation system more carefully when seeking to establish policies to promote eco-innovation and proactivity.

The uneven greening on the market

The NIS perspective tends to neglect changes in economic organization. Recent trends in innovation theory seeks to synthesize evolutionary economic and the more strategy oriented knowledge based theory of the firm in seeking to intersect notions of economic organisation, knowledge management strategies and dynamic market processes (see e.g. Foray, 1991, Langlois, 1992, Dosi and Marengo, 1994, Teece and Pisano, 1994, Langlois and Robertson 1995, Loasby, 1996, Teece, 2000).

These neo-institutional economic theories emphasize the role knowledge based competition has for changes in the economic organization. There are important strategic choices in how companies organize their knowledge production and – related

to this - their production. It is central for companies knowledge access when they decide to produce something themselves, including integrating or outsourcing, when they buy it on the market and when they engage in knowledge sharing with other firms.

These aspects are not only important in considering possible changes in economic organisation resulting from the greening of the market. Rather, they bring attention to the neglected costs of accessing capabilities on the market and coordinating the divided specialised firm activities (Langlois, 1992). There are costs to engage in persuasion and teaching in order to bring the interrelated firms on a similar "wavelength" as the innovator (Langlois, 1992) and costs to building those mediating institutions which facilitate complex information exchange which sink these costs (Andersen, 1999). These costs are sometimes called dynamic transaction costs, dynamic governance costs, coordination costs or information costs (Langlois, 1992, Teece 1986, 1988, Casson, 1997).

For the innovator there are hence a range of strategic choices in how to "pull in" first of all the other companies but also other actors within the innovation system on a similar "wavelength" that will allow the innovation to succeed.

This discussion is important in understanding the implications of the uneven greening of the market (Andersen, 1999, 2001). Companies have very different incentives and resources for dealing with environmental issues (depending in their size, their environmental sensitivity and their position on the market). The less environmentally competent, to which many SMEs belong, function as bottlenecks to the others (Andersen, 1999, 2001).

In the current transition phase towards a greener market economy these differences give rise to very diverse strategic considerations. Not only do we need to consider these differences when making policies to support company eco-innovation, but we need to consider the costs companies are facing in seeking to "pull in" the other actors and create green wavelengths" that will allow their eco-innovations to succeed (Andersen, 1999, 2001). Setting the market standard ahead of the competitors (by being the puller) may turn into a considerable strategic advantage outweighing the costs.

For the NIS perspective this discussion adds greater understanding of the incentives, costs and conditions for organizing knowledge production for the company, sector or nation. It is particularly important for an understanding of systemic change and the need for complementary innovations, which may expand beyond the value chain into the wider innovation system.

The NIS analysis sheds light on the discussion on match and mismatch between the different actors in the innovation system. It puts more emphasis on firm strategizing and reinterprets companies as active market makers. The coordination (push and pull) between companies as well as their ongoing knowledge sharing is central to the innovation process (Andersen, 1999).

Fundamentally the implication for a green strategy is the need to approach all companies. Company innovation is so interdependent that it is necessary to aim for

achieving environmental proactivity and competence building in the entire business community if eco-innovation is ever going to be an easy innovation. Until this is the case there are high coordination costs and risks to eco-innovation.

Usually environmental policy is targeted at companies with a high environmental sensitivity (those with a high environmental load). But some of the most important companies to eco-innovation have no or little environmental sensitivity, e.g. the wholesalers and retailers, and many companies in the value chain processing the products or providing services to these. These companies have typically limited if any experience working with environmental issues, and have accordingly no management systems or technological competences for dealing with eco-innovation.

The criteria for targeting a company should not be its immediate environmental impact but its role in the eco-innovation process. There is a need for a broad but differentiated approach reaching out for all types of business, as they all play important roles in the innovation system – a considerable challenge.

Embeddedness in technological communities

Evolutionary economic theory emphasizes the cumulative and hence path dependent and routinized manner of learning. Learning takes place within technological paradigms where attention rules and search heuristics follow patterns of problem solving activities giving rise to dominant technological trajectories (Dosi, 1982, Nelson and Winter, 1982, David, 1985).

