'Towards a sustainable innovation policy – Institutional structures, stakeholder participation and mixes of policy instruments'

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Abstract
Environmental policy and innovation policy regimes at national and EC levels require a more strategic principle and process based approach to policy coherence, in order to achieve greater integration. This paper investigates potential public-private institutional structures, forms of stakeholder participation, and development of mixes of policy instruments that could play a role in integrating environmental policy and innovation policy regimes into a *sustainable innovation policy* regime. These factors form part of guidance for improving policy processes for promoting sustainable innovation, currently being formulated in a research project under the UK ESRC Sustainable Technologies Programme, aiming to reflect the complexity of both innovation and environmental processes and systems.

This paper analyses three aspects of this guidance – the role of *public-private institutional structures* in policy development; forms of *stakeholder participation* and related consensual policy decision-making designed to include representatives of the innovation constituency; and approaches to the development of a more coherent and integrated *mix of policy instruments*. It draws on a project case study of EC Directives and other policy measures relating to alternative energy sources in vehicles; assessment of Integrated Product Policy as an attempt to achieve greater policy coherence; analysis of the Transition Management approach (developed by Kemp and Rotmans, and now being applied to innovation in energy policy by the Netherlands' Ministry of Economic Affairs); and direct experience of involvement in EC policy processes.

Finally, potential institutional developments to move to a more *adaptive policy making* approach are considered. This would facilitate '*policy learning*', by institutionalising policy review, learning and correction mechanisms, and so facilitate more rapid reaction to the dynamics of innovation. It is argued that such an approach could be beneficial to sustainable innovation policy, the development of more sustainable innovation systems, and also to the integration of environmental policy with other policy areas.

1. Improving sustainable innovation (SI) policy processes

1.1. Rationale for SI policy

At the 2002 Johannesburg summit, Governments committed themselves to promoting moves towards more sustainable systems of production and consumption - broadly defined as systems for which resource use and waste production remain within appropriate environmental limits and socially acceptable levels of economic prosperity and social justice are achieved. This transition will involve *innovation* towards more sustainable technological and institutional processes and systems, i.e. *sustainable innovation*. The challenge of *sustainable innovation policy* is thus to develop enabling policy frameworks, strategies and processes that support technological and institutional innovation in ways that encompass the economic, environmental and social dimensions of sustainability and that lead to the development of better mixes of policy instruments that promote sustainable innovation.

Historically, separate policy regimes have addressed innovation and environmental sustainability – and sectoral interests like energy and transport - because sustainable innovation (SI) was not seen as a subject for deliberate policy delivery. Indeed, current policy-making processes often work against a more integrated approach, because: long-term social and environmental problems tend to receive relatively low priority; the inter-related nature of these problems and radical uncertainties in future costs and benefits creates additional levels of complexity; and the goals required to ensure sustainability are contested.

This challenge of bringing together these separate policy regimes is under active consideration at the EC level, through the Environmental Technologies Action Plan (EC, 2004)[1]. DG Enterprise is examining the potentially positive role of environmental standards, economic measures and voluntary agreements on innovation in specific policy areas (EC, 2002) and in work on future directions in innovation policy (EC, 2003a), and the Communication on Integrated Product Policy demonstrates how product development and product strategy over a product's life cycle will take account of sustainability criteria (EC, 2003b). Hence, there is evidence that the European Community is prepared to reform policymaking processes to advance sustainable innovation.

At the UK level, evidence of a move towards sustainable innovation policy in the energy sector can be found in the government's Energy White Paper (DTI, 2003a) and Innovation Report (DTI, 2003b)[2]. However, many practical and theoretical issues need to be addressed in order to develop better policy processes and mixes of instruments. For example, the problems of interaction and harmonization between the Renewables Obligation, the UK Emissions Trading Scheme, other UK policy instruments and the new European Union Emission Trading Scheme, highlights the issue of securing a mix of climate change policy instruments that work synergistically rather than antagonistically towards a long-term goal—and that are sufficiently effective and flexible to evolve as national and international circumstances change (Boemare et al., 2003; Pearson, 2004; A. Smith 2002; Sorrell, 2002, 2003a,b).

[1] The Action Plan's objectives are (i) to remove the obstacles so as to tap the full potential of environmental technologies for protecting the environment while contributing to competitiveness and economic growth; (ii) to ensure that over the coming years the EU takes a leading role in developing and applying environmental technologies; and (iii) to mobilise all stakeholders in support of these objectives.

