Policies for Climate Change in the long Run: Wiring up the Innovation System for Eco-innovation

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Abstract

Policies for climate change have never received as much attention worldwide as now. At the same time another key policy trend is an increasing synthesis between environmental and innovation policy, a synthesis, it is here suggested, that is captured by the "eco-innovation" concept. This paper suggests that the innovation system frame based on evolutionary economic theory may guide the development of these new eco-innovation policies in important ways. The paper seeks to uncover the theoretical underpinnings and new rationales associated with these policies.

The paper argues that the eco-innovation approach represents a shift in rationale from the traditional regulatory approach within environmental research and policy making towards an evolutionary market based approach to achieve climate and wider sustainability goals; not only in putting more emphasis on the market but also shifting the representation of the economy towards a more dynamic one.
Rather than pursuing immediate environmental goals in climate policy making the paper suggests a long run policy for wiring up the national innovation system for eco-innovation.

This paper has claimed that a innovation systems perspective represents a potential new evolutionary environmental policy rationale in fundamentally viewing the economy as a long run process subjected to path- and time dependencies. The new rational is particularly clear in two ways:
1) In treating the company as (eco-)innovator rather than as polluter
2) In adapting a strong knowledge approach

The innovation system policy approach strives to mould the innovation system so as to make it easy and attractive to engage in eco-innovation for firms as well as knowledge institutions (and to lesser degree consumers). The five pillar strategy suggested reduces the friction to eco-innovation. There is however, a need to identify, through innovation system empirical analysis, the specific charactheristic and

innovation conditions as well as system failures to eco-innovation in the given innovation system.

The innovation system frame is only beginning to be caught up in environmental analysis and mainly from the so-called "functional " perspective; this paper suggests that the "organisational" approach is more needed.

Overall, we need to link up micro-oriented innovation policy with the macro-oriented climate policy so as to align short run targets with the long run target of wiring up national innovation systems for eco-innovation.

1. Introduction

Global climate change is currently one of the hottest international policy issues; the alignment of environmental issues and energy supply targets has created a very powerful political agenda; an agenda that is accelerated by the upcoming central COP15 climate conference next year.

At the same time another key policy trend is the rising attention to "eco-innovation" since the mid 1990s (see e.g. Fussler and James 1996, den Hond 1996, Andersen, 1999, 2004b, 2007, 2008, Fukasako 1999, WBCSD 2000, Rennings 2000, 2003, Markusson, 2001, OECD 2005, Reid and Miedzinski, 2008). Analytically, the concept puts emphasis on green competitiveness, policy wise it seeks to forward greater synergy between environmental and innovation policy. Eco-innovation policy approaches is gaining momentum only very recently, noticeably via the process of the EU Environmental Technologies Action Plan (EUROPEAN COMMISSION 2003, RENNINGS ET AL., 2003, Andersen, 2004a, 2004b, 2004c, (Kemp and Andersen, 2004; Foxon, 2004, Foxon et al., 2004, Foxon et al., 2005b, Foxon and Kemp, 2005). The EU (COM 2006) has started to integrate eco-innovation more systematically in innovation policy, and also other countries are developing a stronger innovation approach to environmental policy (e.g. Japan, Sweden, UK, Finland, Denmark, Holland, China and the US)[1].

This paper seeks to identify core policy challenges and new signals in environmental policymaking related to the eco-innovation agenda. The purpose of the paper is to contribute with conceptual clarifications rather than empirical findings by exploring the innovation systems perspective based on evolutionary economic theory.

The paper argues that the eco-innovation approach represents a shift in rationale from the traditional regulatory approach within environmental research and policy making towards an evolutionary market based approach to achieve climate and wider sustainability goals; not only putting more emphasis on the market but also shifting the representation of the economy towards a more dynamic one.

[1] Compare e.g the "Green growth" strategy of UNESCAP, China´s strategy the "circular economy", Japan's resource efficiency goals, and the US aim for renewable energy production and - efficiency. In the EU, the Innova program of DG Enterprise is especially interesting because it identifies eco-industries as a target of sectoral innovation policy equal to other sectors of economic importance. Eco-innovation is for the first time seen as a means to competitive advantage.

