Systemic approaches to innovation and some lessons for Sustainable Consumption and Production (SCP)[1]

Fernando J. Diaz-Lopez[2]*, Arnold Tukker and Martin van de Lindt* – Netherlands Organisation for Applied Scientific Research TNO, Built Environment and Geosciences - Innovation and Environment, Delft, Netherlands

Oksana Mont – International Institute of Industrial Environmental Economics, Lund University, Lund, Sweden

Sylvia Lorek, Joachim Spangenberg, Stefan Giljum – Sustainable Europe Research Institute, Cologne/Vienna, Germany/Austria

Paper submitted to the Joint Actions on Climate Change conference, 8-10 June, Aalborg, Denmark.

1. Introduction

Sustainable consumption and production can be regarded as one of our current and largest societal challenges. However, the road towards a sustainable consumption and production system is a very complex one. The challenge of achieving sustainable consumption and production presents our society with the need for long-term, structural changes in consumption areas such as: mobility, agro-food, and energy use in and around housing. These tree areas are responsible for 70% of the life cycle environmental impacts of Western societies (EEA 2005; Tukker, Huppes et al. 2006).

Changes in consumption and production patterns are not caused by a single factor, but the result of different types of social-cultural, technical and economic developments (e.g. individualisation, growing incomes, globalisation of the economy, etc). Since multiple factors cause change, it is likely that simple policy approaches will not lead to more sustainable consumption and production patterns (Tukker 2008).A more systemic and holistic perspective seem to be necessary to analyse these persistent consumption and consumption problems, where new forms of complex and reflexive governance could possibly be best suited to solve these problems. A review of systemic and holistic theories that could contribute to SCP is hence desired (Tukker, Diaz Lopez et al. 2009).

A variety of theories takes a more overarching view on consumption and production. They look at *systems* of consumption and production, their institutional setting, and how government and other forms of governance can change this. In particular, we distinguish two main system-related concepts that could be useful for the SCP field: the *system innovation* approach (Rotmans, Kemp et al. 2000; Geels 2002; Loorbach 2007), and the *innovation systems* approach (e.g. Freeman 1987; Lundvall 1992; Nelson 1993; Breschi and Malerba 1997; Edquist 1997; Cooke 2001; Hekkert, Suurs et al. 2007).

This paper seeks to provide lessons from the aforementioned systemic approaches to innovation that could be useful for the SCP domain. In particular, this paper attempts to contribute to the SCP literature by exemplifying the added value of policy interventions done with a systemic mindset, the specific characteristics of systemic instruments, and general lessons and implications for SCP policies (derived from a number of exemplary cases).

---

[1] This paper is based on the results from the European project Sustainable Consumption Policies Effectiveness Evaluation (SCOPE[2]), in: Tukker, Diaz Lopez, et. al (2009). This project was conducted under the EU's 6th Framework Programme. It had the aim to contribute to a deeper understanding on how to promote SCP. The project included an inventory and analysis of the effectiveness of policy instruments, voluntary business initiatives for sustainable consumption and production and more systemic approaches to foster SCP. The current abstract is based on the latter aspects of SCOPE[2].

[2] Corresponding author's address: Netherlands Organisation for Applied Scientific Research TNO, Van Mourik Broekmanweg 6, P.O. Box 49, 2600 AA Delft, Netherlands; T +31 15 269 5465; F +31 15 262 43 41; E fernando.diazlopez@tno.nl

In order to do so, the next section (briefly) specifies the difficulty to realise SCP. Following, a section summarising the two systemic approaches to innovation is presented, including policy instruments. The next section discusses general features of these theories in the light of SCP. In particular, this section illustrates a number of cases where systemic theories were the basis for policy intervention (from the mobility, agro-food, and energy use in and around housing domains). The previous is in turn used to provide lessons to the SCP field (section 5). This section also includes two subsections describing the characteristic of systemic instrumens and a number of white spots and gaps identified for the SCP domain. Finally, some conclusions are presented.

2. Setting up the context

Sustainable consumption and production can be regarded as one of our current and largest societal challenges. However, the road towards a sustainable consumption and production system is a very complex one. This complexity arises from a number of factors. In the first place, sustainable consumption and production pre-supposes a clear balance between economic, environmental and social aspects. Secondly, no actor involved has the power to reach sustainable consumption and production by its own. Hence, it could only be fostered by cooperation actions and synergies between the various actors (i.e. designers, suppliers, producers, consumers, scientists, authorities etc). However these various agents or stakeholders have different goals, needs, perspectives, motives etc. Consequently, there no common sense of urgency and a shared vision on sustainable consumption and production, let alone the agreement on how to reach it. In the third place sustainable consumption and production addresses different scales in terms of time and place. What is sustainable 'here' does not necessarily have to be sustainable 'there'. Therefore, we have to take decisions 'now' that will have impact on 'later'.

The challenge of achieving sustainable consumption and production presents our society with the need for long-term, structural changes in consumption areas such as: mobility, agro-food, and energy use in and around housing. These tree areas are responsible for 70% of the life cycle environmental impacts of Western societies (EEA 2005; Tukker, Huppes et al. 2006). Some of their implications are described below:

1. Mobility has become an essential aspect of our society and quality of life; we travel more often and over longer distances. Growing energy consumption and higher emissions of greenhouse gases are the result of increasing personal travel by road and air, and are a major course of climate change. The expansion of infrastructure to support travel causes fragmentation of natural habitats and thus it affects biodiversity.
2. Sustainability in the food-agro area is related to several different fields from efficiency of the food production and consumption to health issues, from the local and seasonal food production to organic food, from the exhaustion of food sources such as fish population to energy consumption of different diets etc. Our eating and drinking habits lead to significant environmental pressures, often indirectly through agricultural production, processing and transportation of the food we consume. Direct negative environmental effects of food and drink consumption (i.e. travelling to the shops, storing, cooking and generating waste) are less in magnitude than the indirect effects but these are on the increase.
3. Buildings and homes are the main places for energy consumption; in their everyday operation as artificial environments for human life. Many houses and apartments now have multiple electronic appliances and are more luxurious. We build larger homes for fewer people and use more energy in our homes. We also buy increasing numbers of electronic goods such as: TVs, DVDs, and PCs, laptops, mobile phones, stereos and various kitchen appliances. We also replace these more frequently. As a result, even though the energy and resource-efficiency of each unit is improving, households continue

to contribute the same share of greenhouse gas emissions and generate increasing amounts of waste (EEA 2005).

Consumption patterns in Europe are completely different to those fifty years ago. Transport, communication, tourism and leisure have emerged as major components of household consumption. In the future, we can expect rapid consumption growth, especially in the new Member States and accession countries – since they gradually reach the consumption levels of the EU-15.

Changes in consumption and production patterns are not caused by a single factor, but the result of different types of social-cultural, technical and economic developments. Important changes in the factors that drive our consumption may include: individualisation, growing incomes, globalisation of the economy and the opening of markets, technological breakthroughs (e.g. internet and mobile phones), targeted marketing and advertisement, decreasing household sizes and an ageing population. Since multiple factors cause change, it is likely that simple policy approaches will not lead to more sustainable consumption and production patterns (Tukker 2008).

Consumers are often not as sovereign as they might think, since their behaviour is shaped by factors they cannot influence. The same applies for businesses: they are embedded in a system that rewards profit, sales of material goods, growth, using externalities, and so on. A more systemic and holistic perspective seem to be necessary to analyse these persistent consumption and consumption problems. In this way, new forms of complex and reflexive governance could possibly be best suited to solve these problems and be considered as the logical next phase in the evolution of policy making. This in order to understand how policy instruments can lead to greening of the markets and stimulate more sustainable consumption patterns by individuals and households. A review of systemic and holistic theories that could contribute to SCP is hence desired (Tukker, Diaz Lopez et al. 2009). Such a review is presented in the section below.

3. Review of systemic approaches to innovation

A variety of theories takes a more overarching view on consumption and production. They look at *systems* of consumption and production, their institutional setting, and how government and other forms of governance can change this. Carlsson, Jacobsson et al. (2002) cited several early examples of system approaches that included the works of input/output approach of Leontief (1941), the development blocs of Dahmen (1970), the national innovation system approach of Freeman (1987), Lundvall (1992) and Nelson (1993), the Porter's diamond (Porter 1990) and the technological systems of Carlsson & Jacobsson (1994).

In particular, we distinguish two main system-related concepts that could be useful for the SCP field: thee *system innovation* approach (SI), and the *innovation systems* approach. (IS) The empirical focus of the former approach is on 'system innovations'. It sees a partly locked-in, interdependent mainstream regime of technical artefacts, user practices, infrastructure, values; a niche level with novel practices, and a landscape that moulds the degrees of freedom of the regime. Regimes hence usually change in an incremental way. The system innovation approach has, since its origins, a sustainability driver. The empirical focus of the latter approach places knowledge, innovation, and (interactive) learning as core aspects within a well structured network of actors. It is interested in understanding development and diffusion of innovation. The innovation systems approach argues that the right mix of knowledge infrastructure, entrepreneurship, risk capital, launch markets etc. must be in place. In spite of not necessarily being focused on sustainability issues, a systemic and holistic use of the IS framework can give important contributions to the SCP agenda (Andersen 2008). The following two sub-sections present a review of the aforementioned theories.

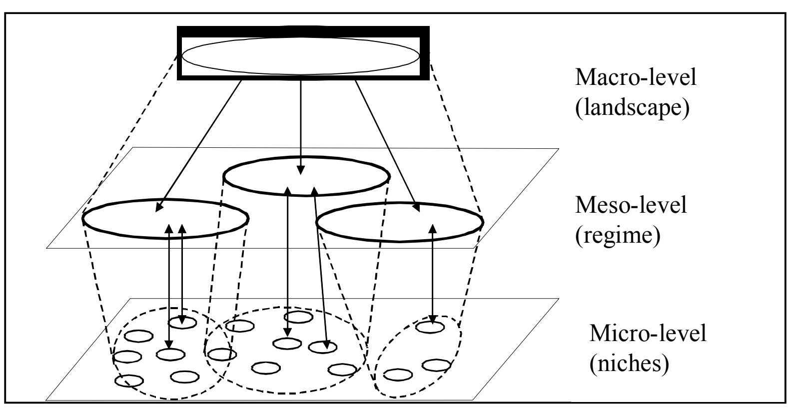
3.1 System Innovation (SI): general features and policy instruments

The notion of transitions has been introduced in a handful of prior innovation studies with various different meanings (e.g. Galli and Teubal 1997). However, the notion of transition we refer to is seen by Rotmans, Kemp et. al. (2000: 11) as*: "[...] a structural societal change that is the result of economic, cultural, technological, institutional as well as environmental developments, which both influence and strengthen each other".* This approach was initially developed for the energy, transport and water supply systems but also extended to other fields (such as healthcare and food production). What is notable about all of these systems is their fundamental importance to human existence: they are framework societal systems which give a far larger array of stakeholders an interest in the transition than usually associated with innovation projects.