The NIS perspective has taken on the concept of "technological communities" or "communities of practice" (Brown & Duguid, 1991) to capture how heuristics and learning modes become embodied among the actors who in various ways are engaged in the same technology development, noticeably across companies and knowledge institutions (Lundvall, 1985, 1992).

This NIS approach uses this to emphasize the importance of the local informal knowledge sharing and networking within the technological communities to the innovation process. This gives rise to local specificity and explains why regional and national innovation systems are still important despite a rapidly globalizing economy (Lundvall, 1992, OECD, 2001a, 2001b, Maskell, 1998, Foray, 1991).

It is, however, equally important to consider how the technological communities within (or transgressing) the innovation system are carriers of certain heuristics guiding the expectations (through established attention rules) and the search processes (through established search rules) (Nelson and Winter, 1982, Andersen, 1999).

This discussion brings attention to the embeddedness of companies in the technological communities and their roles in the ongoing competition between technological trajectories. The carriers of existing technologies and knowledge in companies and knowledge institutions, ministries and other institutions tend to defend the existing trajectories, emphasizing the important roles of new companies and actors from outside for the creation of more radical and systemic innovation (Andersen, 1999, 2004).

The market representation

A central feature of the NIS approach is the more cooperative representation of markets as compared to mainstream neoclassical economic theory. Markets are not coordinated simply by the anonymous arms length prize coordination, rather they are organized in stable learning relations based on shared understandings and trust that facilitate knowledge sharing and coordinated innovation between innovating companies (Lundvall, 1985, 1988, 1992).

Markets have fundamental problems in carrying out the identification of competent learning partners. Arm's length exchanges are insufficient in co-coordinating the innovative activities on the market (Lundvall, 1985, 1988, 1992, Foray, 1991, Casson, 1997). Firms have problems in securing co-ordinated adaptation between interrelated firms because autonomous parties read and react differently to signals. According to standard transaction cost theory such obstacles to efficient transactions and innovation lead to vertical integration (Williamson, 1975, 1985). But the emphasis in the innovation system perspective is rather on the evolution of various forms of market institutions as firms interact on the market in order to innovate; relational assets such as trust, information channels and information codes, which remedy the inherent information problems and uncertainty related to the innovation process (Arrow, 1974, Lundvall, 1985, 1988, 1992).

There is a need to develop stable interfirm relations allowing for an effectivisation and rationalization of the communication and cooperation process. A main argument is that such channels and codes are characterized by inertia. They are not only costly to establish, they also reinforce themselves as they become increasingly effective through learning, and other channels become less attractive. Lundvall proposes from this, that the stability of user-producer relationships is a significant feature of innovation processes, influencing the directions of innovation processes. This stability is mainly given a negative connotation emphasizing the prevalence of inertia and the occurrence of gaps between technological opportunities and the demand (Lundvall, 1985, 1988). Markets are "organised" rather than discrete as firms become tied together in learning relations (Lundvall, 1988, 1992).

This market representation has major implications for a policy discussion. It means fundamentally that market coordination is a more connected rather than discrete affair (Andersen, 1999). Other factors than price influence on market coordination. In such a market populations of interconnected companies to some degree develop shared understandings and entrepreneurial expectations. There is "something in the air", and this something could also be greening (Andersen, 1999). The opportunities for moulding such a market are considerable if the right framework conditions are provided.

5. Policy implications – the NIS approach to sustainable development

The NIS perspective, this paper claims, represents a new rationale in environmental policy making, a rationale first of all giving *knowledge based innovation* and

competitiveness a pride of place. The key objective of such a rationale is to design a well-functioning national innovation system for eco-innovation. The goal of policy, seen from a NIS perspective is in other words to create a greening of the innovation system where eco-innovation has become the “easy innovation”.

To day we are far from this goal and the question is how we design policies to get there. A key point of this paper is that the means, the type of policy applied, and not only the stringency, has a huge influence on the effect, a factor that seems obvious but still has not received proper attention within the environmental policy debate. In other words, environmental policy and administration as hitherto practiced is a part of the problem inhibiting a greening of the market, and not only the solution.