[2] "Innovation will also be essential for meeting the environmental challenges of the future – including moving to a low carbon economy and reducing waste. We need to find new ways to break the link between economic growth and resource depletion and environmental degradation" (DTI, 2003b, p.9).

1.2. Rationale for process guidance

Hence, we argue that there is a need to develop guidance that will inform the development of sustainable innovation policy. In the course of a current research project[3], we have developed such guidance, based on our theoretical and empirical analysis and experience, as well as extensive stakeholder consultation. This is intended for use by policy-makers and other stakeholders involved in sustainable innovation policy processes, including industry and NGO representatives, and consultants providing policy advice. It is not intended to supplant current processes, but rather to aid policy-makers and stakeholders in developing and adapting policy objectives and processes so that they will be more effective in promoting sustainable innovation.

This guidance has been developed using an analytical framework and empirical methodology, which draws on both innovation systems thinking and analyses of the roles of structure and agency in policy-making processes (Foxon *et al*., 2004). The guidance draws on our work on theoretical understanding of innovation systems (see Foxon, 2003), empirical analysis of recent policy developments through two case studies of UK and EC policy making, and insights from practical policy experience. The latter includes work contributing to the UK Renewables Innovation Review (ICEPT/E4Tech, 2003; ICEPT, 2003a,b), and direct involvement in producing draft legislation seeking to generate a mix of instruments for advancing sustainable innovation in the transport sector as it is affected by battery technologies (Makuch, 2003a; 2003b).

1.3. Introduction to SI policy process guidance

Our proposed SI policy process guidance addresses five key features and attributes of a putative SI policy regime, but does not try to impose detailed policy prescriptions. An SI policy regime would entail: the formulation of clear, *long-term sustainability goals*; the understanding of both innovation and policy-making as *systemic processes*; the advancement of the *procedural and institutional basis* for delivery of SI policy aims; and the incorporation of *'policy learning'*, both within individual policy processes and between different policy jurisdictions.

In more detail, we recommend that ***Sustainable Innovation (SI) policy*** processes should aim to:

1) Stimulate development of a SI policy regime, by bringing together the innovation and environmental policy regimes and improving the rationale for public policy interventions to promote SI;
2) Apply systems thinking, by engaging with the complexity and systemic interactions of innovation systems and policy-making processes;
3) Advance the procedural and institutional basis for delivery of SI policy aims, including improved strategies for stakeholder engagement;
4) Develop a more coherent and integrated mix of policy instruments to promote sustainable innovation;
5) Improve policy review, correction and learning mechanisms for adaptive improvement to SI policy processes.

[3] We have developed the guidance in the course of a research project, 'Policy drivers and barriers for sustainable innovation', supported by the UK Economic and Social Research Council's *Sustainable Technologies Programme*: www.sustainabletechnologies.ac.uk. We are undertaking theoretical and empirical analyses of UK and EU policy making relating to sustainable innovation, by applying the framework in this paper to two case studies: low carbon innovation policy in the UK; and EC policy-making processes in relation to alternative energy sources for vehicles (Foxon *et al.*, 2003a,b, 2004a,b; Makuch *et al.*, 2003; Pearson, 2004).

2. Innovation systems context

This paper analyses in more detail points (3), (4) and (5) of our proposed SI policy process guidance. The role of *public-private institutional structures* in policy development is discussed in Section 3.1, and the advancement of forms of *stakeholder participation* and related consensual policy decision-making designed to include representatives of the innovation constituency in Section 3.2. Approaches to the development of a more coherent and integrated *mix of policy instruments* are described in Section 4, whilst Section 5 discussing ideas relating to the role of *policy learning and review*.

We begin, though, by briefly discussing ideas relating to (1) development of an SI policy regime, and (2) the application of innovation systems thinking. These will be discussed in more detail in a subsequent paper (Foxon *et al*., 2005).

2.1. Development of an SI policy regime

As described in Section 1, innovation issues and environmental sustainability issues have generally been addressed through separate policy regimes, based on distinct analyses of problems, types of policy instrument and rationales for policy intervention. We argue that the development of an SI policy regime with the **explicit goal of promoting sustainable innovation** is needed. The main policy avenue for taking this forward at the EU level is through the implementation of the Environmental Technologies Action Plan (ETAP) (EC, 2004), which argues the case for promoting environmental technologies for protecting the environment while contributing to competitiveness and economic growth. We aim to suggest ways of taking forward and, where appropriate, complementing the proposals for overcoming barriers to the development of environmental technologies suggested in the Action Plan. These ideas also draw on two recent reports in Europe for the Blueprint network (Rennings *et al*., 2003) and in the U.S. for the Pew Centre (Alic *et al*., 2003).