Transition management has emerged as a framework fostering large-scale transitions and systemic changes. Following on from the Rotmans, Kemp et al.'s (2000) definition, a transition is a fundamental change in three related aspects of a system. The first is called 'culture' which refers mainly to dominant paradigms, worldviews etc. The second refers to the structure of the system. This is the way the system has organised itself in networks, legislation, governance, infrastructure, markets etc. The third element of change is the so-called 'practices', which is basically composed of our daily routines. The empirical focus of this approach is on 'system innovations', which are considered to be a set of innovations that develops and/or conforms a new system that performs the same function better (than the original) or in a novel way (Weterings, Kuijper et al. 1997). The transition management approach was initially developed for the energy, transport and water supply systems but also extended to other fields (i.e. health, food). This approach is seen as a possible frame to deal with the uncertainty and complexity demanded by the SCP agenda (see section 4)

A transition is a fundamental change in three related aspects of a system. The first is called 'culture' which refers mainly to dominant paradigms, worldviews etc. The second refers to the 'structure' of the system. This is the way the system has organised itself in networks, legislation, governance, infrastructure, markets etc. The third element of change is the so-called 'practices', which is basically composed of our daily routines. One of the main analytical tools of this approach is the so-called multi-level perspective (MLP). The MLP is characterised by the distinction of a number of levels, and we follow Rip & Kemp (1998) in distinguishing three distinct scales of activity within transitions (see Figure 1)

Figure 1 Multilevel perspective

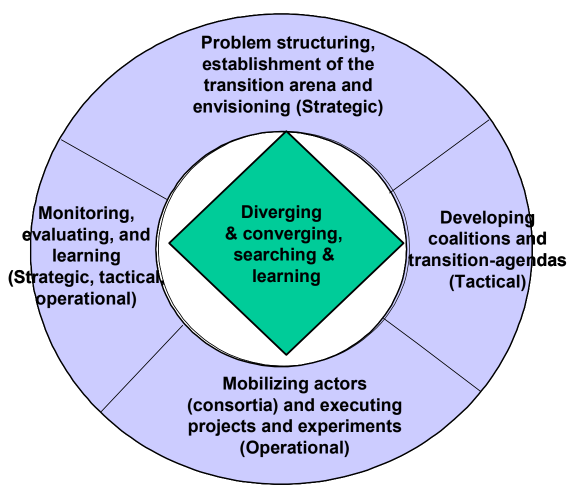


Source: Geels and Kemp (2000)

The first level is the landscape, in which processes of change occur. The landscape consists of the social values and norms, paradigms, economic development and trends at the macro level (i.e. internationalisation, the rise of ICT-technology, demographic developments etc). Although the landscape level develops autonomously, it influences the other two levels, and is also shaped by the aggregation of outcomes at the two subordinate levels. *Landscape* refers to overall societal situation. It reflects the values and orientation of the society, economic situation, population dynamics and demographic changes, political atmosphere and so on. The middle level is the meso-level (regime). On the one hand, the 'regime' level refers to the way the system has organised itself in a way that give societal systems stability. On the other hand the regime is rather rigid and reserved to fundamental changes. *Regime* consists of the predominant technology, norms, rules and practices. The third level is the micro-level (niches) and is where most of the innovations take place. These innovations are not only new technologies, but also new rules and legislation, new organisations or even new projects, concepts or ideas (Geels 2002; Loorbach 2007). The *niche* level expresses the local innovations and experiments. Policy drivers and technology trends reflect the societal atmosphere and can influence all levels. Summing up, the core idea of MLP model is that socio-technical changes – e.g. adaptation to climate change, disruptive change in consumption behaviour - happen in the interplay between different levels. Conflicts and pressures at the societal level - e.g. climate change - can open up possibilities to a large systemic transition. The system transition/adaptation is possible, if all levels support the transition, but in conflict situation local innovations and experiments can be established and foster the system transition.

Based on the above, transition management can be regarded as a process of opening up and closing down (Voß and Kemp 2006). Opening up refers to create space for new visions on the problem, new solutions and a new system. Closing down refers to reducing complexity and ambivalence in order to keep focus in action. Whereas Voß and Kemp consider this as a paradox, within transition management it has to be regarded as complementary and interrelated motions within the transition management process (Grin and Weterings 2005). In this diverging and converging process societal actors are searching together for and exploring possible ways to innovate the system towards a desired (sustainable) state by experimenting, learning and reflecting. This is 'operationalised' in the steering framework for transitions, the transition management cycle (Figure 2). This cycle consists of four activity clusters, which can be related to three different levels that continuously influence one another (Lindt and Loorbach 2005; Loorbach 2007).

Figure 2 Transition management cycle and activity clusters



Source: Lindt & Loorbach (2005) based on Loorbach (2002)

The different activity clusters of the transition management cycle can be described as follows: *Strategic level:* problem structuring and envisioning. This activity cluster starts with structuring the problem on the system level with a small group of frontrunners (start of the transition arena). This will lead to a shared picture of the system at hand and its problems. It will create a stronger sense of urgency to innovate the system. The problem structuring provides the basis for reframing the societal problem (challenge) and opens up the possibility for developing new visions (and solutions and strategies). These visions are no blueprints of the desired state of the system, but more beacons or frameworks for short-term actions. They are used for 'closing down' in the sense that they help to keep focus. *Tactical level:* building, developing coalitions and transition agendas. This activity cluster aims at developing the so-called 'transition agenda'. At this stage of the process, the process 'opens up' for more dialogue between all kinds of societal actors (NGOs, scientists, business, organisations etc) who have a stake in the new direction. They translate the broad vision into specific goals and actions. Furthermore they create their own networks and coalitions to influence the dominant regime to meet their own strategic goals and to (contribute to) the emerging of a new culture, structure and practices. *Operational level:* mobilising actors and implementing transition experiments. The objective of this activity cluster is to create space (niches for innovation) and to open up possibilities to set up a portfolio of experiments with all kinds of consortia. To keep focus, the experiments are derived from the various agendas developed at the tactical level. Simultaneously, these experiments provide new insights, knowledge etc for the strategic and tactical levels by connecting the experiments, learning and reflecting on them. *All levels*: Monitoring, evaluation and learning. The monitoring, evaluation and learning is an explicit part of the transition management. It is based on the notion of social learning and can be defined as a participatory process of describing, evaluating and reflecting on all ongoing activities in order to stimulate the steering of the system innovation by further refinement of and/or reorientation of the transition management activities at all levels.

The use of this transition management cycle in (policy) practice is rather complex. One reason for this is because content and process are intertwined. Another reason of complexity is the fact that for a the greater part of the people involved transition management and its underlying concepts are new and requires new ways of thinking and breaking through existing (policy) routines. A third reason for the complexity of the transition management process is that the activities in the four clusters and even the activity clusters themselves are in practice not ordered in the ideal way of the transition management cycle. Nonetheless, since the early 2000 transition management as a policy approach has been firmly embraced by the Dutch government. The UK government has also started to show a positive interest in this concept, especially for the topics of energy and transport. At the regional level, the region of Flanders in Belgium has also recently adopted the transition management approach for specific environmental problems (i.e. waste management) and housing. In addition to these, the concept of transition management is also getting more and more attention in other European countries such as Switzerland, Finland, Sweden, the UK and Germany. However, the interest in most of these countries has been mainly restricted to the scientific community. To date, some small-scale experiments have been set up following the concepts and elements of transition management (see Loorbach 2008 for a review of cases).

The Dutch transition management school distinguishes the use of regular policy instruments and transition instruments (Loorbach 2007). Under regular policy instruments we mainly see economic instruments, informative instruments, and regulation (legislation). For persistent problems such as the increasing unsustainable consumption patterns by individuals and households, regular policy instruments may not to be sufficient. This means that new (systemic) instruments may be needed to foster long-term changes to sustainability in systems of consumption. In this point is where transition instruments could be particularly useful. Kemp and Rotmans (2004) noted that instruments for transition management are endogenous to the process. Moreover, transition management does not call for the upheaval in policy instruments but suggests that different policy fields should be better coordinated (e.g. innovation, environmental, science and technology policies). Transition management implies focussing on continuously connecting various scale levels, policy domains, societal questions, contextual developments and all kind of stakeholders. Within this complex process the four clusters and the activities within them have to be seen as anchors for keeping the process on track (see Figure 2). The various tools used in this approach are summarised in the table below.[3]

Table 1 Policy instruments in Transition Management

Level	Goals	Transition Instruments
Strategic	Integration	Integrated systems analysis (ISA)
	Giving direction	Transition Arena, Transition visions
	Reframing	Transition Arena, Integrated systems analysis Transition vision
Tactical	Translating	Transition images, transition paths
	Agenda-building	Transition agenda transition coalitions
	Networking	Transition paths Innovation networks
Operational	Innovation	Transition experiments, testing grounds
	Development	Experiment portfolios
Monitoring / evaluation	Social learning	Transition monitoring
	Adaptation	Participatory evaluation

Source: Loorbach (2007)

An example of the implementation of transition management framework at the national level can be found in the 'BSIK' programme in the Netherlands.[4] This programme started in the year 2003 under the coordination of the Ministry of Economic Affairs. Its aim was to stimulate innovation and scientific research towards a high-quality knowledge economy. The BSIK-programme started with a budget of around 800 million euro for a period of five years. The thematic areas were: Information and communication technology; micro and nano-technology; breakthroughs in health, food, genomics and biotechnology; high-quality use of space; and, sustainable system innovation. There are various programmes and sub programmes within the five themes afore mentioned. In all of them, business, knowledge institutions, government, NGOs etc are participating and working together. The theme 'sustainable system innovation' is particularly important for the SCP agenda. It has a number of innovation programmes towards sustainable development in the fields of agriculture and mobility. Besides that, there is a sub programme called Knowledge Network of System Innovations (KSI). This latter programme aims to develop, disseminate and implement the knowledge on transitions and transition management towards a sustainable society.

3.2 Innovation Systems (IS): general features and policy instruments

According to Lundvall (1992: 2), an innovation system*: "[...] is constituted by elements and relationships which interact in the production, diffusion and use of new and economic useful knowledge."* Following on from the definition above, the innovation systems approach places knowledge, innovation, and (interactive) learning as core aspects within a well structured network of actors (Edquist 2005). In this approach, knowledge can take several forms and it is normally referred to processed information. Learning is a central aspect for the use of this useful knowledge, since it provides a deep understanding on the interaction between users and producers as part of the innovation process (e.g. Nonaka and Takeuchi 1995). The innovation systems approach also includes both firm dynamics and particular technology characteristics and adoption mechanisms (Hekkert, Suurs et al. 2007).

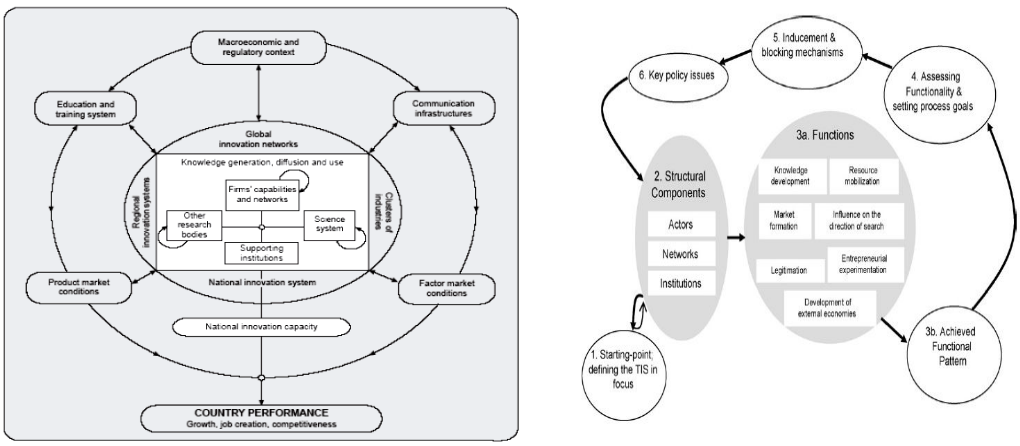
---

[3] For a full description, see Loorbach (2007) or annex 3 of the SCOPE[2] report in Tukker, Diaz Lopez, et al (2009)

[4] BSIK stands for 'Besluit Subsidies Investeringen Kennisinfrastructuur' or 'decisions on subsidies for investment in knowledge infrastructure'.

The interactions among institutions are the factors that determine the innovative performance of national firms (Lundvall 1992; Nelson 1993).[5]The reason for this is that the factors that according to innovation system theories determine economic capacity, are mainly locally or regionally oriented (i.e. learning, the relation with research and development, educational systems, etc). Summing up, the innovation system approach emphasises the role of markets, innovation at company level, the supply-demand interaction, and the institutional context where innovations are developed and transferred.