The paper suggests that a strategy for green competitiveness entails a major policy renewal. The point of departure in the NIS approach is the need to establish framework conditions that reinforce the incentives for companies to undertake eco-innovations themselves. For this to happen competitiveness must be made a primary driver. This policy approach we may call *eco-entrepreneurship*, it involves enhanced self-regulation and it should play a central role in a NIS inspired environmental policy. Such an approach presupposes widespread environmentally proactive companies and hence a new division of labour between the public and companies.

This approach applies innovation policy instruments in seeking to wire up the innovation system to create favourable conditions for companies’ voluntary eco-innovation. It resembles and builds on the integrated product policy (IPP) but differs from this in several ways.

Regulation and fiscal measures, the traditional approaches in environmental policymaking, are necessary framework conditions in the environmental innovation system. Part of their function will be to ensure a certain minimum foundation of corporate environmental conduct.

Box 1. Environmental policy approaches

<p>Regulation Environmental regulation sets the legislative conditions defining companies’ minimum acceptable conduct in relation to the environment. They confine a space for the polluter within which it is acceptable to degrade the environment.</p>
<p>Fiscal measures Eco-taxes manipulate market pricing to internalize the costs of resource use or pollution. The polluter is brought to pay. Where applied they provide powerful incentives for eco-innovation</p>
<p>Eco-entrepreneurship Seeks to wire up the innovation system to create favourable conditions for companies’ voluntary eco-innovation activities.</p>

It is not the intention here to go into a lengthy discussion of the potentials and drawbacks of these two established groups of instruments. Merely to state that while important and necessary they cannot on their own secure an integration of

environmental issues into the economic process. Both instruments are too crude, making it impossible to provide incentives for eco-innovation for the broad business community, i.e. addressing both the environmental laggards and the environmental leaders. Also regulation and fiscal measures are having problems in catching up with rapid technology development and in dealing with lock-ins. Finally, they tend to effect only the later stages of the innovation process while missing the early stages, where most of the direction of technological change is formed.

Consequently, regulation and taxes have fundamental problems in providing incentives for continuous innovation. We need innovation policies aimed at breaking the lock-in into reactive strategies and none-green practices for eco-innovation.

The point made here is not only to argue that the eco-entrepreneurship approach is an essential means to achieve a greening of the innovation system and should be upgraded. But also to say that more attention should be made to the interplay and the trade-off between the three types of instruments. If company eco-entrepreneurship is to play a major role, regulation and eco-taxation must provide incentives for this.

Regulation and taxes represent a stick approach. They both presume companies are reactive, and need to be forced to take on environmental action. They are not helpful in breaking the reactive lock-in and make companies see the environment as a business opportunity. Rather, if not properly designed, they will make companies adhere to their reactive strategies upholding dissociation to environmental issues. If the bulk of companies are to perceive of the environment as something positive that represents a business opportunity policy needs to support this clearly.

We need, in other words, policies that strongly signal that companies are part of the solution and not only causing the problems. We need to sell the message that environmental issues could be a business opportunity and not just a burden, not only through demonstration, indicators ect., which is certainly important, but also through regulation, taxation and environmental administration itself.

Rewarding the environmentally proactive companies should be a core unifying principle behind all policy approaches, e.g. rewarding those with environmental management systems, high eco-efficiency, triple bottom line reporting ect. This is far from the case today where many companies feel dissuaded by inconsistent incentive structures related to eco-innovation. This principle should have prior rank to the hitherto dominant polluter pays principle which only applies to part of the involved actors in the innovation process (the environmentally sensitive) and places emphasis only on the burden side while ignoring the asset side of eco-innovation. The polluter pays principle fits with the command and control policy style but is insufficient, sometimes even damaging, in a partnership approach. Its limitations should be realized and addressed.

Rewarding the proactive principle should be accompanied by an innovation friendly environmental policy style. This includes the continuing challenge of updating environmental regulation in step with technological and market developments. The development of new market-oriented means, (such as life cycle appraisals, eco-labels, the promotion of environmental management, triple bottom line reporting, taxes), etc., should be harmonised with companies' strategic maturity and ability in the areas of

environmental innovation and CSR strategizing. Overall, it should be ensured that environmental regulations and financial measures are so designed that they at any given time and place create strong incentives for companies to make their own environmental efforts. Such policies must be very dynamic and differentiated to provide continuous incentives for proactivity for both the environmental leaders and the environmental laggards (Kemp and Andersen, 2004).