Firstly, we argue that it needs to be recognised that **systemic changes in current technological and institutional systems**, as well as in social systems, will be required in order to achieve long-term sustainability goals. Current technological systems, such as carbon-based energy systems, and the institutional frameworks of regulations and ways of thinking that support them, have benefited from long periods of increasing returns, due to learning, scale, co-ordination and adaptation effects. An associated cost, however, has been the growth of systemic barriers to radical change – known as 'lock-in' (Arthur, 1989; Unruh, 2000). One manifestation of this is that actors, such as large firms, who have power under the current system will act to prevent or inhibit changes to rule systems that could reduce their power (see Pierson, 2000; and Section 3.1).

This suggests the value of a ***long-term, stable and consistent strategic framework*** **to promote a transition to more sustainable systems**. Such a framework would encourage investment in sustainable innovation for the long term. The Dutch transition approach (Kemp and Rotmans, 2001) provides an example of how this could be implemented. It seeks to combine the formation of a vision and strategic goals for long-term development of a technology area, with steps forward, termed *experiments*, that seek to develop and grow niches for more sustainable technological alternatives. This approach was adopted in the 4th Netherlands Environmental Policy Plan, and the Dutch Ministry of Economic Affairs (2004) is now applying it to innovation in energy policy. The Ministry sees the transition approach as a way of dealing with uncertainties and avoiding apparent certainties. The government is not 'choosing' specific options, but organising its policy around a cluster of options: the transition paths (main roads). These enable

the government to give direction to the market, whilst giving market players the opportunity to develop their own products based on their own market analysis, ambitions and entrepreneurship.

The Ministry of Economic Affairs (2004) argues this requires a new form of concerted action between market and government ('policy renewal'):

- *Relationships built on mutual trust*: Stakeholders want to be able to rely on a policy line not being changed unexpectedly once adopted, through commitment to the direction taken, the approach and the main roads formulated. The government places trust in market players by offering them 'experimentation space'.
- *Partnership*: Government, market and society are partners in the process of setting policy aims, creating opportunities and undertaking transition experiments, e.g. through ministries setting up 'one stop shops' for advice and problem solving.
- *Brokerage*: The government facilitates the building of networks and coalitions between actors in transition paths.
- *Leadership*: Stakeholders require the government to declare itself clearly in favour of a long-term agenda of sustainability and innovation that is set for a long time, and to tailor current policy to it.

Mixes of policy instruments will be needed within such a strategic framework. They will include market-based instruments, such as taxes or tradable permits, designed to internalise environmental externalities. However, moves to introduce market-based instruments will inevitably be politically contested, as they effectively create and distribute new 'property rights'. Consequently, the strength of these instruments is often watered-down, so that they fail to promote the level of systemic innovation needed to achieve sustainability goals (Foxon and Kemp, 2004). Section 4 below addresses the development of a coherent and integrated mix of instruments to promote sustainable innovation.

2.2. Applying systems thinking to innovation and policy processes

Current understanding views innovation as a complex process arising out of the systemic interaction between actors and structures involved in the production, diffusion and use of new and economically-useful, knowledge (Lundvall, 1992; Foxon, 2003). The systems approach emphasises the interaction between technological developments and the institutional framework of social rules, conventions and organisations in determining the rate and direction of technological innovation. Policy measures form a key part of this institutional framework (van der Steen, 1999).

The systems approach emphasises the role of uncertainty and cognitive limits to actors' ability to gather and process information relevant for their decision-making - 'bounded rationality', (Simon, 1955, 1959). Innovation is necessarily characterised by uncertainty about future markets, future technology potential and future policy and regulatory environments, and so firms' expectations of the future have a crucial influence on their present decision-making. Expectations are often implicitly or explicitly shared between different firms in the same industry, giving rise to trajectories of technological development, which can resemble self-fulfilling prophecies.