Figure 3 Examples of NIS and TIS



Source: OECD (1999) for NIS and Bergek, et. al. (2008) for TIS

Innovation systems can exist in several dimensions, namely technological (Carlsson, Jacobsson et al. 2002), regional (Braczyk, Cooke et al. 1998; Asheim and Gertler 2005), sectoral (Malerba 2002), and national (Lundvall 1992; Nelson 1993) (see Figure 3). In principle, a national innovation system may be seen as the aggregate of a set of technological, sectoral or regional systems (Carlsson, Jacobsson et al. 2002). The common underlying notion of all of these types of systems is that (organisational or technological) innovations are created at the individual and at the collective level within innovative firms.[6]

Where the NIS approach puts the institutions (and firms) as the central aspect of the innovation system, the functions that an innovation system can perform are seen as dominant factors in fostering innovation. This functional approach of IS is based on the contributions of 'technological systems' studies. It diminishes the complexity of the innovation system by reducing the number of actors, networks and institutions. The functional approach is more problem oriented, and aims to analyse and seek to promote innovation in specific sectors. It is commonly referred as to the 'technological innovation systems' (TIS) (e.g. Carlsson, Jacobsson et al. 2004; Jacobsson and Bergek 2004; Bergek, Jacobsson et al. 2008). Functions may include the provision of research and development, competence building, formation of new product markets, articulation of user needs, creating and changing organisations needed for the development of new fields of innovation, networking around knowledge, creating and

[5] The NIS approach uses the term 'institution' both in terms of normative structures (organisations) and things that pattern a behaviour (i.e norms, rules, laws). Unfortunately, the indistinct use of these terms can lead to a constant confusion. This topic is subject of an ongoing debate, but our review does not intent to contribute to it. See for example the clarifications on this topic provided by Edquist and Johnson (1997)

[6] The technological innovation system is used to describe the cases in table 3 (section 4). This approach is focused on generic technologies that could have many general applications in different industries, irrespectively of being developed or not within the firm. For reasons of space, we cannot provide a full description of each approach to innovation systems. See the Annex 3 of the Scope2 report for a full review of these approaches (Tukker, Diaz Lopez et al, 2009). Alternatively, see Coenen and Diaz Lopez (2008) for a review of technological & sectoral innovation systems and socio-technical systems.

changing institutions, incubating activities, financing of innovation processes and other activities, provision of consultancy services, etc (Edquist 2005).

In the context of the enlarged attention for fostering innovation and competitiveness (i.e. via the Lisbon Agenda and the new knowledge-based economy), the concept of innovation systems has been explored and firmly embraced by the OECD (1997; 1999; 2002; 2005) and the European Commission (EC 2003; 2004; 2004; 2006). It is well known that the innovation systems approach have greatly influenced innovation policy making in the last decade. Examples of the implementation of this approach can be found at the national level, e.g. in Finland (STPCF 2003; STPCF 2006), Sweden (Sandström, Backlund et al. 2004; VINNOVA 2006; 2007), the UK (DTI 2003; DfT 2007), etc. Hitherto, the IS approach has extensively promoted the use of specific (innovation) instruments to promote (technological) innovation and to provide aid in correcting system failures. Among such instruments we account: fiscal support for technology development and R&D (subsidies), the promotion of university-industry linkages, networks building/ support, intellectual property rights, standards setting, tools for strengthening human resources for science and technology (highly skilled labour supply and mobility), direct provision of scientific infrastructure in research and education, etc (Jaumotte and Pain 2005; Georghiou 2006).

The IS approach accepts policy intervention when a system failure has to be amended. In this regard, Edquist and Chaminade (2006) suggested that two conditions must be fulfilled for justifying public intervention. Firstly, a problem must exist from the inability of firms and the market mechanism to achieve the objectives formulated (systemic problem). Secondly, the government must also have the *ability* to solve or mitigate the problem. This can be called policy competences. Such problems can be identified by SI analyses. Hitherto, we could infer that sustainability and the SCP agenda poses this sort of systemic failures. Therefore, public intervention would be justified – especially by means of public procurement and systemic instruments.[7]

At the European level, the EC communication on 'Innovation Policy' of 2003 clearly adopted an 'innovation system' approach (EC 2003). It listed seven groups of innovation policy activities used to promote innovation (under the 6th framework programme). This list included: the trend chart on European innovation (good practice dissemination and analysis of information on innovation policies), the European scoreboard (quantitative data on framework conditions and innovation behaviour), the Community Innovation Survey (quantitative data on innovation dynamics), specific studies and projects on innovation dynamics and framework conditions (i.e. Innobarometer, and framework programme funded-projects), mechanisms to support the start-up of innovative firms and entrepreneurship (via the support of networks, such as the 'Gate2Growth' initiative), knowledge diffusion and transfer via networking (with the 'innovating regions in Europe', 'Europe INNOVA' and the 'innovation relay' networks as examples), and information services (e.g. the CORDIS website on R&D and innovation information and the European SME portal) (EC 2006). However, two major problems seem to exist when using 'traditional' innovation policy instruments for the SCPagenda: first, innovation policy instruments do not necessarily make use of environmental and social variables for assessing innovation dynamics (i.e. for measuring innovation performance); second, there is an uneven balance on the supply side of innovation policy instruments – where the role of consumers/end users has been rather marginal.

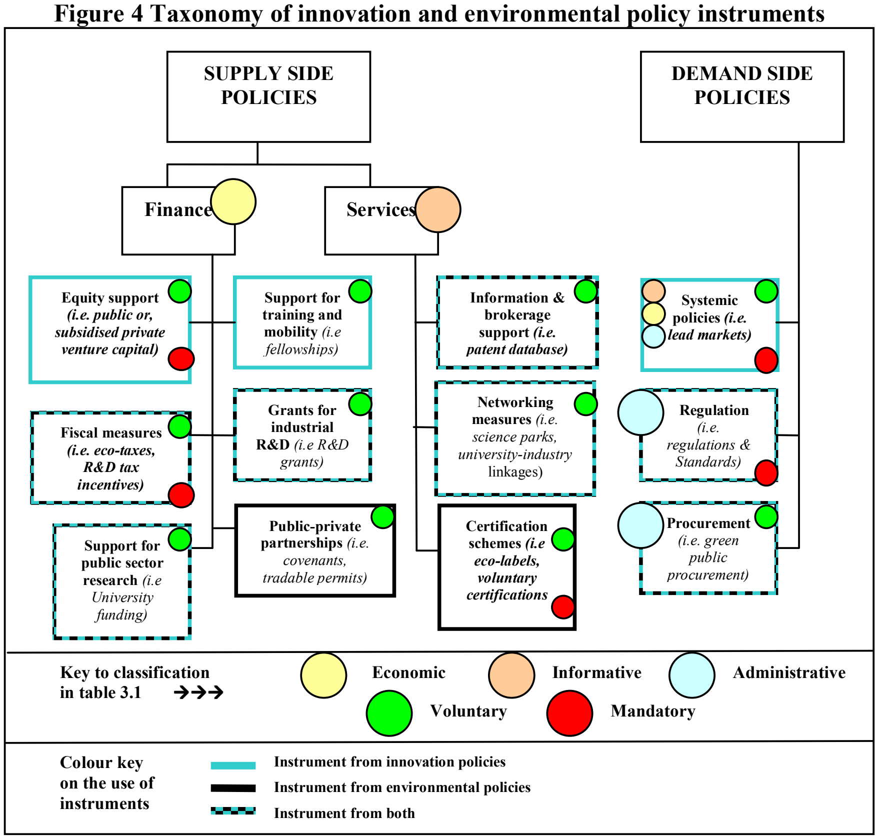
As noticeable from the figure below, the innovation systems approach has tended to favour the 'supply' side of innovation. Edler and Georghiou (2007: 952) sustained that the lack of orientation of European innovation policies towards the demand-side is evident. These

---

[7] See Edler, J. and L. Georghiou (2007) for a review on the rationale of public intervention in regards to public procurement and the demand side of innovation.

authors provided evidence from two innovation policy databases compiled under the sponsorship of the EC which supports such asseveration. According to these authors, the EC's trend chart on European innovation provides data on seventeen different innovation policy measures. This instrument provides zero measures explicitly oriented towards demand and gives little participation to the final user. Edler and Georghiou also found that a second database of business support measures also shows little support for technology diffusion. Why is this aspect so important? The demand side of innovation can be seen as related to consumption. Therefore, there would be a big risk that social demands would be ignored if consumers/final users would not be acknowledged. The latter is evident in below, where less than a handful of innovation and/or environmental policy instruments can be regarded as part of the demand side of innovation.

Figure 4 Taxonomy of innovation and environmental policy instruments



Source: modified from Georghiou (2006), p 23

Figure 4 also highlights the (European) need for coordination of innovation and environmental policies. Here, the main goal has been oriented to the 'greening' of the markets and the innovation system. However, the policy response for the greening of the innovation systems has been often referred as to the development of the right "policy mixes" or the best combination of single instruments contained in a "policy toolbox" (e.g. regulation and standards, fiscal measures and self-regulation, etc). In spite of this (still) linear view of innovation, positive messages arise: it is clear from recent EC communications on competitiveness, growth, research and innovation that the recognition of a new policy rationale for eco-innovation has been acknowledged (e.g. EC 2005; 2006). Under this context, there was also an urgent sense for the coordination and interaction of innovation policies with other related areas (i.e. competition, labour, environmental policies, etc) (e.g. EC 2006). From these, the contribution of on the technology and innovation impacts of environmental policy instruments has been widely studied in the literature (e.g. Kemp 1997; 2000; Foxon and

Kemp 2007).[8] The results of such analysis have tended to point out that the contribution of such instruments to higher innovative capacity is rather limited. In this sense, a long period of command and control policy making lead to a reactive pattern of actor behaviour in the innovation system (e.g. firms, consumers, stockholders).

Undoubtedly, enhancing innovation as a corner stone of the European Council strategy adopted in Lisbon in the year 2000 has favoured the introduction of a notion of 'long term', 'coordinated' and (to a certain extent) a 'systemic' vision of innovation policies. Clearly, a well functioning of the innovation system was needed and promoted as a first step (i.e. entrepreneurship, market conditions, framework conditions, interactions between the different actors, creation of a knowledge base, etc). In the context of the EU Environmental Technologies Action Plan –ETAP (EC 2004) and the preparation of action plans on SCP and sustainable industrial policy (EC 2008), some positive messages on the use of instruments and tools for SCP from a innovation systems approach can be regarded. Recent studies such as POPA DACT (Montalvo, P. ten Brink et al. 2007), the 'STRATA' project (Rennings, Kemp et al. 2003), the report 'Strategies for eco-efficiency innovation' presented during the Dutch EU presidency in 2004 (Kemp, Andersen et al. 2004) and the recent EC document on Sustainable Consumption and Production(EC 2008) all give suggestions how the approach can be used to 'green' the innovation systems. The relevance of these studies/ communications lies in the issue that they have contributed to place eco-innovation in a broader societal perspective. One of the most promising examples of the use of innovation systems approach for policy making can be seen in the initiative of lead markets (EC 2007) (briefly discussed in this paper), where the SCP domain could have the most promising options. Andersen (2008: 325) noted that eco-innovation policies could serve as a model and provide synergies for SCP polices. Therefore, is in the context of the promotion of eco-innovations and the integration of innovation and environmental policies is where the best chances to promote SCP can be regarded.

4. Systemic approaches to Innovation and SCP

4.1 System Innovation (SI) and SCP

By definition, transition management presupposes an aggregate change in institutions, infrastructure and technology. Loorbach (2008) noted that a key aspect in the transition management cycle is the inclusion of relevant societal actors. Actors develop a systemic understanding of a complex problem, which in turn enables them to reflect upon sustainability challenges in terms of transitions (transition arenas and agendas). Transition management is also concerned with 'creating space' for frontrunners (niche and regime players), so new coalitions are created and the desired goal is better targeted. Content (system analysis, envisioning, arenas and agendas) is tightly related to processes of change (network building, experiments, monitoring). Its analysis creates possibilities for fostering and managing change to a certain direction.