The NIS green strategy approach rests on the principle of rewarding the proactive. Fundamentally, the policy approach reflects a new division of labour based on an increased shared responsibility between companies and government, a partnership whose justification is the beginning rise of a responsible knowledge economy.

Policy should support the transition towards a responsible market economy by supporting eco-entrepreneurship much stronger. We need innovation-oriented policy aiming for green competitiveness as a clear goal.

Below we shall look further into NIS inspired policies for promoting eco-entrepreneurship.

Wiring up the innovation system

Policies for eco-entrepreneurship focused on wiring up the innovation system to create competitive conditions for companies' proactive environmental activities.

Whereas regulation and taxes are *hard* framework conditions that manipulate or control the market, the eco-entrepreneurship approach is based on building *soft* framework conditions. The soft framework conditions *mould the market* by correcting those market imperfections associated with turbulent markets that hamper innovation, in this case eco-innovation.

The European Commission states in their communication on innovation policy, that the innovation system perspective entails a shift in policy rationale in research and innovation policy from "simply addressing market failures that lead to under investment in R&D towards one which focuses on ensuring the agents and links in the innovation system work effectively as a whole, and removing blockages in the innovation system that hinder the effective networking of its components" (EC, 2002).

The NIS frame essentially represents a *knowledge approach* to environmental issues. Traditionally environmental policy, including IPP, takes a point of departure in the environment. Focus is on achieving environmental impacts on targeted environmental issues. The NIS approach applied to eco-innovation, on the other hand, takes a point of departure in company strategizing and green competitiveness. Focus is on the long-term goal of building up a knowledge and capital infrastructure aiming at a high innovative capacity on environmental issues at the national or regional level. Actions are taken to strengthen the green industrial dynamics and wire up the innovation system for eco-innovation. This means that action is targeted at the system failures related to eco-innovation rather than at specific environmental goals as such.

Applying the NIS approach hence points to the possible trade-off between aiming at (urgent) environmental goals and aiming at building up a (long term) high green innovative capacity. Handling this trade-off is one of the key challenges of a partnership approach.

Recognizing that innovation fundamentally is an interactive venture initiatives should be made to *strengthen the coordination and learning* between the many actors involved in the innovation process, which goes beyond the strict product perspective of IPP. Targeted action should be made towards *the bottlenecks* (the eco-laggards), which are currently holding back the proactive actors on the market (the eco-leaders).

Undertaking such action presupposes ideally an analysis of the industrial dynamics of the greening process applied to the specific innovation system in order to identify the key system failures. Hereby it becomes possible to decide how most efficiently to target the action to wire up the green industrial dynamics and create self-reinforcing market mechanisms. Unfortunately, as it is now, empirical analysis of the greening of national innovation systems are rare and consequently we know little of the distinct features of and distribution in the innovative capacity on eco-innovation (Rand Europe, 2000, Hübner et al. 2000, Hübner and Nill, 2001).

Wiring up the innovation system for eco-innovation means making eco-innovation the *easy innovation* (Nelson and Winter, 1982). This is the case when the lock-ins into none-green practices have been diminished and environmental aspects are institutionalised in the innovation system, i.e. when they form a natural part of the market communication practices and tools, the companies and knowledge institutions knowledge basis and search rules, the technical standards and tests and overall corporate and investor strategizing.

All in all, policy should strive to create a selection environment, which will favour the survival of eco-innovations and companies with proactive CSR strategies. Customers, investors and employees will not select companies, technologies and service products, which are not sufficiently eco-efficient and responsible and gradually they will die out. In time the proactive companies will come to dominate the market and make up a new eco-efficient market standard.

Instruments for wiring up the innovation system for greater eco-efficiency

This paper is not going into a detailed discussion of NIS inspired environmental policy instruments, for that see Andersen, (2004). The intention here is to shortly provide an overall NIS framework .