The paper seeks to bring attention to the theoretical underpinning of environmental and climate policies which tends to be neglected. Economic research on environmental studies has hitherto been dominated by neoclassical approaches. Innovation policy on the other hand, and the innovation research that forms the basis of it, is grounded in evolutionary economic theory which seek to treat economics as a process; that is long run, real time economics as opposed to the idealised, short run allocation focus of orthodox neoclassical economics. Environmental and innovation policy hence are based on very different basic assumptions, a factor that tends to be neglected in the current climate debate (see also Andersen, 2004b).

The eco-innovation evolutionary agenda implies, this paper suggests, that we need to reconsider both how we understand environmental issues, innovation and economic development, and what we know of the greening of industry and markets. Hitherto, there has been a serious lack of insights into innovation dynamics in environmental policy making and administration (Andersen, 2004b).

The innovation systems theory is by now a well-established framework for a broad evolutionary perspective on innovation and long-run economic change (see e.g. Freeman, 1987; Freeman, 1995; Lundvall, 1988, 1992 (ed.), 1999, 2005; Johnson, 1992; Nelson, 1993; Metcalf, 1995; Edquist, (ed.) 1997, OECD, 2000, Perez, 2000, Freeman and Loucã, 2001, Fagerberg et all. 2008). The perspective rejects the "linear model" of innovation. Rather than being an exogenous factor leading to predictable economic results, innovation is an endogenous phenomenon. The core idea of this approach is that the the dynamics and performance of economies depends not only on a set of core innovation actors (companies, knowledge institutions, financial institutions, government) but on their interactions restricted by but also forming wider institutions.

This framework forms today the basis not only for much national, regional and sectoral innovation analysis but also for much innovation policy. As yet environmental policy has only been little influenced by this perspective, a factor which illustrates the still limited synergy between the two policy areas (see though e.g. Andersen, 2004a, 2004b, Kemp and Andersen, 2004, Foxon, 2005, Foxon and Kemp 2007, Andersen 2007 for discussions of innovation systems thinking and environmental policy).

This paper seeks to situate eco-innovation policy within such an innovation systems analytical frame. The paper claims that an innovation system perspective could represent a key frame in operationalizing an evolutionary climate policy approach. This policy strategy places the market as a key driving force for climate policy goals. It strives to "mould the innovation system" so as to make it easy and attractive to engage in eco-innovation for companies as well as knowledge institutions. Rather than pursuing short run environmental goals the paper suggests *a long run policy for wiring up the innovation system for eco-innovation*. The paper will seek to specify such a policy and its rationale more in detail.

The advantages of the innovation system approach are several but two core arguments are presented. The first is that the innovation system approach allows us to situate the climate discussion and the related economic process in specific space and time; more specifically it enables us to identify the distinct features and eco-innovative dynamics

of different (national) innovation systems. To day there is a serious knowledge gap on these issues. Policy wise this will allow us to target the system failures related to eco-innovation in the given innovation system. A neglected related issue in climate policy is the path dependent and cumulative nature of change. We need to perceive of greening as a transition process where the eco-innovation conditions in the innovation system change over time. Hence, this paper argues, the "greening" of the innovation system may be understood by referring to the "green learning curve"; i.e. how different actors (firms, sectors, knowledge institutions, consumers and innovations systems) and institutions are affected at different stages on this curve. The point is not only that eco-innovation conditions have been undergoing dramatic change over time and is likely to do so in the future, but rather that different actors are at very different stages on the green learning curve. This has major implications for the organisation of production and (green) learning across actors in the innovation system, a factor that has major policy implications, as we shall expand on below.

The other main argument is that the innovation system approach allows us to develop a positive climate vision; a vision of the innovation system with a high innovation capacity for eco-innovation, and where eco-innovation has become the "easy and natural innovation.

Currently, climate policies only have negative goals: reduction targets that need to be met, but little vision about what a low-carbon society may consist of. The innovation system approach may contribute to this visioning in important and meaningful ways for specific actors and hence create incentives for their eco-innovative action.

It matters greatly how we define the system. Currently there are two main strands in innovation systems thinking, respectively the functional and the organizational approaches. The former defines the innovation system as consisting of a set of functions central to the innovative performance of a nation or technology area; the latter the innovation system as a set or actors. Currently the (national) innovation system frame is beginning to be caught up in environmental analysis but mainly from the so-called "functional " perspective ((Segura-Bonilla, 1999, Andersen 1999, 2002, 2004a, 2004b, 2004c, Andersen and Rasmussen 2006, Rand, 2000a, 2000b, Markusson 2001, Hübner et al. 2001, Smith, 2002, Foxon 2003, 2004, 2005, Foxon et al. 2004, 2005, Foxon and Kemp 2005, Kemp and Andersen 2004, Midttun and Koefoed, 2005, Scienstock, 2005, Saviotti, 2005, Weber and Hemmelskamp 2005).