As noted by Andersen (2008) the central policy suggestion of transition management is to identify and develop "transition experiments", via the establishment of confined technological niches that may allow an open process for new technologies. The transition management model and the multi-level perspective represent an operational way to capture evolutionary transition processes and a feasible way to attract policy attention to radical eco-innovation. The strength of the multi-level framework is that innovation and transition processes can be

[8] We do not provide a review on this topic, albeit such studies were acknowledged for the elaboration of the background and rationale of this paper. Please note that our work is focused on innovation theories and policy instruments, so that we do not focus on environmental policy. Traditional environmental policy instruments may account: R&D subsidies, standards, innovation wavers, taxes and tradable permits, covenants (voluntary agreements), standards, innovation waivers, communication and information instruments (i.e. eco-labelling) and network promotion. In addition to the instruments previously listed, other public policies areas may have some effect on innovation. Among these additional policy areas we acknowledge: competition policy, regulation (i.e. health, environment), public procurement, education, and macro-economic policies (Georghiou, 2006).

explained by the interplay of stabilising mechanisms at the regime level and (regime-) destabilising landscape pressures combined with the emergence of radical innovations at the niche level. The potential contribution to the SCP agenda is therefore remarkable – as long as we are aware of its limitations.

Transition management has shortcomings since it is macro-oriented –it does not necessarily looks at the micro-dynamics of innovation (Coenen and Diaz Lopez 2008). According to Markard and Truffer (2008) the most significant limitation of the multilevel perspective is that it is largely confined to the niche level it the analysis of emerging novelties (Markard and Truffer 2008). Another limitation is the somehow absolute view of the notion of 'system innovation' and its relation to its eco-efficiency level, e.g. system innovations are good per se but do not mention to what extent. To say, system innovations might be the solution for certain problems in certain domains, but the interdependencies of incremental, radical, generic and stand-alone innovations along the innovation cycle are not always acknowledged. Certain eco-innovations are systemic to some extent, but still need the complementarities of the other types of innovation for certain problems (or within specific domains). Finally, this approach also presupposes the mobilisation of a number of (internal and external) key actors towards common agreements – which is not entirely clear how this would happen at the global level. Historical, cultural and political differences in different countries/ regions may become a burden to transition management policy implementation (Andersen 2008).

The system innovation approach overall has a strong policy focus, seeking how to facilitate gradual and non-disruptive regime shifts and major system innovations towards sustainability (Kemp and Rotmans 2004). There are significant differences between regular policy and system innovation (or transition) policy. Albeit transition management cannot work without the former: system innovation policy without the legitimacy from prevailing policy does not stand a chance. Moreover, the prevailing policy on its own is probable not capable to realise long-term changes to sustainability in systems of consumption and production.

Following on from the above, transition management does not intend to substitute effective environmental policies, such as taxes and pricing. Transition management recognises the value of such instruments since they are necessary to establish framework conditions for process and system change. Conversely, transition management seeks for complementarities with existing policy and does constitute an important addition to them. This novel approach has the potential to improve the coordination of different policies in different domains, creating room for systemic changes in an adaptive, reflexive, participative, consensual, and anticipatory mode (Kemp and Rotmans 2004). Some successful examples are provided in the table below.

Table 2 Exemplary system innovation cases

Case	Actors	Lessons Learned
The **Dutch energy transition** started in 2001 when the Ministry of Economic Affairs (EZ) adopted the early transition management principles (Rotmans, Kemp et al. 2000). It aimed at accelerating and directing a transition of the Dutch energy supply system. At the present time, it would be premature to establish a conclusion that a transition of the Dutch energy supply is successfully established. In spite of being far from being concluded, one might suggest that there is already a significant impact on the Dutch energy policy system. The Dutch energy transition is one of the core programmes in the Netherlands for competitiveness and innovation. Among transition management scholars, the Dutch transition energy is considered as one of the earliest and probably one of the most exemplary cases. It also represents a case vastly documented, which examples have been used to analyse and illustrate specific aspects of the overall transition management framework (see Figure 2 Transition management cycle and activity clusters). One point must be kept in mind while analysing these cases: the Dutch energy transition represents a policy process far from being finalised as it is a long-term ongoing process of system change. Therefore, its trajectory is full of experimentation and learning by doing experiences; constant feedback loops and monitoring of progress.	KETI (knowledge and technological innovation) task-group, Ministry of Economic Affairs (EZ), the Taskforce for the energy transition (formed by: the Ministry of Economic Affairs, the Ministry of Housing, Spatial Planning and the Environment, the Ministry of Agriculture, Nature Management and Food Quality, the Ministry of Finance, the Ministry of Foreign Affairs, the Ministry of Transport, Public Works and Water Management), Universities, research centres and R&D centres (e.g. MERIT, ICIS, Erasmus University), NGOs (e.g. Klimaatbureau), industry associations (e.g. VNP – the Dutch Paper and Carton Manufacturers Association), businesses (e.g. Shell, Rabobank, Essent, Gasunie, etc); the Interdepartmental Project Directorate for the Energy Transition (IPE); and end-consumers.	This case exemplifies the use of the transition management framework in policy practice. As noted in section 2, the transition management cycle (Figure 2) is an interesting analytical tool for structuring the content and process of system innovation. It is clear with the example provided above that the Energy transition has been a bottom-up process full of experiments, trial and error efforts and feedback loops. Since the early stage of development, many relevant actors were included in a transition arena for the conformation of the transition for a sustainable energy. Ultimately the Dutch characteristic of being a country of 'agreements and cooperation' helped for the successful development of this initiative. As a result of a consensual approach to policy making, the different societal actors defined a vision of the 'main routes' to be followed in the short, mid and long run. Inherently, the credibility of the Dutch government and government officers also played a strategic role. In the overall, the use of visions, coalitions and creation of niche markets could be some of the most important contributions to policy instruments for SCP. The document "More with Energy: opportunities for the Netherlands" (EZ and ETTF 2006) clearly defined the path for the transition to a sustainable energy in the Netherlands. With the release of this strategic document, a national transition plan was created. The message from the Dutch 'Transition Action Plan' was clear in the sense that it provides the strategy to achieve the Energy transition, and the individual actions and technology areas to be promoted. In addition to the technological component, the social component was required as a pre-requisite for its inclusion within a transition platform. This plan demands changes in the way society faces the energy production and use in order to foster new and more sustainable relationships. Transition policy does not only focus on technology development, but in the process that lead to a desired goal and the removal of obstacles to a particular desired transition. In this context, policy renewal is a strategic aspect of the 'transition action plan'. This plan is adapted every year so new and novel insights and relevant feedback can be inputted (EZ and ETTF 2006). This document contains all the specific needs, goals and tasks that will support the 'operalisation' of the Dutch transition in different topics. Clearly, an example of action plans for a long-term and systemic use of policy instruments.
The **switch to organic food in Switzerland** represents a transition case of the shift from industrialised agriculture to precision (or integrated) farming and ecological agriculture (especially for organic food) in Switzerland, in the period between 1970 to 2000 as described by Belz (2004). Formally, this case did not follow the (ideal) transition management framework described in Figure 2. Alternatively, Belz focused on the multi-level perspective analysis of the transition approach, and transition management concepts and instruments can be easily identified. More importantly, this case suggests that the use of regular policy instruments with transition concepts could lead to interesting positive results. Switzerland is by far, one of the most advanced in terms of agricultural methods that include a balance between the dimensions of sustainability. However, the market penetration of organic farming has been (and still is) relatively low, when	Farmers' cooperatives, large-scale food retailers (e.g. Migros, Coop, Spar), independent or specialised food retailers, organic farming associations (e.g. Bio-Suisse), consumer groups (e.g. Konsumentinnen-Forum), environmental groups, international institutions (e.g. GATT), the Swiss government, and international organisations (e.g. WTO).	It is evident that transitions involve long-term transformations. A combination of factors can lead to instability in the current landscape and regime, where opportunity windows arise for new and emergent niches. Multi-level analyses (Geels 2005) are useful multidisciplinary tools for the understanding of long-term complex real life phenomena. As exemplified by Belz (2004: 109), the multi level perspective helps the identification of complex factors of real life events that would not be easily identified otherwise. Innovations are not triggered by a single factor or event, but a combination of them. Transitions are the result of the combination of linkages between the different levels. This case represents the combination of bottom-up and top-down nature of the transition management process. The first was represented by the organic farming, whereas the latter by precision farming. It followed a consensus, negotiation, learning by doing-based approach. External events conditioned the existence of a given socio-technical regime. Moreover, it favoured changes in social values that lead to the creation of favourable conditions for the introduction of a new regime –more according to those new values, demands and user preferences. Here, this case also exemplifies that no single actor or social groups can foster major system changes. Again, the combination and interplay between them is a major condition for transitions. It is also important to note the role that laws had in the conformation of a new regime. The organic law determined that organic production would receive more subventions than integrated production. This event

compared to food products from precision farming (Belz 2004). In general, this case required public intervention, entrepreneurship, sustainable visions and changes in user practices, guiding principles, and strong social networks for production, distribution, sales and use of the final products.		clearly supported the development of the former, and will have effects in the future growth of the regime. An interesting question arises on the limitations of current laws that support organic production, since they are mainly referred to budgetary compensations. Compared to the overall Swiss food production, organic farming still represents a reduced-scale and some questions remain unsolved. Interestingly, a major shift in the agriculture regime was promoted by business strategies that lead to the introduction in the market of organic dairy products. Government support also contributed to this aim. However, recent studies such as the EIPRO (Tukker, Huppes et al. 2006) have posited that dairy products head the list of the two groups of products with the largest environmental impacts of private consumption. In particular, milk, cheese and butter (organic or not) do have potential contribution to global warming (of around 4%). More attention will be need to paid to social demands, business strategies and government legislations that take into account the environmental impacts of food products, organic or not.
The **Dutch** energy transition does not only include the creation of a sustainable-supply energy system. It has also defined six topics that can contribute to the achievement of the transition goals –**sustainable mobility** included. The Ministry of Economic Affairs has clearly posited that the portfolio of transition paths has been created following three main criteria: reduction of CO_2 emissions, feasibility and opportunity of Dutch businesses. Ultimately, a coherent and flexible combination of measures is expected to the achievement of sustainable energy housekeeping. From the whole range of instruments, possible the use of transition paths, transition experiments, financial measures, regulatory changes and policy renewal are the most relevant. One important characteristic of these measures is clear: they have managed to gain the prospective support of at least three or four Dutch cabinet periods by a long term government policy. To date, a number of transition experiments related to sustainable mobility are being developed. This list includes the following transition paths: intelligent transport systems, multi-modal transport, hybridisation, bio-fuels, driving on H_2, etc. In this sense, the energy transition and the transport transition are interconnected. The content of the case study was taken from Kemp and Rotmans (2004) and official documents from the Dutch government (EZ and ETTF 2006). It is important to note that contrary to the experience of the energy transition sustainable mobility in the Netherlands is less advanced (or at least, not as well documented by the academic community as the energy transition).	Ministry of traffic and transport, Ministry of Economic Affairs (EZ), car user association (ANWB), car dealers and garages associations (RAI and BOVAC), traffic safety organisation (3VO), freight transport companies (KNV), Dutch International Distribution Council for motorised transport, the national railways company (NS), public transport companies, Universities and R&D centres, environmental groups (e.g. Friends of Earth), and transport users (pedestrians, cyclist, motorists).	At the general level, the policy practice of the energy transition and the sustainable mobility case provides important lessons in terms of systemic policy. It has been developed as a bottom-up initiative full of experiments, trial and error efforts and feedback loops that jointly help to provide empirical evidence on how system innovations are developed. The transition management approach in practice aims to use systemic instruments along the different stages of the innovation cycle, albeit results are still to come. It has a very strong focus in the technology side, which is balanced by attending social needs and including social actors. It is clearly a policy approach designed to tackle sustainability challenges. For the policy practice, critical aspects for success are summarised in the following points: collective responsibility and fulfilment of individual roles, long term vision, instruments and means, transition path as a centre of analysis and instruments and means focusing on it, continuous monitoring towards a desired future (EZ and ETTF 2006). It is important to note that the studied case highlight the need for new structures, proper framework conditions (called additional measures in the official documents), albeit it also makes a comprehensive use of existing instruments. As a result, existing systems can co-exist and new ones can be promoted. One of the main contributions from the sustainable mobility case is the use of transition experiments. An important answer to what to be experimented is found in the literature of strategic niche management (Kemp and Rotmans 2004). There is a vast collection on empirical work on strategic niche management experiments for sustainable transport (Hoogma, Kemp et al. 2002), albeit not as an overall case for sustainable transports at the policy level. This empirical work has suggested that strategic niche management is an interesting policy tool that can contribute to successful niche creation for new technological options since the early stages of development and diffusion. In this sense, strategic niche management experiments, pilot and demonstration projects are a good source of inspiration for transition experiments. Ultimately, this approach provides understanding of the management of the process of niche creation. The latter is a very important element for the enablement of conditions and alternatives for regime shifts at the meso and macro levels, central aspect of the transition management perspective –as exemplified by multi-level analyses.