This paper suggests that a strategy for moulding the market for eco-innovation should aim on the following three pillars:

Box 2. A three pillar strategy for greening the innovation system

Policy areas	Targets	Possible action themes
Policy area 1		
Well-functioning green markets	The environment as a natural criterion in all purchase and sales situations throughout the value chains nationally and internationally.	-Qualifying the green demand.
Policy area 2		
Green organizational development	The environment as an integrated part of companies' competitive strategies and day-to-day decisions.	-Promote market-oriented environmental strategizing and management.
Policy area 3		
Green technology development	Building strong environmental competencies in companies and knowledge institutions for a high overall innovative capacity on eco-innovation.	-Promote a forward-looking and coordinated green R&D effort.

Source: Andersen (2004)

A major limitation of the NIS approach is that it tends to be quite focused on technology push, while market development perspectives are neglected (Andersen, 1999). The NIS perspective forwarded in this paper has sought to overcome this issue by arguing for a three pillar strategy with a simultaneous focus on building well-functioning markets, organizational development and coordinated technology development.

The common denominator for the three policy initiatives mentioned here is a strong focus on knowledge. The demand side, pillar 1, is basically sought strengthened by building more environmental knowledge on products, i.e. to find new ways to tell the “stories” behind the products, stories that will allow knowledge to be formed on the causal relation between a product or activity and its environmental impact for consumers and professional customers.

The technology push side is sought strengthened by building widespread environmental competencies and knowledge sharing in and between business and knowledge institutions, strong clusters on core environmental competencies, dynamic incubator environments and good access to capital. Targeted policies for eco-innovation should focus and position the innovation system towards key strategic

areas. But at the same time it should be realized that all environmental competencies are important as they feed into a common knowledge base. E.g. from a knowledge point of view, a strong environmental sector is important for a high innovative capacity on eco-innovations.

The second pillar on organizational development focuses on empowering the key organizations in the innovation system towards proactive environmental and responsible behaviour. It is a key issue from the NIS perspective to widespread proactive CSR strategies among the bulk of companies. There is a substantial need for management, organizational and competence renewal to change company (reactive) strategizing from environmental regulation towards a stronger market approach. Efforts should be made to change environmental management systems from the current technical exercise carried out by technicians into an eco-efficiency management strategy forming a part of the overall competitive strategy of companies. The internal organization matters too, i.e. the location and position of companies' environmental and ethical work affects the influence this work gains. There is among other things a need to build new eco-technical competencies in the sales and marketing departments to deal with the new complex environmental communication towards customers (Andersen, 1999).

The green organizational development area ties together the demand side (policy area 1) and the technology push side (policy area 3). Action on organizational development should be targeted towards key actors in the greening of the innovation system. The leaders pushing the green market development should be supported and the bottlenecks (the laggards) should be mobilized. E.g. currently noticeably the retailers and wholesalers (so important for policy area 1) and investors (important for policy area 3).

The uneven distribution of incentives and resources on the market should be taken into account in developing a differentiated approach and a step model for implementing proactive CSR in the business community. It is, as said, necessary for a green market development, however, to aim at all companies so as to achieve a similar "green" wavelengths and complementary adaptation of eco-efficiency strategies in the business community.

Governments should provide consistent and ongoing strong incentives for the development of proactive environmental and responsible issues in business strategies. Regulation and fiscal measures should consistently reward the proactive companies. But also demonstration (of business opportunities), accounting, indicators and benchmarking (of eco-leadership) are important instruments.

The mentioned three policy areas are closely intertwined and presuppose each other. A key point of the NIS approach is that policy measures need to be introduced in a well-coordinated and timely way. It matters when and in what order which actors or elements within the innovation system are mobilized for the green industrial dynamics to function.

These policy measures should aim to create more cohesion and better coordination in the very asymmetric national and international (e.g. EU) environmental innovation

systems, by focusing on removing bottlenecks and furthering interactive learning and coordination among the many interdependent players in the innovation system.

6. Aligning policies for green competitiveness

Who, then, can and will implement such a strategy for green competitiveness?

Pursuing such a strategy for green competitiveness sets new demands on the overall rationale but also the competencies applied in working out and administering policy instruments. It will require substantial renewal at both central and local levels of government.

Very few environmental ministries possess any competencies in industrial economics and innovation dynamics. The employees are primarily from the natural sciences, with a few neo-classical economists and people with mixed backgrounds. Furthermore, both authorities and companies are locked-in to the traditional command and control division of labour perception.

The innovation authorities, on the other hand, almost completely lack environmental competencies. They are filled with people with a business or policy education, possibly a few engineers, but there are most likely nobody from the natural sciences.