This paper suggests, however, that the "organisational" approach is more fruitful [in putting greater emphasis on the structural explanations and insights and the agency of different actors in the innovation system (Lundvall, 2005). See also Andersen 2007 for a discussion on different innovation systems approaches for sustainable change.

The current climate policy agenda seems on the one hand to follow a fairly traditional environmental regulatory approach in focusing on setting up global and national CO2 reduction targets and using fiscal measures and trading schemes to regulate markets. On the other hand, the climate policy agenda also increasingly includes a focus on green growth and competitiveness, noticeably in the area of low-carbon technologies (renewable energy supply, innovations for greater energy efficiency ect.). However, focus is quite narrowly on R&D (under)investments whereas the innovation dynamics and -policy aspects potentially involved in this are as yet not fully addressed; there is

a room for a stronger and more consistent innovation policy approach to the climate agenda which this paper seeks to elaborate on.

The title of this paper "wiring up the national innovation system for eco-innovation" implicitly assumes that current innovation systems are not adequately set up to further eco-innovation. That is indeed also the starting point of this paper.

The overall argument of the paper is hence that the innovation system frame may contribute in important ways to link up the aggregate global climate policy targets to the national and sectoral innovation policies oriented at creating incentives for specific actors in specific settings.

2. Innovation systems as an analytical frame

Innovation system research has evolved the least 20 years within evolutionary economic theory. The research is nowadays well consolidated making up the main basis for innovation policy at the international level (OECD, EU) and in many countries (OECD 2000, 2001a, 2001b, European Commission 2003, COM 2006). By now there are quite well-defined empirical frames and methods for innovation system analysis (Freeman 1987, 1995; Lundvall 1988, 1992 (ed.), 2001, 2005; Nelson 1993; Metcalf 1995; Edquist 1997; Edquist ed. 1997, Edquist and Hommen 1999, Fagerberg et al. 2008). It has been further operationalized as a policy frame by the OECD and European Commission (OECD 2000, 2001a, 2001b, 2005; European Commission 2003, 2006).

The development of innovation systems theory was originally motivated by a wish to illustrate that national economic performance depends on a lot more than simple labour productivity (Lundvall, 2005). Hence the concept is closely related to the understanding of knowledge based competitiveness and the knowledge economy, or as it is sometimes also referred to, the learning economy (Lundvall, 2005, Gregersen and Johnsen, 2008). The basic assumption on the knowledge economy is that the current high rate of economic change makes knowledge generation, absorption and use and the overall ability to learn the key factor for competitiveness.

An innovation system (from the organisational approach) is defined as "those elements and relations, which interact in the production, diffusion and use of new and economic useful knowledge"(Lundvall 1992). The innovation system basically consists of three main elements:
The innovation dynamo key knowledge producers and users – firms and knowledge institutions.
The transfer factors: interactions and flows of knowledge and funding in society.
The wider institutional setting influencing on innovation, noticeably policy conditions. (European Commission 2002).

The broad national innovation system perspective should not indicate that innovation depends on everything; rather the attempt is to identify the core actors and institutions which influence most on the innovation process and economic development. Innovation systems should be considered open systems in which different systems (regional, sectoral, technological and even global) overlap. The innovation systems

frame is primarily applied at the national level. The argument is that despite a globalizing economy, learning is still very localized and a major part of the national institutional setting, noticeably policy but also cultures and various other institutions (Maskell 1999). Increasingly the frame is also applied to broader regions like the EU, treating it as one innovation system that is compared to e.g. the US, Japan and China.

The essence of the innovation systems thinking lies in a focus on the co-evolution of it constituents (science, technology, organizations and institutions) (Lundvall, 2005, Andersen, 2006). The development and transformation of an innovation system is based on co-evolutionary processes in which the development of firms and industrial sectors interacts with and are affected by a (predominantly national) public knowledge infrastructure, policies and wider institutions and demand structures.