Two proposals for SI policy that arise from the systems approach are:
(i) Apply the concept of systems failures as a rationale for public policy intervention:

Given the importance of uncertainty and expectations in a systems view of innovation, Edquist (1994, 2001) and K.Smith (2000) have proposed the concept of 'systems failure' as a rationale for

policy interventions. This advocates undertaking concrete empirical and comparative analyses of innovation systems (cf. OECD, 2002) to identify systems failures that can be rectified. It identifies two conditions for public intervention in a market economy:

(a) a problem must exist, i.e. a situation in which market mechanisms and firms fail to achieve objectives that have been socially-defined, through a public policy process; and
(b) the state and its agencies must also have the ability to solve or mitigate the problem effectively (i.e. the issue of potential government and bureaucratic failure must be addressed).

In many cases, this concept of systems failure leads to similar or identical policy prescriptions to the economic concept of market failure, e.g. the use of policy instruments to internalise negative environmental externalities. The crucial difference, however, is that it does not presume that public policy interventions can recreate ideal market solutions, which are assumed to have maximal economic efficiency. In some cases, this will have practical policy consequences, where other policy measures, e.g. to overcome institutional barriers to change, may be required to complement or substitute for instruments like environmental taxes or emission trading schemes.

***(ii) Take advantage of windows of opportunity*:**

The systems approach highlights the importance of feedbacks within both innovation and policy-making processes. When positive feedbacks occur in innovation processes, e.g. between a new product design and an unmet market need, this can give rise to so-called techno-economic windows, i.e. stages in the innovation process which provide opportunities for the innovation or diffusion of technological alternatives (Nill, 2003). Similarly, positive feedbacks may occur in policy-making processes between perceived political problems, proposed solutions and opportunities for political action, giving rise to policy windows, i.e. opportunities for the introduction of new policies or policy instruments (Kingdon, 1995).

These ideas give rise to two lines of implementation. Firstly, there is the possibility that policy window opening could become a more regularised event such that sustainable innovation can be addressed in a more systematic manner, e.g. through policy review, long term planning and institutionalized policy learning. This is discussed in more detail in Section 5. Secondly, the idea that the opening of 'techno-economic' and 'policy' windows could be better aligned. Work by researchers in Berlin has identified the types of policy that may be appropriate to different stages of technology development, e.g. 'window preparation', 'window creation', 'window utilisation' (Nill, 2003; Zundel and Sartorius, 2004).

Studies of past innovations (Utterback, 1995; Christensen, 1997) suggest that a new technology will typically first commercialise in niche markets, where the particular technology's advantages are strongest. These markets allow the technology to benefit from learning effects, so that costs reduce and the technology's performance can improve. If this occurs sufficiently, the new technology may then become competitive with the existing technology in the wider market. Shifts to new technological regimes then occur through the cumulation of niches, which gradually swell and coalesce to form a new regime (Geels, 2002). Other factors identified as key to successful innovation include the development of a skills base, and the creation of knowledge networks in the new technological system.

As described earlier, eventually these effects can lead to the 'lock-in' of mature technological and institutional systems, such as carbon-based energy systems. Hence, SI policy should seek to ***promote a diversity of technology and institutional options to overcome lock-in of unsustainable technologies and supporting institutions*.**

3. Procedural and institutional basis for delivery of SI policy aims

3.1. Role of public-private and other institutional structures and activities

In line with the above ideas about the complementary roles of government and industry in promoting sustainable innovation and the need for mutual dialogue, we now consider in more detail institutional considerations that might be addressed in advancing policy development and decision-making processes in this field. We argue that there is a need for a *public-private institutional structure* designed to enhance regulator/regulated relationships and stakeholder activities, for information gathering and analysis, pilot projects, research and development and dissemination activities. This may be established at the national or EU level and could feed into international standard setting bodies, in order to harmonise approaches and create positive expectations about future outcomes.[4] We consider two specific proposals for institutional structures that may be facilitated by government and led by industry - ***Sustainable Innovation Strategy Units (SI Units)*** (and its relation to ***Sustainable Innovation Incubators***) and ***Sustainable Innovation Enablers (SI Enablers).***

Discussions with policy makers (Prime Minister's Strategy Unit, 2004) and regulators suggest that there are a number of barriers to encouraging joined up and innovative policy approaches towards sustainable innovation. Examples of such barriers include the following:

- **Time pressure** embedded in the policymaking process which makes comprehensive Governmental consultation (including all relevant Departments) more difficult;

- The existence of a **risk averse policymaking** culture. Hence, political leaders will often be reluctant to take policy initiatives where possible unintended or otherwise unpopular consequences may arise. Short term thinking and a preference for the status quo may be favoured by the Party politics of policymaking; and,

- The need to implement internal procedures which are time consuming and may effectively **straightjacket innovation in policymaking processes**. Examples would include regulatory impact assessment, stakeholder consultation guidelines, "value for money" criteria and cost benefit analysis.