These differences in competencies provide much of the explanation for the differences in rationalities outlined, and why these are not easily changed.

The implication of these differences is that making such a strategy necessities either building up new units (in the ministries primarily) with new competencies (building innovation competencies among environmental authorities or building environmental competencies among innovation authorities) if any of these ministries seek to take on the task alone, or a close collaboration between them.

In both cases there will be a strong need for a shared consistent framework and a vision that may ease the integration of the different rationales and competencies. The NIS frame is a good suggestion for such a framework that seeks to align competitiveness and sustainability issues and hence innovation and environmental policy.

To achieve a mobilisation of the bulk of business community for eco-innovation, it is vital that government talks the language of business and understands industrial dynamics. It is much easier for the ministries of innovation and research to be seen as a partner to business because they already are. For the environmental authorities this cannot take place without considerable policy renewal. This argues for the need to place green competitive strategies in innovation authorities and build environmental units there. Also, it is properly easier to build environmental competencies here (relatively few people can add that dimension) than building business competencies in among environmental ministries (more fundamental competencies and rationales). We have seen this recently in eg. the UK, Sweden, Finland, Japan, the Philippines.

This is not unproblematic. There is still a need for environmental authorities to keep an eye on a proper trade off between achieving environmental goals and green competitiveness. Environmental authorities are not likely to want to give up some of their responsibilities. And finally the ministries of innovation are generally little interested in taking on these tasks as they do not see environmental issues as being interesting to competitiveness and as their domain.

Possibly the ETAP process will provide a platform that may aid this needed process of policy integration further. But the ETAP lacks a (NIS) framework that can clarify the challenges and the opportunities ahead for both parties.

7. Conclusions

The national innovation system (NIS) perspective represents a much needed framework for aligning environmental and innovation goals for policy makers. It may provide the basic premises for making new synergies between environmental and innovation authorities.

The NIS perspective represents a new policy rationale, which gives *knowledge based innovation* and *competitiveness* a pride of place. The NIS perspective is important because it places eco-innovation within the wider context of the knowledge economy and the changing competitive conditions it represents. Much indicates that strong environmental competencies could be an important competitive factor in the future.

The NIS approach argues that for the green market economy to take off, green competitiveness must become a primary goal and driver for business. We need innovation-oriented policy to obtain a widespread greening of the innovation system.

The paper has argued that substantial policy renewal is needed if policy makers are to pursue a NIS inspired strategy for green competitiveness.

So far policy integration to a large extent has focused on integrating environmental issues into other policy domains (i.e. sector integration). But little emphasis has been placed on the need for opening up environmental policy towards other policy areas. A serious strategy for eco-innovation and green competitiveness cannot take place without making room for the rationale and insights of innovation policy influence on existing environmental policies. An important step in this policy renewal, the paper suggests, is to make the *principle of rewarding the proactive* a cornerstone in environmental policy making.

Applying the NIS perspective to eco-innovation in many ways also presents a challenge to NIS theory and innovation policy (Andersen, 1999). Innovation research and policy has so far to a wide extent managed to ignore the wider societal consequences of innovation. A focus on environmental innovation systems may help remedy this.

It is therefore important that innovation oriented ministries are cooperating with environmental ministries or, alternatively, are integrating eco-innovation into their domains. Possibly a partnership policy approach requires a new division of labour in between the ministries as well.

The NIS approach is only emerging in the environmental field, but it carries promising perspectives for a renewal of environmental policy. Most importantly, it provides a frame for analysing the dynamics and distinct features of (national) innovation systems and their conditions for eco-innovation. On the basis of such an analysis it becomes possible to make a strategy for wiring up the innovation system for eco-innovations, aiming at identifying and rectifying the system failures of eco-innovation.

The (insufficient) rationalities and competencies of respectively the environmental and innovation authorities seriously inhibit the possibility for developing rigorous strategies for eco-innovation. The suggested NIS framework presented here could provide an important means in bridging the to policy areas by clarify the challenges and the opportunities involved for these two parties.

If we manage that, eco-innovation and CSR may become an important agenda in the knowledge economy and the Lissabon process, for the good of competitiveness as well as the environment.

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