The empirical comparative analyses of different innovation systems allow for an understanding of their structural characteristics, specific innovation patterns, and development over time. Such studies show that innovation patterns vary widely between different national innovation systems (Nelson 1993; Metcalf 1995, Edquist and Hommen, eds. 2006). However, despite the co-evolutionary interest still most empirical innovation system analysis tends to focus more on how national innovation systems perform (undertaking snapshot benchmarking of innovation rates and competitiveness) than how they form and evolve over time (Lundvall, 2005, Andersen, 2006a, Fagerberg et. al. 2008).

This paper seeks to contribute to the research that states that the development of innovation systems is best studied as a historical process, emphasizing the path-dependent and cumulative nature of change. (see also Martin and Sunley, 2006, Fagerberg et al. 2008.) Evolutionary theory emphasizes variety creation, selection, adaptation and retention as core factors in the innovation process which are all subject to path-dependency (David 1986, Arthur 1989, North 1990, Pierson 2000, Martin and Sunley 2006). The economic path dependency literature focuses on the mechanisms that may give rise to economies of scale, such as the adoption of standards, but also institutions, including policies and informal “rules of the game”, may give rise to scale advantages as they are costly to establish but efficient to run with widespread effects once well-established (North 1990, Pierson 2000).

The innovation system(s) forms the selection environment for new innovative activities and entrepreneurial ventures; that goes particularly for the national innovation system where most institutions are founded. Established structures and practices in the innovation system seeds the selection processes and tend to preserve existing practices while winnowing out new ones that are ill adapted to the existing innovation system. Only the new practices and ideas that at a given time and place are well adapted to the selection environment are likely to be applied and form the basis for further adaptation and development.

The co-evolutionary processes of the innovation system may particularly give rise to path dependencies, because of the interdependent nature of its constituents. Changes in one part of the system requires complementary changes in other parts. It is therefore important to be attentive to the path dependencies and lock-ins that prevail in different innovation systems.

The specialization pattern, or sectoral composition, forms an essential part of the structural characteristics of the national innovation system. In recent years interest in is rising into "sectoral innovation systems" as a new research field (Breschi and Malerba 1997, Malerba 2002, 2005, Jacobsson and Bergek 2004, Bergek et al. 2005). This research tries to link up in-depth analyses of sector specific innovation patterns with wider national innovation system analyses.

The sectoral composition is important because the innovation patterns and performance of different industries vary considerably (Pavitt 1984, Malerba 2004). E.g. more high-tech industries depend more on codified and science based knowledge and the formal protection of intellectual property rights while other sectors rely more on experimentation, interactive learning with suppliers and customers and secrecy for their innovation performance (Malerba 2004).

The sectoral composition of a given national economy influences the operation and structure of its national innovation system (Fagerberg et. al 2008). To some degree the firms operate within a shared national knowledge and institutional framework, and to some degree sector-specific institutions evolve and may play significant roles for the innovation conditions at the firm level. The relationship between sectoral and national innovation systems is a co-evolutionary one; i.e. sectoral characteristics influence the development of the knowledge infrastructure and institutions at the national level, while at the same time the latter characteristics influence the subsequent evolution of the national economy and its sectoral composition (Fagerberg et al. 2008).

Also informal organisations and institutions such as communities of practices and codes of conduct are considered important constituents when seeking to characterize the innovation system (Lundvall 2005).

The focus on the agency of different actors within the innovation system puts attention to the different, possibly conflicting, perceptions of and expectations to the economic development and wider societal trends; a difference which influences the action that different actors might undertake to gain support for their innovative activities.

The above discussion underlines the importance of the structural characteristics of the innovation system and the analysis of the matches and mismatches of the activities and perceptions of different actor groups and hence the need to apply an organisational approach to innovation system analysis.

Below we will seek to expand the above discussion on innovation system dynamics in shortly interpreting the dynamics and trends of the greening of innovation systems.

3. The green learning curve and the formation of innovation systems

The environmental agenda has emerged as an important policy issue over the last 45 years. During this period the environmental agenda and its impact on the economy has changed considerably. The last 10-15 years we have seen a marked shift from a pure regulatory approach towards the rise of greening as a corporate issue. The greening of markets is now becoming apparent although at an early stage of development