Source: elaborated from Tukker, Diaz Lopez, et al (2009)

From the content in Table 2, some remarks on the contributions of transition management to the SCP agenda could be summarised as follows:

- Transition management is used in various processes with an impact on innovation, energy, and environmental policy on the national level.
- The various trajectories show that there is a wide range in ways to implement the concept of transition management. The multi-level perspective is a substantial element for the understanding of changes in the system.
- In general the influence of bottom-up initiatives is quite substantial. The transition management frame approach and tools functions as a framework for connecting this initiatives and playing a role in developing a more overall vision and paths. This is a promising conclusion regarding the initiatives in business and society in general.
- The transition management approach can help to set up and give direction to an innovation system, aiming at a sustainable system as a whole.

Some questions remain open, since possibly the emergent area of sustainable socio-technical transitions, as noted by Smith, Stirling et al (2005), could provide a theoretical link between transitions management and innovation systems theory. This is an interesting area that could be explored into more detail and further work should address it. If this option would be refuted, new connective frameworks that truly asses the SCP agenda should be developed.

4.2 Innovation Systems (IS) and SCP

As noted in section 3, the contributions of the innovation systems literature have gained a high momentum at the European policy level (and especially at the heart of the OECD countries). The IS approach represents a powerful analytical framework to understand the dynamics of general (technological and organisational) innovations. IS analyses are often regular and have comparative and benchmarking aims on specific innovation patterns, structural features and its development and performance. The concept of innovation systems (both in its organisational as functional form) has been mainly used to analyse the difference in structure of the innovation system in different countries, and to identify factors that block innovations in specific systems so framework conditions can be enhanced.

For instance, with IS analyses one could see that in a specific (national, sectoral, regional or technological) innovation systems there may be a lack of venture capital, insufficient innovation support, insufficient knowledge transfer at the supply side or insufficient demand-supply interaction, etc. Government action could then be used to correct system failures, to direct policy efforts, to remove such blockages, and to help the innovation process flowing again. Inherently, such understanding of the micro-level of the innovation process is a very useful input for the SCP agenda. As noted by Andersen (2004: 3): *"[...] the NIS perspective is especially important for identifying and breaking the non-green production and consumption practices locked-in to almost all parts of the innovation system"*.

Andersen (2008) noted that the innovation system approach was not explicitly designed towards achieving the sustainability principles or was closely aligned to the SCP domain. The IS concept is mainly used to benchmark performance of innovation systems rather than how they form and transform. Such dynamics are seen as an unplanned path dependent process of co-evolution of science, technology, organisations (firms) and institutions. In this sense, Andersen posited, the focus of this approach deviates from the coordinated system transitions that are of interest for SCP. System transitions are seen as part of business/innovation cycles and are commonly known as "techno-economic paradigm change" (Dosi and Orsenigo 1988; Freeman and Perez 1988).[9] Only in the last decade studies based on innovation systems

[9] The concept of *technological paradigm* is particularly important in the innovation systems literature since it is considered as the core issue of any technological development. Evolutionary economics literature describes this concept as a pattern for the solution of selected techno-economical problems based on scientific principles, tasks, material technology and the basic artefacts

approach have been applied to environmental aspects of innovation, namely eco-innovations (e.g. Rennings 2000; Montalvo 2002; Kemp, Andersen et al. 2004; Weber and Hemmelskamp 2005; Foxon and Kemp 2007; Diaz Lopez 2008).

Another recurrent critic to the NIS approach is often related to its static nature. In spite of its emphasis on firm's supply-demand interactions at different sectoral/ national dimensions, traditional innovation system studies seem to have been more aligned to the 'production' side of SCP rather than to the 'consumption' side. According to Edquist (1997, further developed in Edquist and Hommen, 1999) innovation systems literature has unevenly recognised the role of the demand side of innovation (which might be in turn related to consumption). In spite of its importance, Edquist adds, the traditional view of innovation systems studies has had a linear view of innovation policy instruments (i.e. R&D subsidies). However, a more balanced emphasis of supply-demand is needed so that system failures could be better addressed. This situation seems to be changing, especially with the launching of the lead markets initiative and the introduction of the notion of public procurement in the 'mixes' of innovation policies (Georghiou 2006).

Andersen (2008) suggested that, possibly, the sectoral (and technological) versions of the IS approach are more useful for the SCP domain. This author has posited that the TIS approach of sectoral innovation systems seems to be more relevant for the SCP as it is more problem-oriented approach.[10] Andersen suggested that this theoretical approach clearly aims at identifying key factors to be influenced by policy (i.e. guidance of the search), albeit it is still an approach focused on micro-dynamics of innovation. Andersen (2008: 322) did the following proposals to enrich innovation systems with a sustainability component: to develop well-functioning markets for green products, via green public procurement, lead market initiatives, fiscal incentives to promote green products; to promote organisational change (e.g. proactive environmental strategies in companies and financial institutes) and showing the benefits of eco-innovations; to facilitate green knowledge production and learning across various actors in national and sectoral innovation systems; and to promote green entrepreneurship. The aim of these recommendations is to ensure that eco-innovations are more likely to break through than 'dirty' innovations, that environmental issues could become a source of competitive advantage, to foster a shift in policy attention towards currently SCP practices, to 'green' the innovation components of the SI approach, and to promote the use of systemic policies.

Related to the above, Andersen (2008) concluded that in order to achieve breakthroughs of domain-specific systemic eco-innovations, extraordinary systemic policy efforts in line with the transition research thinking are needed. The sectoral and technology specific innovation system approaches could be used, since they favour the establishment of a 'right policy mix' between soft, regulatory and fiscal policy measures that may allow new eco-innovations to go through both the formative and consolidation stage. For the latter, supporting of lead markets, spin-offs and strategic niches would be desirable. As posited by Andersen (2008: 322) *"the assumptions on innovation and system dynamics developed within this framework could guide policy development for SCP in important ways, leading to a stronger knowledge based and market focused approach"*.

Some successful examples are provided in the table below.

---

to be developed and improved (Dosi and Orsenigo 1988:16; Freeman and Perez 1988:47)..The *technological trajectory* is defined by the paradigm, or *techno-economic paradigm*. The latter was chosen by Freeman and Perez (1988: 47) because all changes needed for technological change go beyond technological issues. It includes economic variables, such as costs and conditions for production and distribution.

[10] See Coenen and Diaz Lopez (2008) for a review of the TIS approach in the light of sustainability and innovation.

Table 3 Exemplary innovation system cases

Case	Actors	Lessons Learned
Energy use in the Nordic building sector. Buildings account for the largest share of the total EU final energy consumption (around 40%) (EC 2007: 6). In the last five decades, the building sector has been acknowledged for its increased energy performance. However, such a performance has been attributed to gains in purchased electricity rather than to improvements in the energy efficiency of buildings. There have been many successful energy-efficiency demonstration projects with a high level of government support. However, the adoption rate of energy efficiency innovative solutions is rather low. Context specific features of the sector condition the innovation and eco-innovation features of this industry. Energy-efficient innovations have been driven by a combination of regulatory pressures and business strategies (Emtairah, Tojo et al. 2008). However, there seems to be system failures in the sector that are likely to be amended with policy intervention using initiatives such as the EC's 'lead markets'. This case study is divided in two parts: the first part is a description of the Nordic case for efficient energy use in housing, with special emphasis on an innovation systems analysis (Emtairah, Tojo et al. 2008). The second part will draw on the recently developed lead market for 'sustainable buildings', where different policy instruments would be used in a coordinated and strategic fashion. Finally, we will provide: a discussion of the lessons learned from both parts, and some implications for the successful use of systemic policy instruments.	The European Commission, national governments, building developers (financial resources), project contractors (which may be part of the former), building materials suppliers (few actors with high market share, sometimes owned by the building developers/ contractors), building service installation firms (highly varied amount of subcontractors mainly for heating, ventilation, water supply and drainage), renovation and home repairs firms, construction unions, individual engineers and designers, universities and R&D centres (weak linkages).	The Nordic case of efficient energy use in housing case reported by Emtairah, Tojo et al. (2008) used the national and sectoral innovation systems approaches, in particular Edquist (1997) and Malerba (2002; 2004). It also used a reference case of the (functionalist) IS approach in the energy sector (Jacobsson and Bergek 2004). Emtairah, Tojo et al.'s (2008) analysis departs from the notion that existing polices have had very moderate effect on innovation, typically resulting on incremental innovations in existing products and diffusion of existing technology. Their conclusions support this first assumption. Eco-innovation dynamics in this sector has been driven by regulation, certification and standards. The previous suggests that IS-analysis at the sectoral and technology level might represent a critical factor for the understanding of the system and what system failures should be amended –if any. Lessons can be learnt out of the Nordic for the use of systemic instruments and its relevance for the greening of the innovation system and the SCP agenda. There is an evident lack of connectivity between policy instruments in the aforementioned case in the Nordic building industry. A combination of business strategies and public intervention has been the common factor for the development of eco-innovations. As a result, high uncertainty in experimentation was created. In addition, knowledge transfer and information flows are inefficient. The traditional use of tax incentives and subsidies for energy efficiency measures has not been sufficient, since they tend to create temporal markets of limited success. This could be expected to change in a traditional way with the EC directive on energy efficiency in buildings (see Annex 1, section 3.4.1). In this context, effective demonstration projects for more radically innovative solutions may offer positive learning experiences. However, an important aspect to bear in mind is to reduce the chances of failure for technology diffusion via market formation.
This case describes the recent **UK initiative for a low carbon transport system**. It departed from the premise that the development of carbon technologies required public intervention, as clear market failures were present. The UK government mainly based its approach to innovation in this sector via taxation and fiscal measures. After four years of analysis, which were based on studies based on the innovation systems approach, the UK government launched a promising initiative for innovation in the low carbon transport sector. This strategy includes all modes of transport. However, our review only makes reference to the road sector. This case was build based on an extensive literature review; in particular the contributions from Foxon (2003), ICCEPT & E4Tech (2003), Foxon, Gross, et al, (2003; 2005), DTI (2003) and Dft (2007) are acknowledged.	DTI (Department for Business, Enterprise and Regulatory Reform); DfT (Department for Transport); local authorities (e.g. City, District and County authorities); the Carbon Trust; public/private action and advisory boards (e.g. LowCVP); Universities and education centres; R&D centres and technology spin-offs (public and private); car/motor manufacturers; components & parts suppliers; key technologies suppliers (mainly fuel & energy technologies); system integrators; financial institutions; technology-specific innovation networks (e.g. Cenex); industrial associations; NGOs; the European Commission…	The Carbon Trust study commissioned to the Centre for Energy Policy and Technology on the 'state of the art on inducing innovation for a low-carbon future' (Foxon 2003) had a standpoint from the systems of innovation approach (e.g. Edquist, 2005), and provided NIS, SIS and TSIS analyses for the case of low-carbon energy and transport options in the UK. In addition, they included notions from transition management such as 'long term visions', 'learning experiments' and 'transition paths' (e.g. based on the Energy transition case in the Netherlands) as examples of initiatives to be included in a broad low-carbon initiative for the energy and transport sectors. This report clearly influenced the final UK strategy for the Department of Transport (DfT 2007) and it can be clearly seen in the content of the 'low carbon transport strategy', as noted below. In terms *knowledge development* of *guidance of research*, the UK energy paper and low-carbon strategy give clear messages on what areas are to be promoted. In this sense, the UK government intents to support the development of demonstration programmes (e.g. hybrid and electric vehicles, bio-fuels, and hydrogen and fuel cells) and 'innovation platforms' along specific route maps or transition paths. It is interesting to note that in spite of not being explicitly developed as a policy approach, the term 'transition' do appears in the 'low carbon strategy' –especially for the transition to a low carbon transport system. In practice, the introduction of 'niche experiments' and 'experimenting' give the idea that in policy practice some transition management elements are being introduced. For the