To overcome these barriers, we argue that there may be a role for a public-private Sustainable Innovation Strategy Unit (SI Unit), which would be given specific sectoral tasks towards the implementation of sustainable innovation for specific environmental challenges. An SI Unit, which would receive minimal Government sponsorship, could take up a programme of advancing sustainable innovation according to the mandate set for it. Bodies with a similarly defined mandate have been established in the waste management context to advance reduction, reuse or recovery targets. In Canada, a Waste Reduction Advisory Committee (WRAC) was established (1991) for this purpose and, more recently, in the UK a Waste and Resources Action Programme (WRAP) (2001) has been created with a dedicated mandate to promote the development of markets for recyclable materials. Similarly, the UK Carbon Trust is a government-funded,

[4] Both the IPPC Bureau and Codex Alimentarius feature structures that have significant private sector participation in their deliberations towards the advancement of technologies and regulatory standards and guidance. Such bodies assist in the development of these outputs in a way that enhances governance in their relevant fields, so regulatory and policy instrument development time lags are shortened and outputs are more predictable for market actors.

industry-led organisation, with a mandate to promote the innovation of low carbon technologies, by acting like a venture capital company for carbon reductions.

An SI Unit would be primarily private sector in nature and would thus have the flexibility and legitimacy to engage companies while possessing checks and balances to ensure value for (Government) money and the promotion of explicit SI policy goals in a given sector. The existing WRAC and WRAP (particularly the latter) models could be adapted to take the further step of advancing explicit sustainable innovation goals, e.g. with a mandate of stimulating market pull for more sustainable technological systems[5]. Potential examples could include an SI Unit to drive hydrogen-fuelled public sector infrastructure or to promote dangerous substance-free or completely recyclable vehicles. This idea also shares some of the features of the ***technology platforms***, proposed in the ETAP, as a mechanism to bring together all interested stakeholders to build a long-term vision to develop and promote a specific technology area or solve particular issues.

Discussion of public/private partnerships for R & D purposes suggest that this form of co-operation will lead to new competitive advantages and elements for increasing productivity and welfare (Tekes, 2004). In fact, a number of dedicated research programmes, including the European Commission's Sixth Framework for Environmental Action Programme, encourage joint collaboration between companies, universities and research institutes. The SI Programme of the SI Unit could also inform **governmental assistance on R & D, pilot programmes and dissemination activities as well as specific policy development**. In terms of composition, special emphasis might be placed on balanced representation of SME representatives and the "innovation constituency".

A critical measure of an SI Unit's success would be the delivery of specific mandates as determined by Government. However, in addition, its success should be measured by a targeted effort to stimulate and engage **SI incubators.** SI incubators would generally be small companies comprised of innovators. Following the Silicon Valley model, innovators would effectively develop ideas for technologies, techniques and processes, providing a service that has been outsourced by firms who would be their main clients. The innovators would obtain intellectual property rights over inventions and design processes, which are then licensed/sold to firms that have the capital, distribution and marketing capacity to develop and bring the technologies, techniques and processes to market. These incubators would be small firms since the innovator's spirit is often synonymous with the entrepreneurial spirit, which is easier to stimulate in smaller less bureaucratic and structured institutions such as transnational corporations. There are also legal advantages for the innovators and financial advantages for their clients in that risk taking is left to the innovators in the initial phases of idea development. This idea fits well with other policy incentives to promote local or regional clusters of innovative firms, by stimulating the sharing of knowledge and the development of physical and social networks and infrastructures (OECD, 2001, 2002).

In support of the SI incubator concept, we observe that the United States is undergoing a trend towards the migration of innovation capacity into small units of innovation firms (Arora et al, 2001). This evolving innovation culture contrasts sharply with traditional corporate culture. In effect, corporate culture in the United States is witnessing a revolution in which core activities are kept in-house while virtually all other activities are being outsourced (Quinn, 2000; Chiesa et al, 2004)). This strategy is consistent with large increases in demand and significant growth in the

[5] In the UK, the mandate could be directed by a body like the new DEFRA Corporate Strategy Unit, which aims to constitute a Centre of Excellence for creativity, innovation and strategic thinking

knowledge economy as large numbers of knowledge workers enter the economy and communication interaction capacities surge ahead. R and D, technology, industrial design, engineering and process innovation are being outsourced in increasing numbers even in the high tech sectors.