(Malaman, 1996, Hitchens, et al. 1998, 2002, Andersen, 2002, Rand, 2000a, 2000b, Ecotec 2002, Esto 2000a, Frondel, Horbach and Rennings 2005, European Commission 2006). It is this greening of market and hence the rise of "eco-innovation" that forms the point of departure of this paper. Eco-innovation is here defined as "innovations which are able to attract green rents on the market", i.e. the concept is closely related to competitiveness (see also Andersen, 1999, 2001, 2008). The concept thus defined focuses on the degree to which environmental issues are becoming integrated into the economic process. In doing so, the eco-innovation concept emphasises the dynamic nature of environmental innovations. Greening is a moving target and the market conception of what is considered environmentally benign will inherently change over time. This, however, not only concerns environmental issues but also the externality tag more generally, in accordance with evolutionary economic thinking (Nelson and Winther 1982). With ongoing innovation and co-evolutionary changes in institutional structures it will necessarily vary over time and space what is considered environmental problems, green solutions and the capacity of respectively the market and public authorities to deal with these (for an in-depth discussion on defining eco-innovations see Andersen, 2008).

It goes beyond this paper to go into a detailed analysis of the drives, trends and conditions of the greening of markets and the specificities of eco-innovation as opposed to other innovations. Rather a few core main trends and issues will be pointed to of relevance for policymaking.

Quite many researchers have pointed to the rise of the greening of markets as part of an overall techno-economic paradigm change (Summerer 1989; Kemp and Soete 1990; Kemp, 1994; 1996; Gladwin 1993; Freeman 1992, Andersen, 1999, 2002). The paradigm discussion is first of all important because it puts emphasis on the radicality and path dependency of the greening process and the cognitive structures underlying the economy. The analyses have, however, so far been on a very general level. This green paradigm change is likely to have increasing pervasive impacts on the economy. Rather than discussion the possible stage of this current paradigm change the core and neglected point of this is that we need to consider the strong cognitive aspects of the greening process. Going green requires new search rules and capabilities and the creative destruction of old practices and capabilities. Despite the complexity of the greening process there are some fundamental heuristics and learning associated with the greening process. We may hence perceive of the green techno-economic paradigm shift as a shift from, and a competition between, a "wasteful" trajectory, with little attention to the exploitation of resources in normal problem solving activities, towards a "resource efficient trajectory" where there is strong attention to an efficient use of resources (the sink and the source functions, the life cycle impacts) in normal problem solving activities (see Andersen, 1999). As the trajectory research shows us learning and search is strongly subject to path dependencies (Dosi, 1982).

The core argument of this paper is that we need a stronger focus on the time- and path dependencies of the greening process. We need to perceive of greening as a continuous transition process where the eco-innovation conditions in the innovation system change over time. Hence, this paper argues, the "greening" of the innovation system may be understood by referring to the "green learning curve"; i.e. how different actors (firms, sectors, knowledge institutions, consumers and innovations

systems) and institutions are affected at different stages on this curve. The point is not only that eco-innovation conditions have been undergoing dramatic change over time and is likely to do so in the future, but rather that different actors are at very different stages on the green learning curve.