		function of *mobilisation of resources*, the UK government has supported the development of the LowCVP which has the role to serve as advisory board but also to gather stakeholders and coordinating the efforts of the low carbon transport agenda. In terms of *knowledge diffusion through networks*, the creation of Cenex and KTN are clear signs of public intervention for the diffusion of knowledge in this topic. These centres will also serve as a mean to legitimise and counteract the resistance to change. The functions of entrepreneurship and market formation will be supported by public procurement initiatives (e.g. public procurement of small fleet demonstrations) and funds (e.g. environmental transformation fund and OMEGA). Finally, the DfT clearly recognised the need to improve the coherence and coordination of all of these R&D funding initiatives.

Source: elaborated from Tukker, Diaz Lopez, et al (2009)

The examples summarised in Table 3 are interesting for the SCP agenda because they include both supply and demand aspects of innovation, which in turn emphasise the formation of markets and the direct guidance of the direction of search among users and suppliers of technology – somehow unusual within 'traditional' economics of innovation. The guidance of search is often seen in terms of funding, allocation of resources for R&D, and tax exemptions. This would be clearly a narrow and lineal innovation perspective that keeps on being not sufficient for achieving major systemic changes demanded by the SCP agenda. Nonetheless, we could acknowledge that it well may be a good first step for creating a larger momentum for social demands and the gradual adoption of systemic instruments – as suggested by the lead market initiative example (not included in the table, but discussed below).

The lead markets initiative, as an example of the IS approach, represents the first EU-based systemic combination of (traditional) innovation and environmental policy instruments.[11] Some remarkable aspects for SCP could be summarised as follows:

- This systemic policy instrument can be seen as a top-bottom approaches combined with bottom-up actions, which is directly related to the greening of the system and the promotion of eco-innovations –hence with good possibilities for SCP.
- The role of demand has been finally recognised in the policy context. Lead markets will be promoted/ used as long as they provide sufficient demand for innovations (demand pull instead of technology push)
- IS analyses could play a very interesting role (especially national, sectoral and technology specific), by identifying those elements that may not be well functioning within such a system
- It is not only pulled by environmental policy, but with a proper combination of mutually interdependent innovation (and other industrial) policy instruments. It does not only demand proper coordination of existing initiatives, but demands the creation of new framework conditions –if needed.
- It acknowledges the role that SCP policies should ideally have. The LM initiative is seen as a policy that fosters innovation at the time it meets societal goals.
- The focus of the LM initiative has been designed with a thematic approach, which requires that different products and services would be addressed in a particular fashion. All the innovation themes must be sustainability-oriented.
- Competitive forces of the markets will act upon the creation of lead markets –no 'picking-up' winners

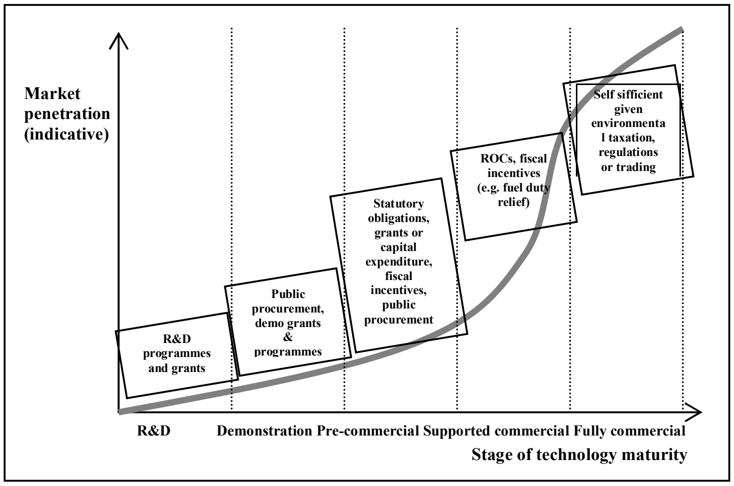
Summing up, the EC sees the promotion of lead markets as a policy measure justified by the existence of fragmented markets meeting the criteria of a system failure (Edler and Georghiou 2007). The policy instruments in support of lead markets have been broadly designed to complement the supply side activities such as R&D funding, fiscal measures, intellectual property rights, etc (EC 2007). In this way, a systemic combination of traditional innovation instruments would be used, as long as they would provide sufficient demand or scale for innovations in order to favour the creation of a lead market (Georghiou 2006). If successful, the EC foresees positive effects of the LM initiative on the European GDP, growth, welfare, health and the environment, entrepreneurship and labour, globalisation effects (e.g. low-cost competition), adaptation to structural change, and overall industrial competitiveness (EC 2007; 2007).

Finally, from the content of table 3, Foxon, Gross et al's (2003) recommendations to the UK government for a stable and consistent policy framework is worth to be mentioned. These set of recommendations also constitute a very interesting case of a systemic approach for the use

[11] Note that the 'lead markets' notion, as originally posited by Beise, M., J. Blazejczak, et al. (2003) derivates from work in the field of ecological economics. Nonetheless, the current EU vision of this approach could be more related to an innovation systems thinking. For a discussion of this issue, see the Annex 3 of the Scope2 report, in Tukker, Diaz Lopez, et. al (2009)

of policy instruments. The following figure represents an ideal picture of the different policy instruments to be used depending on the stage of the degree of maturity of a given technology and its market penetration.

Figure 5 Coordinated use of policy instruments along the degree of technology maturity



Source: Foxon, Gross et al. (2003), p. 18

The illustration above is important in terms of understanding how demonstration experiments (e.g. using strategic niche management or transition experiments) can progress along the different stages of development until reaching the commercial stage. More importantly, it suggests how policies can help technologies to overcome lock-in effects created by the nature of the institutional framework.

5. Lessons learnt for SCP policies

5.1 Systemic intervention has added value

As indicated in the introduction of this paper, policy intervention is acceptable when individual actors or markets doe not achieve objectives that from an overall society perspective are desirable (Edquist and Chaminade 2006). Traditional policy approaches imply the application of regulatory, economic and informative instruments that adjust framework conditions. Often, a single instrument or a limited mix of instruments is applied that has to do the trick: a 'silver bullet' that changes market and framework conditions is asked for, in the hope that such changes in market and framework conditions create a dynamics that makes consumption and production more sustainable.

Such approaches forego the lessons that are clearly depicted by the discussion of system innovation and innovation system theory (section 3). These theories focus on failures in the socio-economic system, which is so much broader than the interaction in a production-market-consumption value chain. Consumers are not as sovereign as they think and businesses depend on corporate and stockholders perception of opportunities and challenges imposed by the external environment. But more importantly, businesses and consumers are locked-in in trajectories of socio-economic development that go beyond their power to change. It is such 'system failures' that are addressed by systemic instruments. The various cases briefly introduced in the precedent section show how systemic instruments and co-ordinated application can have added value:

- Energy efficiency in the Nordic countries: a lack of connectivity between policy instruments and lack of knowledge transfer and learning networks resulted in lower diffusion rates as possible. The lead markets initiative on sustainable construction represents an interesting alternative to correct these systemic failures. This case shows the importance of system innovation analyses.

- Energy transition in the Netherlands: This case represents possibly one of the most comprehensive systemic bottom-up approaches to sustainable policy making. It represents a consensual approach to policy making where different societal actors defined a vision of the main routes to be followed for a transition to a sustainable energy system with short, medium and long run strategic planning.
- Low carbon transport in the UK: the British strategy for a low carbon transport system shows a case where a shift from traditional policy making (i.e. R&D funds) is being transformed to a more coordinated and systemic approach. More importantly, it is a case where the transition and innovation system policy practice seems to have good chances to co-exist and reinforce one another.
- Sustainable mobility in the Netherlands: The recent experience of the sustainable mobility in the Netherlands calls for an understanding on the role that transition experiments along the innovation cycle. It highlights the need for new structures, proper framework conditions and monitoring and learning.
- Organic food in Switzerland: Due to changes in rules for agricultural support enforced by WTO, in the 1990s Swiss agriculture switched in a very short time to organic and precision farming. However, this switch would have been impossible without that in the decades before a broad and matured experience with such alternative farming had been gained. This case shows the added value of creating lead or niche markets of alternative systems.

The main idea behind the use of systemic instruments is that they truly differ from traditional policy –they are realistically achievable but require great coordination efforts. Clearly, the use of systemic instruments might allow the identification of targeted solutions for specific problems but they would also attempt to tackle the problem as a whole. The functioning of the system can be understood, framework conditions can be enhanced, specific areas can be targeted, broad (technology) areas can be developed, market and societal penetration is facilitated, and system change is intended. If technologies or social instruments are targeted towards amending specific social demands, behavioural change can be induced. Ultimately, the use of systemic instruments may lead to a 'tailor made' approach for amending system failures that would contribute to producer and consumer behavioural change. SCP is a systemic challenge where the application of individual, traditional policy instruments is not always sufficient. Systemic failures hinder changes to SCP, and hence systemic instruments are needed.

5.2 Characteristics of systemic instruments for SCP

The content of section 4 highlighted the notion that SCP requires coordinated and systemic use of instruments in order to amend system failures (see the lead markets and the energy transition examples). System theory and practice has suggested a collection of elements for the greening of the innovation system that could serve as a model for the SCP arena. As the main characteristics of systemic intervention, we may highlight the following aspects and instruments that would be required for adopting such an approach:

- Systemic thinking
- Long term vision and frameworks
- Clear alignment to societal demands
- Guiding principles are necessary (e.g. strategic agenda, transition plan, etc)
- Require great coordination efforts, sound knowledge of the system, and proper understanding of framework conditions (nation, region, sector, technology)
- Recognition of national, sectoral, regional, domain and technology-specific characteristics that make each system to be unique –or at least particular

- Involvement of relevant stakeholders; bottom-up and top-bottom approach could be combined
- Identification of complementarities and synergies between different instruments
- Coordinated use of existing instruments, modification of relevant aspects of them, and creation of new ones; targeted policies along the different stages of innovation is recommended
- Allowing experimenting, learning, feedback loops and monitoring
- Understanding of innovation (social, organisational, technological, process, product, eco, systemic) as a system
- The use of systemic use of instruments per domain and/or /per technology area is important since sectoral differences matter.