Government policy should encourage its development in the European context as well. To some extent, this is already happening as universities produce spin-off companies whose primary role is the development of technologies, techniques and processes for eventual sale to or buy-out by large firms. In implementing the device of SI incubators, demonstration and dissemination activities could be supported and enhanced through government programmes such as the Department of Trade and Industry Faraday Programme and the EU Sixth Environmental Action Plan. Promising sustainable technology systems developments being contributed by SI incubator firms would likely benefit from receiving funding priority until such time as these sustainable innovation incubators are firmly structured in the European knowledge economy.

Aligned with SI incubators, Government sustainable innovation policy could be directed at creating a **permanent structure of multi-stakeholder SI Enablers** that can develop sectoral pilot "capacity building" programme schemes that implement SI policy. The SI Enablers could be appointed by the SI Unit in order to enhance policy implementation and the implementation of work programmes.

Both the SI Unit and SI Enablers could take steps to foster industry association strength as a means of enhancing sustainable technology/technique uptake. Often, industry associations are without the time and resources to address SI in their respective fields. One solution to this challenge is to stimulate trade association actions towards sustainable innovation through the proposed SI Unit and SI Enabler structure. As well, Government programmes could deliberately target this shortfall and provide for collaboration among associations and stakeholders (e.g., through programmes like the Faraday Partnership). The same could apply to support for and the integration of potential downstream customers into SI Unit activities.

3.2. Forms of stakeholder participation

Ensuring broad *stakeholder participation* from industry, commercial downstream users, NGOs, regulators, investors, representatives of innovators and consumers with the necessary knowledge/experience to participate constructively in SI policymaking activities is vital in determining strategic paths towards sustainable innovation, given the sociotechnical nature of this policy field.[6] According to the Complex Adaptive Systems (CAS) theory of human learning and adaptation, it is a self-organised and self-propelled process that takes place in an adaptable social context (McElroy, 2000). Hence, it should not be surprising that the same factors are in play in the innovation process itself.

We are innately all knowledge developers and yet the traditional institutional structure of the firm or the civil service may incline the majority towards a culture of "knowledge following" rather than "knowledge developing". This knowledge drive is an essential part of what it means to be human. Our social systems are characterised by this fundamental drive. Thus, our policies and programmes should be developed with the concept of innovation stimulus in mind and applied broadly among stakeholder groups. Such an approach could be applied both within the firm and within sustainable innovation policymaking processes.

[6] In the field of environmental law and policy the Aarhus Convention (ratified by the European Union) mandates this participation model.

A priority aim of sustainable innovation policy should be to enhance policy responses to, and the participation of, the *innovation constituency*. Small-scale innovators (individuals and in SMEs[7]) are currently poorly supported by government programmes and are not very active in policymaking activities, due to limited time and resources. Positive incentives for their involvement may be needed as well as an institutional vehicle (SI Unit as further elaborated in section 3.1 above) for their participation.

On a more general note, the policy basis for stakeholder involvement is well-established through impact assessment procedures at both the UK and EC Member State levels as part of an inclusive approach to policy and lawmaking functions. Targeted and direct consultation formats, focus groups, surveys and traditional written consultation processes have been combined codified in the standard operating procedures of Government bodies. There is, however, a need to identify and incentivise those constituencies that are not normally involved in policy deliberations (i.e. the innovation constituency referred to above, as well as upstream suppliers and downstream buyers). Further to this point, key stakeholders should feature as an integral part not only in later consultation processes but in policy formulation itself, particularly where scoping or visioning processes of the kind demanded by sustainable innovation policy. They could also be involved in the policy review and learning activities described in section 5 of this paper.

With respect to specific stakeholders, we argue that policymakers will benefit from creating and generating business interest in sustainable innovation as a permanent policy goal – Governance systems do not generally capture this resource, which could be delivered by instilling a spirit of co-operation and promotion of new ideas among primary movers/supporters of innovation. It could be captured in part through the institutional principles raised in section 3.1 of this paper.