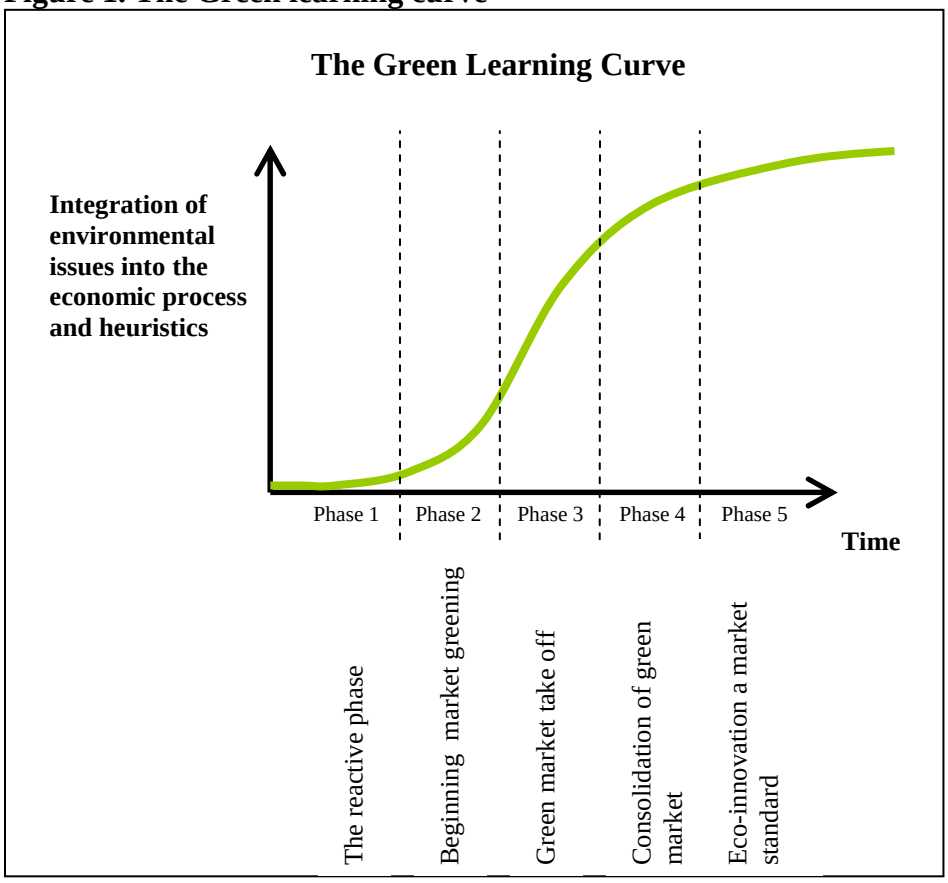
A core argument of this paper is that the greening process is inherently uneven, particularly at the firm level (Andersen, 1999). For the firm the greening process appears as turbulent changes in the selection environment, entailing new legitimacy needs and/or requirements for technological and organisational innovations. The firm may seek to acquire a premium price for its green reputation or product. However, incentives for engaging in eco-innovation strategies vary widely for different types of firms and sectors depending on the "environmental sensitivity" of the firm or the sector (Malaman, 1996). Some types of firms are inherently more polluting than others because of the character of their production or product. Because of this, as well as regional instituttional differences and historical events such as environmental crisis in different technology areas, sectors, regions or for given firms firms have been subjected very unevenly to environmental policy making. However, the limited research into the industrial dynamics of the greening of industry means that possible patterns in the greening of industry have so far not been identified nor addressed by policy.

In viewing the firm not as polluter but as as (eco-innovator) opens up for a radical redefinition of the firms or sectors possible "environmental sensitivity" (Andersen, 2008). All firms and sectors play a role for eco-innovation though these process are currently ill understood. Hence the current still highly uneven greening of firms is an important driver but even more importantly a central barrier to eco-innovation.

The uneven greening of other parts of the innovation system as greening aspects co-evolve naturally also plays important roles. In wiring up the innovation system for eco-innovation a core focus is to address and rectify the "green mismatches" in between different segments of the innovation system .e.g. between different policy areas, research areas, financial institutes, technical standards ect.

Below the green learning curve is sought illustrated.

Figure 1. The Green learning curve



Source: Own source

The greening process is here focusing on the degree to which environmental issues are becoming integrated into the economic process and less so the heuristics). The figure illustrates the first reactive phase which has been dominated by demand and control enviromenta lregulation. This phase has prevailed for over 30-50 years and has cemented the environment as a burden to business. Phase two illustrates the formative phase with a beginning greening of markets. Phase three is the green market take off phase which now dominates the global economy though with considerable regional differences. Phase four is the consolidation phase and in phase five eco-innovation has become a market standard.

While we may perceive of this green learning curve as referring to the economy, it could also be interpreted at the organisational and individual level, i.e. the transition in environmental strategy (from reactive to proactive) and heuristics (from a wasteful to a resource efficient trajectory. Below table 1 seeks to illustrate the co-evolutionary processes of the greening of the innovation system.

Table 1. The green learning curve and the co-evolution of the innovation system

Phases Actors	**Reactive**	**Beginning green market**	**Take off**	**Consolidation**	**Market standard**
Firms	Uneven greening, obstructive and reactive strategies to regulation, environment a burden	Early movers environmental strategizing (risks and opportunities)	Environmental proactive strategies on the rise, Building up organisational structures and capabilities	Widespread proactive environmental strategies,	Routine environmental strategies, high environmental profile
Sectoral Innovation systems	Uneven greening depending on regulation	Uneven greening,	Development of sectoral strategies, Building up capabilities & institutions	Widespread proactive environmental strategies, Sector specific green knowledge base	All sectors high environmental profile, Well-functioning green markets
Knowledge institutions	Attention to environmental issues only in traditional environmental research areas	Attention to environmental issues only in traditional environmental research areas	Rising interest into environmental areas, building up green capability	Widespread green search	Routine green search
Consumers/ families	Reactive, No green capability	Few green lead users	Rising green consumerism & knowledge	Widespread green demand (and search)	Widespread/routine consideration of green demand (and search)
National/global Innovation system	Regulatory institutions, Government clean up role	High friction to early eco-innovation	Formation of institutions and green knowledge base	Institutions seeding eco-innovation, Strong green knowledge base	Eco-innovation the "easy innovation"