The theory and case-based evidence presented in this work may suggest that before any policy mix can be applied, a sound knowledge of the system is required. The experience from the cases in tables 2 and 3 highlighted the idea that a proper understanding of the dynamics of a (complex) system can be obtained via a number of tools, such as innovation system analyses and multi-level analyses. IS (national, sectoral and technology specific) analyses represent a very interesting tool for the identification of those elements that may not be well functioning within a system. An interesting alternative to avoid an underestimation of system failures was provided by Klein Woolthuis, Lankhuizen et al. (2005). These authors developed a very practical and user friendly IS-system failure framework to analyse, evaluate and to identify potential bottlenecks in policy actions.[12] For example, applying such analysis to the 'lead markets initiative' may highlight the need to support it with 'intelligence approaches' in order to provide a good performance of the system. The analysis of the cases noted that a possible way to amend possible limitations of the lead markets approach on the selection of relevant innovation areas would be by using methodologies for the identification of potential lead markets based on for IS (national, sectoral and/or technological) analyses. Multilevel analyses and transition experiments (e.g. strategic niche management) provide understanding of the system towards paradigm change. It seeks to provide an understanding of the system so that a gradual and non-disruptive regime shift for sustainability can be induced. Complementarily, the transition management cycle is an interesting framework for structuring the content and processes of a system innovation. Visions and paths, transition experiments, and supporting activities are part of such a transition process and require constant feedback and monitoring in an appropriate learning network

5.3 Gaps and white spots

The lessons extracted from IS and SI theory and practice provide some clues on the existence of gaps on systemic policy implementation.

First, a main gap is the application of systemic policy instruments by themselves. Systemic instruments are mainly used in innovation policies, and hardly in sustainability policies. This is worrying, since most of the sustainability problems (mobility, energy use, food, and housing) require radical changes that are clearly hindered by systemic inertia. The exceptions are the transition management programs in the Netherlands and the use of some systemic instruments in the EU's SCP and public procurement policy (e.g. linkages between SCP and lead markets, leveraging of innovation, cleaner and leaner production via eco-innovation). The use of systemic approaches in other areas of interest for SCP such as competition, regulation (i.e. health, environment), education, and macro-economic policies is rather

[12] System failures are categorised by Klein Woolthuis, et al (2005, 612-614) in terms of: infrastructure, institutions (soft, hard), interaction (strong/weak network failure, myopia due to internal orientation, lack of weak ties, and dependence on dominant partners) and capabilities. System failures cannot be addressed in a direct manner, so the proposed framework aims to provide a tool for policy analysis on: where the systemic failures occur, which actors should be addressed to make change possible, and a sense of prioritising of them. Lastly, this framework can be used for evaluation of policy programmes.

inexplicit. Indeed, one could wonder if existing SCP policies acknowledge the systemic character of the challenge.

Second, one can identify clear white spots from a geographical perspective. Innovation instruments, systemic or not, are highly dependent on country and sector specific conditions. In practice, systemic instruments are being used in certain countries (e.g. the Netherlands) whereas some countries are moving onto that direction (e.g. the UK, Nordic countries). Examples of this account the use of the lead markets initiative at the European level for the areas of energy provision, sustainable construction, and recycling. It may be that lead countries in these sectors at the European level such as Sweden, Germany, the Netherlands and Finland may be benefited from such a 'leading' approach. An additional example is the support to innovation in low carbon technologies (for mobility and energy) in the United Kingdom. Such geographical white spots are much more relevant than sector-oriented white spots. In countries where systemic instruments are applied, one sees in general an application in a variety of sectors.

A final gap could be the limited learning and exchanges across countries with the applications of systemic instruments in similar sectors. Examples of this may account: the lead markets initiative for recycling could benefited from the transition management case of recycling. Another example is the UK experience of the transition to lower carbon technologies in setting up experiments, which could receive inputs from the energy transition in the Netherlands.

It is interesting to see that both the SI as IS approach does not challenge the basic paradigms of growth and wealth. None of these approaches have directly included demographic or growth related aspects in the type of systemic failures to be amended. Implicitly, they suggest that socio-technical changes are the most important contribution to face societal problems. Indeed, the IS approach mainly is geared towards the goal of enhancing competitiveness. Even the SI approach seems to avoid carefully issues like de-growth, consumer sovereignty, the quest for status via wealth and material goods, and equity at global level.

6. A *guise de conclusion: wrapping up and further research needs*

To sum up, the content of this paper has argued that the change to SCP is a systemic challenge where the application of individual, traditional policy instruments is not always sufficient. Systemic failures hinder changes to SCP, and hence systemic instruments are needed. Two strands of theories and related cases were presented: the system innovation and innovation system approaches. System innovation approach has a strong policy focus and as such was designed to face sustainability problems by promoting major system changes. The core goal of innovation systems policy is to promote competitiveness through a high innovative capacity (Andersen 2008). Added value of systemic instruments is that they point at the need to have a holistic view on the system in which change is desired, to address various functions that may need change, and to acknowledge that change is too complex and hence often cannot planned. The latter then implies the need for experimenting, organising learning networks, etc.

Finally, a few punctual aspects of the implication of the use of systemic approaches for SCP can be noted and (perhaps) explored into more detail:

- In the overall, both approaches need to address the SCP agenda into more depth (e.g. both approaches focused on innovation and eco-innovation).
- The division of the SCP agenda in domains seems to be a feasible alternative, so transition processes and innovation dynamics can be easily fostered/ identified.
- Added value of systemic instruments vs. individual approaches is self-evident (e.g. from the initiative of lead markets or the energy transition case)

- In spite of the attempts to include the demand side in IS and SI policies, it is clear that SCP policies demand the introduction of an explicit consumption domain (e.g. shift to ecological agriculture in Switzerland).
- Coordination of instruments should be envisaged along the entire innovation and business cycle and they should allow room for experimenting, learning by doing, constant feedback and diminishing the associated risks (e.g. EU sustainable construction case). As an analogy of the supply and demand taxonomy of innovation instruments presented in Figure 4, it could serve as a basis for the distribution of policy instruments in terms of consumption, market and production in SCP policies. In addition, examples such as the one presented in Figure 5 could give a clear indication what 'coordination' of policy instruments may represent

A final aspect to be noted are the implications of systems approaches and SCP for climate change mitigation and adaptation. As noted by Adger, et al (2005), successful adaptation to climate change involves a number of (cascading) decisions across different levels, which are made up by different stakeholders (e.g. firms, NGOs, governments, individuals, etc), at different levels (e.g. municipalities, regions, countries). Actions for adaptation may include creating policies or regulations in order to build such capacities (e.g. SCP communication and information policies), and actions that implements operational adaptation decisions (e.g. reducing the cumulative impacts of climate change, ensuring that measures are actually adopted by organisations, etc) (Adger, et al 2005). Often, bottom up (e.g. a community initiatives, such as the ones initiated by a system innovation approach) and top-down adaptation actions (e.g. higher level government decisions framed by the innovation systems thinking) are facing constraints. Moreover, institutions (e.g. norms and rules) are often conflicted with the interest of sector groups (e.g. a trade union).

It has become almost a platitude that (radical technological) innovations are needed to prevent Nature from breaking down under the combined pressure of major societal challenges (Tukker and Buiter, 1007), including climate change. As noted by Tukker and Butter (2007, p 94): *"Scientists and policymakers have argued in varying terms that this challenge can only be met if system innovations are set in place. Singular innovations that change elements of production-consumption chains (e.g. implementing a material recycling system for end of life vehicles, or striving for a circular economy in general) may lead to improvements of 50 or 75% […] But only innovations at system level create such a large scope for change that really radical reductions of environmental pressure come into sight"*. This type of innovations focus on societal needs (e.g. future technical specifications for transport modes) and the systems that determine how these functions are fulfilled (e.g. the setting up of such standards based on natural relations between frequency and magnitude of the problem, and the available resources and technical capacity to fulfil it).

Clearly, a more systemic-view of adaptation to climate change is needed in order to analyse the whole system (framework) where those decisions (are to be made). New forms of complex and reflexive governance could possibly be best suited to solve these problems, where different stakeholders may be involved. In addition to the (innovation) system approaches here presented, it could also be useful for adaptation and mitigation policies to climate change to include other forms of systemic governance approaches: resilience and adaptive capacity. The linkages of systemic approaches to innovation, SCP and climate change mitigation and adaption should be explored into more detail, and perhaps be more explicit in the current SCP research agenda.

References

Andersen, M. (2004). Innovation System Dynamics and Sustainable Development - Challenges for Policy. Innovation, Sustainability and Policy Conference. Kloster Seeon, Germany**:** 22.

Andersen, M. (2008). Review: System transition processes for realising Sustainable Consumption and Production. System Innovation for Sustainability 1. Perspectives on Radical Changes to Sustainable Consumption and Production. A. Tukker, M. Charter, C. Vezzoli, E. Sto and M. Andersen. Chippenham, Greenleaf Publishing Ltd.

Asheim, B. and M. Gertler (2005). The Geography of Innovation. Regional Innovation Systems. The Oxford Handbook on Innovation. J. Fagerberg, D. Mowery and R. Nelson. Oxford, Oxford University Press**:** 291-317.

Belz, F. (2004). A transition towards sustainability in the Swiss agri-food chain (1970-2000): using and improving the multilevel perspective. System Innovation and the Transition to Sustainability. Theory, Evidence and Policy. B. Elzen, F. Geels and K. Green. Cheltenham, Northampton, Edward Elgar**:** 97-113.

Bergek, A., S. Jacobsson, et al. (2008). "Analyzing the functional dynamics of technological innovation systems: A scheme of analysis." Research Policy **37**(3): 407-429.

Braczyk, H., P. Cooke, et al. (1998). Regional Innovation Systems. London, UCL press.

Breschi, S. and F. Malerba (1997). Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries. Systems of Innovation: Technologies, Institutions and Organisations. C. Edquist. London, Washington, Routledge**:** 130-156.

Carlsson, B. and S. Jacobsson (1994). "Technological systems and economic policy: the diffusion of factory automation in Sweden." Research Policy **23**(3): 235-248.

Carlsson, B., S. Jacobsson, et al. (2004). Dynamics of Innovation Systems: Policy-Making in a Complex and Non-Deterministic World. International Workshop on Functions of Innovation Systems. Utrecht, University of Utrecht,.

Carlsson, B., S. Jacobsson, et al. (2002). "Innovation systems: analytical and methodological issues." Research Policy **31**(2): 233-245.

Coenen, L. and F. Diaz Lopez (2008). Comparing systemic approaches to innovation for sustainability and competitiveness. DIME International Conference “Innovation, Sustainability and Policy”. University Montesquieu Bordeaux IV, France., DIME; GREThA, University Montesquieu Bordeaux IV**:** 32.

Cooke, P. (2001). "Regional Innovation Systems, Clusters, and the Knowledge Economy." Ind Corp Change **10**(4): 945-974.

Dahmén, E. (1970). Entrepreneurial Activity and the Development of Swedish Industry, 1919-1939. Homewood, IL., American Economic Association Translation Series.

DfT (2007). Low Carbon Transport Innovation Strategy. London, Department for Transfort (DfT)**:** 82.

Diaz Lopez, F. (2008). Environment, Technological change an Innovation. The Case of the Mexican Chemical Industry. Faculty of Social Sciences. School of Development Studies. Norwich, University of East Anglia. **PhD in Human Geography:** 302.

Dosi, G. and L. Orsenigo (1988). Coordination and transformation: an overview if structures, behaviours and change in evolutionary environments. Technical Change and Economic Theory. G. Dosi, C. Freeman, R. Nelson, R. Silverberg and L. Soete. London, Pinter Publishers**:** 13-37.

DTI (2003). Our Energy Future - creating a low carbon economy. London, Department for Trade and Industry, Department for Transport, Department for Environment, Food and Rural Affairs**:** 142.

EC (2003). Innovation Policy: updating the Union's approach in the context of the Lisbon strategy. Brussels, Commission of the European Communities. **COM(2003) 112 final:** 27.

EC (2004). Fostering Structural Change: an industrial policy for an enlarged Europe. Brussels, Commission of the European Communities. **COM(2004) 274 final**.

EC (2004). Science and Technology, the Key to Europe's future - Guidelines for future European Union policy to support research. Brussels, Commission of the European Communities. **COM(2004) 353 final:** 12.

EC (2004). Stimulating Technologies for Sustainable Development; and Environmental Technologies Action Plan for the European Union. Brussels, Commission of the European Communities. **COM(2004) 38 final**.