As with many policy and lawmaking processes, industry does not often speak with one voice or represent one interest on innovation policy. There may be a need to counterbalance the prevalence of dominant unsustainable technological systems in the interest of smaller scale innovators. As discussed in Section 2.1, one manifestation of 'lock-in' is that actors representing unsustainable yet dominant technologies/technological systems may exert disproportionate control, compared to other key stakeholders, in Government policy-making, consultation and related lawmaking processes. This imbalance can provide a barrier discouraging moves towards sustainable innovation. Both the automobile and energy fields provide examples of policy stigmatism towards small scale technologies, such as fuel cell vehicles or decentralised generation, which may be traced back to current dominant ways of thinking, which are reinforced by the power of vested interests.

Opportunities for the development of more sustainable technologies that challenge the lock-in of current systems could be promoted by implementing greater policy support for the creation and development of niches for such technologies (see Section 2.2 and Kemp *et al*., 1998). Greater democratisation of decision-making processes is one means of obtaining policy correction for this purpose, though the trend towards smaller scale technologies could also be promoted by actively seeking out and incentivising the innovation community in the relevant sector. A similar strategy might be employed to break user-supplier relationships that suffer from lock-in in the absence of

[7] The need for representation of the "innovation constituency" is based on the empirical finding that many important technological systems innovations were made by individuals or groups of individuals who were outside the mainstream established industry in that sector – so-called "disruptive innovation" (Christensen, 1997).

incentives and knowledge, information exchange to introduce new more sustainable innovation techniques, processes and technologies.

Finally, it is prudent to involve the end-user in policy processes and design outcomes as closely as is practical, while encouraging upstream solutions (reward supply stream action that achieves targets on a synergistic basis). Policy incentives for downstream or supply chain user involvement should, where possible, be built into the policy framework. Equally, connections between producers and end-users must be made/reinforced in the regulatory context so that all actors have SI incentives in-built. In the spirit of the European Commission's Integrated Product Policy even final consumers could be given incentives or should, at least, receive information about supporting sustainable innovation in products through their product choices[8].

4. Coherent and integrated mix of policy instruments

As described in Section 2.1, the promotion of sustainable innovation is likely to require a mix of policy instruments, include R&D support, market-based instruments, technology-forcing regulations and voluntary agreements. The project case studies investigated the mix of instruments employed in UK low carbon energy innovation policy, and in EC policy-making processes supporting alternative energy sources in vehicles. These studies showed that ther is often a lack of coherence and integration in the design of the policy mix. For example, in UK low carbon innovation policy, Capital Grants for specific technologies (biomass energy crops and offshore wind) were introduced as an ad hoc measure to address the failure of the main instrument, the Renewables Obligation, to promote the development of a wider range of renewable technologies, other than onshore wind and landfill gas.

These type of examples highlight the need for a more integrated, synergistic mix of processes, policies and instruments, and for ongoing processes that ensure compatibility with existing instruments and anticipate interactions with future instruments.[9]

Such a policy mix would need to consider different instruments for different stages of the innovation process, in order to promote drivers of sustainable innovation and overcome barriers. Key issues include the following:

An *integrated flexible mix* with regulatory backstopping may be appropriate. It may be useful to examine policy development in terms of *pinch–points*. Accordingly, a focus on one or two qualities of a product/technology (e.g., the replacement of dangerous substances, durability) could be all that is needed to make real sustainability gains for given technological systems.

The *structure of markets* is a key issue (so simple prescriptions to rely only on market-based instruments are unlikely to be sufficient). Different mixes could be explored and presented as packages of options for choice by policy decision makers.

The process of determining a mix of instruments that is appropriate to a given policy/regulatory goal could take account of three methodological considerations:

[8] This is already happening in the UK through the use of CO2 dependent vehicle tax

[9] For example (voluntary) environmental agreements and economic instruments are compatible with backdrop legislation whereas positive and negative subsidies/rebates are not, cf. the 1994 draft EC carbon tax (Cameron and Makuch, 1996).

- ***Apply sustainability indicators and sustainable innovation criteria;***
- ***Balance returns on investment/economic efficiency with sustainability gains;***
- ***Utilise a dedicated SI risk assessment tool in developing policy support instruments***.