Source: Own source

The table focuses on evolution at the firm, sectoral, knowledge institution and consumers/families level as well as the overall national/global innovation system. As we move up the green learning curve none-green actors are winnowed out, new green entrepreneurs enter and green competitiveness becomes increasingly important and influences on the selection of suppliers and customers, learning partners, employees, financial institutes ect. None-green sectors may be threatened by competing greener technological trajectories. In the final phase, which makes up the vision of the eco-innovative innovation system, eco-innovation has become a market standard and eco-innovation has become the easy and natural innovation.

Due to the highly uneven greening process we need to consider the distribution of green strategies, capabilities and search rules in different parts of the innovation system at a given time. Particularly we need attention to the sectoral composition in this regard.

The long reactive phase 1 means that there is considerable lock-in into none-green practices and strategies in the innovation system. There is hence, generally high friction to –eco-innovation, though this seems to be changing considerably in the later years with the rising popularity and acceptance of the climate agenda. There seems to be new global expectation that the climate agenda is here to stay as a business case.

The uneven greening and the path dependencies have major implications for the efficient organisation of eco-innovative production and learning across actors in the innovation system. These factors have major policy implications, as we shall expand on below.

4. Policies for wiring up the national innovation system for eco-innovation

An innovation systems approach represent in many respects a potential new policy rational, first of all in viewing the economy as a long run process. Rather than pursuing immediate environmental goals the paper suggests *a long run policy for wiring up the innovation system for eco-innovation*. This policy aims to mould the market and create a selection environment that favours eco-innovation.

However, for such a policy approach to be efficient it is necessary to identify and address the distinct national eco-innovation patterns, i.e. how the green knowledge production is organised within different economic sectors as well as the wider knowledge system in the given national innovation system. And it is necessary to pay attention to the uneven distribution of green strategies, capabilities and search rules.

Overall, the innovation system concept is potentially helpful to the climate policy area in shedding light on the system dynamics and failures of specific national and sectoral innovation systems that need to be addressed to achieve a high eco-innovative capacity. This is especially important when considering globalisation aspects of climate policy and hence the need to discuss policies in very different specific (national or regional) contexts.

The innovation systems frame is important both in providing the analytical insights in eco-innovation dynamics and hence the possibility to address eco-innovation in specific time and place. And it is important in creating a positive vision; a vision of the eco-innovative society where innovation is moving in a green direction, rather than negative targets of current climate policies.

To wire up the the innovation system for eco-innovation thus entails two main overall goals:

1. to strengthen the innovative capacity of the national innovation system towards eco-innovation
2. to make eco-innovation the “easy innovation” in the economy

On the one hand, such a policy should seek to address the general friction to eco-innovation in the global innovation system. A five pillar strategy is suggested here:

1. Making well-functioning green markets:
2. Making proactive firms: specify: proactivity/organisational change
3. Making green green search rules and capabilities: technological and service inn: green search rules, green trajectory among not only companies but also knowledge institutions and among consumers
4. Making institutions in favour of eco-innovation
5. Making green consumption patterns

These policies are not going to be discussed in detail her. Only a few core essential points will be pointed to:

Ad.1 Making green well-functioning markets means improving the capacity of markets to communicate and handle environmental parameters. In a well-functioning green market environmental parameters are routinely used and understood in transactions. Environmental issues are credence characteristics that need standards to be verified. These standards are as yet not well-consolidated. But we need more than good market standards. We need more knowledge (green capabilities) among professional and private users to allow more green purchasing and organisational structures to handle green purchasing. ICT may have a considerable potential for improving the green market communication, a factor that needs to be pursued policy wise (see also Andersen, 2004a, 2004b) .

Ad.2 Making proactive firms. It is essential that the majority of firms and industrial sectors hold proactive environmental strategies or they function as bottle necks and inihibit eco-innovation strongly. It is therefoe important to identify the green laggards at the firm and sectoral level and try to mobilize them as eco-innovators. Given the current uneven greening, as referred to above, this is a major task.