EC (2005). More Research and Innovation - Investing for Growth and Employment: A Common Approach. Brussels, Commission of the European Communities. **COM(2005) 488 final:** 22.

EC (2006). Putting knowledge into practice: A broad-based innovation strategy for the EU. Brussels, Commission of the European Communities. **COM(2006) 502 final:** 18.

EC (2007). A lead market initiative for Europe. Brussels, Commission of the European Communities. **COM(2007) 860 final:** 11.
EC (2007). A lead market initiative for Europe (Annex I). Brussels, Commission of the European Communities. **COM(2007) 860 final SEC (2007) 1730:** 25.
EC (2007). A lead market initiative for Europe. Explanatory Paper on the European Lead Market approach: Methodology and Rationale (Annex II). Brussels, Commission of the European Communities. **COM(2007) 860 final SEC (2007) 1729:** 75.
EC (2008). Background document to the consultation on the Action Plans on Sustainable Consumption and Production and Sustainable Industrial Policy. Brussels, Commission of the European Communities**:** 15.
EC (2008). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. Brussels, Commission of the European Communities. **COM(2008) 397 final**.
Edler, J. and L. Georghiou (2007). "Public procurement and innovation--Resurrecting the demand side." Research Policy **36**(7): 949-963.
Edquist, C. (1997). Systems of Innovation: Technologies, Institutions and Organisations. London, Washington, Routledge.
Edquist, C. (2005). Systems of Innovation. Perspectives and challenges. The Oxford Handbook on Innovation. J. Fagerberg, D. Mowery and R. Nelson. Oxford, Oxford University Press**:** 181-208.
Edquist, C. and C. Chaminade (2006). Rationales for public policy intervention from a systems of innovation approach: the case of VINNOVA. CIRCLE Electronic Working Paper Series. . Lund, CIRCLE -Center for Innovation, Research and Competence in the Learning Economy, Lund University**:** 25.
EEA (2005). Household consumption and the environment. EEA Report No 11/2005. Copenhagen, European Environment Agency**:** 72.
Emtairah, T., N. Tojo, et al. (2008). Green Markets and Cleaner Technologies (GMCT) - The challenges of energy efficiency innovations in the Nordic building sector. Lund, International Institute for Industrial Environmental Economics (IIIEE), Lund University**:** 45.
EZ and ETTF (2006). More with Energy. Opportunities for the Netherlands. The Hague. Westervoort, Ministry of Economic Affairs. Energy Transition Task Force (ETTF). Senternovem**:** 53.
Foxon, T. (2003). Inducing Innovation for a low-carbon future: drivers, barriers and policies. A report for the Carbon Trust. London, Centre for Energy Policy and Technology Imperial College London (ICCEPT)**:** 56.
Foxon, T., R. Gross, et al. (2003). Innovation in long term renewables options in the UK - overcoming barriers and system failures. ICEPT report for the DTI Renewable Innovation Review. London, Centre for Energy Policy and Technology Imperial College London (ICCEPT)**:** 45.
Foxon, T. and R. Kemp (2007). Innovation impacts of environmental policies. International Handbook on Environment and Technology Management (ETM). D. Marinova, D. Annandale and J. Phillimore. Cheltenham, Edward Elgar**:** 119-139.
Foxon, T. J., R. Gross, et al. (2005). "UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures." Energy Policy **33**(16): 2123-2137.
Freeman, C. (1987). Technology Policy and Economic Performance: Lessons from Japan. London, Frances Pinter.
Freeman, C. and C. Perez (1988). Structural Crises of adjustment, business cycles and investment behaviour. Technical Change and Economic Theory. G. Dosi, C. Freeman, R. Nelson, R. Silverberg and L. Soete. London, Pinter Publishers**:** 38-66.
Galli, R. and M. Teubal (1997). Paradigmatic Shifts in National Innovation Systems. Systems of Innovation. Technologies, Institutions and Organisations. C. Edquist. London, Washington, Pinter**:** 342-370.
Geels, F. W. (2002). "Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study." Research Policy **31**(8-9): 1257-1274.
Geels, F. W. (2005). "Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective." Technological Forecasting and Social Change **72**(6): 681-696.
Geels, F. W. and R. Kemp (2000). Transities vanuit socio-technisch perspectief. Maastricht, MERIT.
Georghiou, K. (2006). Effective innovation policies for Europe - the missing demand side. Helsinki, Prime Minister's Office. Economic Council of Finland**:** 23.

Grin, J. and R. Weterings (2005). Reflexive monitoring of system innovative projects: strategic nature and relevant competences. Amsterdam, Apeldoorn, UvA, TNO.

Hekkert, M., R. Suurs, et al. (2007). "Functions of innovation systems: A new approach for analysing technological change." Technological Forecasting and Social Change **74**(4): 413-432.

Hoogma, R., R. Kemp, et al. (2002). Experimenting for Sustainable Transport. The approach of Strategic Niche Management. London, New York, Spon Press.

ICCEPT and E4Tech (2003). The UK Innovation Systems for new and renewable energy technologies. A report to the DTI Renewable Energy Development & Deployment Team. London, Imperial College London Centre for Energy Policy and Technolgy and E4Tech Consulting**:** 128.

Jacobsson, S. and A. Bergek (2004). "Transforming the energy sector: the evolution of technological systems in renewable energy technology." Industrial and Corporate Change **13**(5): 815-849.

Jaumotte, F. and N. Pain (2005). An Overview of Public Policies to Support Innovation. OECD Economics Department Working papers no 456. Paris, OECD**:** 32.

Kemp, R. (1997). Environmental Policy and Technical Change. A comparison of the Technological Impact of Policy Instruments. Cheltenham, Brookfield, Edward Elgar.

Kemp, R. (2000). Technology and Environmental Policy-Innovation effects of past policies and suggestions for improvement. Paper for OECD workshop on Innovation and Environment. Paris, OECD.

Kemp, R., M. Andersen, et al. (2004). Background report about strategies for eco-innovation. Maastrichct, VROM, TNO-STB, MERIT, RISO.

Kemp, R. and J. Rotmans (2004). Managing the transition ot sustainable mobility. System Innovation and the Transition to Sustainability. Theory, Evidence and Policy. B. Elzen, F. Geels and K. Green. Cheltenham, Northampton, Edward Elgar**:** 137-167.

Klein Woolthuis, R., M. Lankhuizen, et al. (2005). "A system failure framework for innovation policy design." Technovation **25**(6): 609-619.

Leontief, W. (1941). The Structure of American Economy, 1919-1929. An Empirical Application of Equilibrium Analysis. Cambridge, MA., Harvard University Press.

Lindt, M., van de and D. Loorbach (2005). DUWOBO process. Brussels.

Loorbach, D. (2002). Transition management: governance for sustainability. Conference on the Human Dimensions of Global Environmental Change "Knowledge for the Sustainability Transition: The Challenge for Social Science" Berlin., German Political Science Association (DVPW)

Loorbach, D. (2007). Transition Management: new mode of governance for sustainable development. Rotterdam, International books.

Loorbach, D. (2008). Why and how transtition management emerges. IHDP. Berlin., German Political Science Association (DVPW)

Lundvall, B. (1992). National Innovation Systems. Towards a Theory of Innovation and Interactive Learning. London, Pinter Publishers.

Malerba, F. (2002). "Sectoral systems of innovation and production." Research Policy **31**(2): 247-264.

Malerba, F. (2004). Sectoral Systems of Innovation. Concepts, issues and analysis of six major sectors in Europe. Cambridge, Cambridge University Press.

Markard, J. and B. Truffer (2008). "Technological innovation systems and the multi-level perspective: Towards an integrated framework." Research Policy **37**(4): 596-615.

Montalvo, C. (2002). Environmental Policy and Technological Innovation. Why Do Firms Adopt or Reject New Technologies? Cheltenham, Northampton, Edward Elgar.

Montalvo, C., P. ten Brink, et al. (2007). Policy pathways to promote eco-innovations (POPA-CTDA) – Scientific summary report. . European Sixth Framework Program, Contract no. 502487,. Delft, TNO - The Netherlands Organisation for Applied Scientific Researc.

Nelson, R. (1993). National Innovation Systems: A Comparative Analysis. New York, Oxford, Oxford University Press.

Nonaka, I. and H. Takeuchi (1995). The knowledge creation company. Oxford, New York, Oxford University Press.

OECD (1997). National Innovation Systems. Paris, Organisation for Economic Cooperation and Development.

OECD (1999). Managing National Innovation Systems. Paris, Organisation for Economic Cooperation and Development.

OECD (2002). Dynamising National Innovation Systems. Paris, Organisation for Economic Cooperation and Development.

OECD (2005). Governance of Innovation Systems. Synthesis Report. Paris, Organisation for Economic Cooperation and Development. **1:** 120.

Porter, M. (1990). The Competitive Advantage of Nations. London, McMillan Business.

Rennings, K. (2000). "Redefining innovation -- eco-innovation research and the contribution from ecological economics." Ecological Economics **32**(2): 319-332.
Rennings, K., R. Kemp, et al. (2003). Blueprints for an Integration of Science, Technology and Environmental Policy (BLUEPRINT), Strata Project**:** 45.
Rip, A. and R. Kemp (1998). Technological Change. Human Choice and Climate Change. S. Rayner and E. Malone. Columbus, Ohio, Battelle Press. **2:** 327-399.
Rotmans, J., R. Kemp, et al. (2000). Transities en Transitiemanagement: de casus van een emissiearme energievoorziening. Maastricht, ICIS, MERIT**:** 83.
Sandström, A., A. Backlund, et al. (2004). The Swedish biotechnology Innovation System. VINNOVA Policy VP 2004:1. Stockholm, VINNOVA- Swedish Govermental Agency for Innovation Systems**:** 68.
Smith, A., A. Stirling, et al. (2005). "The governance of sustainable socio-technical transitions." Research Policy **34**(10): 1491-1510.
STPCF (2003). Knowlegde, Innovation and Internationalisation. Helsinki, Science and Technology Policy Council of Finland (STPCF)**:** 61.
STPCF (2006). Science, Technology and Innovation. Helsinki, Science and Technology Policy Council of Finland (STPCF)**:** 55.
Tukker, A. (2008). Conclusions. Change management for SCP. System Innovation for Sustainability 1. Perspectives on Radical Changes to Sustainable Consumption and Production. A. Tukker, M. Charter, C. Vezzoli, E. Sto and M. Andersen. Chippenham, Greenleaf Publishing Ltd**:** 393-423.
Tukker, A., F. Diaz Lopez, et al. (2009). Sustainable Consumption Policies Effectiveness Evaluation (SCOPE2). Final Report. Delft/Lund/Cologne/Vienna, TNO/Lund University/SERI. **June 2009**.
Tukker, A., G. Huppes, et al. (2006). Environmental impacts of products. Seville, Spain, ESTO/IPTS.
VINNOVA (2006). In search of Innovation Systems. VINNOVA Policy VP 2006:02. Stockholm, VINNOVA- Swedish Govermental Agency for Innovation Systems**:** 64.
VINNOVA (2007). Public procurement as a driver for innovation and change. Report on goverment commission to NUTEK and VINNOVA. VINNOVA Policy VP 2007:03. Stockholm, VINNOVA- Swedish Govermental Agency for Innovation Systems**:** 100.
Voß, J. P. and R. Kemp (2006). Reflexive Governance and Sustainable Development. Reflexive Governance for Sustainable Development. J. Voß, D. Bauknecht and R. Kemp. Cheltenham, Edward Elgar**:** 419-438.
Weber, M. and J. Hemmelskamp (2005). Merging Research Perspectives on Innovation Systems and Environmental Innovation: an introduction. Towards Environmental Innovation Systems. M. Weber and J. Hemmelskamp. Heidelberg, Springer**:** 1-7.
Weterings, R., J. Kuijper, et al. (1997). 81 options, technology for sustainable development. Delft, TNO/STB.