Ad. 3. Making green search rules and capabilities. This pillar adreses the cognitive level and seeks to promote the formation of green knowledge base as well as widespread green search rules, both among firms and knowledge institutions (the innovation dynamo). It is important here to address the knowledge institutions and even knowledge areas, which currently show little attention to eco-innovation, such as e.g. nanotechnology (Andersen and Rasmussen, 2005).

Ad. 4. The institutional is multiple and many aspects could be pointed to. Here the idea is to focus more fundamentally on the the need to revisit current policy making towards intruding rewarding the proactive and eco-innovative as a core principle. It is necessary to reconsider climate polices as well as other policy areas many of which influence on eco-innovation, to consider how to develop dynamic policies that consistently and with increasing greening creates incentives for eco-innovative action and strategies, particularly for firms but also other actors in the innovation system.

Ad.5. Making green consumption patterns is not only a market problem but also depends on organisational structures embedded in every day life. We learn very much from the way we live and the things that surrounds us. Creating clever houses and cities which make it easy to be resource efficient and inform us on our consumption regularly may form a key step towards an overall greening of consumption patterns. Again ICT may play a key role here.

The first three pillars are within the traditional domain of innovation policy whereas the two latter are more horizontal, which makes them no less important but difficult to address politically.

On the other hand, the innovation system policy should seek to identify and address the specific national (and sectoral, technological) system failures to eco-innovation in the innovation system. Ideally such a policy should take into consideration how different actors are positioned on the green learning curve

National or regional policies should on the other hand also seek to identify the strengths and focus on creating a high eco-innovative capacity. But also seek to position the economy in the currently rapidly changing global division of eco-innovative production and learning. This includes developing green strength holds and lead markets.

6. Conclusions

This paper has sought to apply an evolutionary economic frame, the innovation systems frame, to inform climate policy. The innovation system concept is increasingly being used on environmental issues but also abused by not taking the core assumptions seriously. If properly used the system approach could present a framework for promoting climate policies targeted at the conditions of different innovation systems around the globe. It could in important ways inform us about the conditions for eco-innovative activities in different settings, insights which are currently strongly lacking as a basis for climate policies.

The innovation system approach may provide a frame for empirical analyses of the structure of and the specific organisation of green knowledge production within national innovation systems; this may bring important new insights into the dynamics and trends in the greening of innovation systems and the overall economy. Such analyses may facilitate more efficient learning and coordination on eco-innovation across the many actors in the innovation system.

The innovation system frame is also important in providing a positive vision of the eco-innovative society. The green learning curve presented illustrates the step towards this vision and highlights the uneven and cumulative nature of the greening process.

This paper has claimed that a innovation systems perspective represents a potential new evolutionary environmental policy rationale in fundamentally viewing the economy as a long run process subjected to path- and time dependencies. The new rational is particularly clear in two ways:
1) In treating the company as (eco-)innovator rather than as polluter
2) In adapting a strong knowledge approach

The innovation systems approach as here interpreted puts attention to the neglected cognitive aspects of the greening process. Taking on a long run perspective on the economic process attention is brought to how eco-innovative activities draw on and

contribute to a shared underlying green knowledge base and search rules (a resource efficient trajectory). This green knowledge base feeds into search practices and strategies and forms the basis for the development of greener technological trajectories and overall technological paradigm change. Fundamentally, thegreening process is a learning process and wiring up the innovation system for eco-innovation means first of all the building of strong green knowledge. Acknowledging the significance of this suggests a stronger knowledge based approach to environmental issues than generally practiced in climate policy and analysis. This is a necessary step in treating the firm as an eco-innovator rather than a polluter.

The innovation system policy approach strives to mould the innovation system so as to make it easy and attractive to engage in eco-innovation for firms as well as knowledge institutions (and to lesser degree consumers). The five pillar strategy suggested reduces the friction to eco-innovation. There is however, a need to identify, through innovation system empirical analysis, the specific charactheristic and innovation conditions as well as system failures to eco-innovation in the given innovation system.

Overall, we need to link up micro-oriented innovation policy aiming to seed the innovation process in a green direction to the macro-oriented climate policy. The innovation system approach may form an important contribution to facilitating this.

The assumptions on innovation and system dynamics developed within this framework could guide climate policy development in important ways, leading to a stronger knowledge based and market focused approach.

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