The project case studies demonstrate the potential for applying the first element to policy development towards carbon reduction in the energy sector and alternative energy sources in vehicles. Sustainable innovation criteria could include the ideas raised in our SI policy process guidance: *encouraging long-term thinking, overcoming lock-in, promoting niche development and technological diversity, encouraging knowledge networks and skills development, broad stakeholder participation*. With respect to balancing activities, the application of the "proportionality principle" of EC policy and law should be employed such that gains in sustainable innovation are proportionate (or are not outweighed by the costs). In this regard, the *ecological footprint* of the emerging technology/technological system, the possibility of *market substitution*, and, the capacity for a *stable supply* of the replacement technology/technique should be examined. Historically, SI policymaking has generally been without risk assessment criteria in determining the possible range of policy winners and losers. In particular, *risk assessment* factors have not been present in deliberations among government bodies over technology/technical assessment. Risk assessment could be a useful tool in advancing SI as a concept because, in so doing, decision-makers will be informed of both the economic and "sustainability" risks that attend new technological systems or systems concepts.

Considering the type of policy instruments which could be used, the EC ETAP (EC, 2004) identified two broad categories: *getting research to market*, and *improving market conditions*. Similarly, the IEA report on 'Creating markets for energy technologies' (IEA, 2000) recommended three broad types of measure:

- Invest in niche markets and learning, in order to improve technology performance and reduce costs;
- Remove or reduce barriers to market development, that are based on instances of market failure;
- Use market transformation techniques that address stakeholders' concerns in adopting new technologies and help to overcome market inertia that can inhibit the take-up of new technologies.

Thus, measures may address promoting research and demonstration of new technologies ('technology-push'), the creation and development of markets ('demand-pull'), and framework conditions, such as other government policies and investment opportunities.

Measures to promote technology-push and getting research to markets could include:

a. **Direct R&D subsidies** – Sustainable innovation-enhancing subsidies should be available provided that they do not violate the 20 % rule under the WTO TRIMs Agreement.

b. Policy support to **Environmental Innovation Network Concepts such as SI Incubators** – This should generally be a feature of all SI policy development processes. Support to SI incubators will enhance innovation modulation cycles.

Measures to promote market- or demand-pull could include:

c. **Investment strategy concepts -** loans or dedicated funding mechanisms of the kind that are emerging under the UK Landfill Tax (which guarantees investment in sustainable waste management activities, among other objectives) are a prime example.

d. **Negative (environmentally damaging or lock-in inducing) subsidies** should be discouraged and phased-out. It is recognised that there can be fierce political resistance to such a prohibition. However, international investment rules are moving in this direction and phase-outs should soften the political and economic side effects of subsidy removal.

e. **Charges** - on processes, products, by-products, environmental damage cost internalisation on a sliding scale according to environmental performance. The tax should be progressive such that products and processes that are sustainable benefit in proportion to the penalties to be attributed to unsustainable processes and products. Such charging systems are in place in large continental European states.

f. **Covenants** – technology foresight programmes are an example of the covenant mechanism.

g. **Voluntary Agreements** – voluntary environmental cost reduction initiatives such as DuPont's Responsible Care programme (a form of product substitution legislation) represent a positive example of non-binding industry self-regulation.

h. **Contractual voluntary agreements towards regulatory targets** – These VAs are generally sector-based. They have been employed in the Netherlands.

i. **Contractual** voluntary agreements in anticipation of regulation – These are generally sector based. They have an explicit structure and tend to feature phased in investment towards improving sustainability on a phased-in basis

j. **Permits/trading** – One of the better examples of this category of instrument is the United States Clean Air Act emissions trading scheme for acid rain emissions, which fostered both emission cuts and technological system modulation to sustainable innovation-type technological systems.

k. **Standards based regulation** – though regulation might be discouraged as a first-choice instrument option, firms continue to cite regulation as a key reason behind technological adaptation. This type of regulation features prescribed units of permissible emission/effluent outputs. It appears in the best available techniques concept of the IPPC Directive.

l. **Target-based regulation** – This instrument is useful in that it can be made to correspond to medium and long-term investment and environmental adaptation strategies. It can also be a key feature of contractual voluntary agreements.

m. **Performance incentive regulation** – This type of instrument specifies technological, technique and process-based performance requirements. It is performance rather than end-of-pipe or end-of stack focused in nature.

n. **Technology regulation** – BAT is the best example of technology regulation as a flexible evolving concept determined by the establishment and period review and updating of installation and activity-specific technologies, techniques and processes.

o. **Eco-labels and awards** – this category is self-explanatory. It is proposed that SI eco-labels and awards should form a discreet new category of the Eco-label regulation. The award scheme could even be applied to emerging rather than market ready technologies.

Measures to address framework conditions could include:

p. **Taxation policy** – Taxation policy should be directed to SI goals rather than general revenue-raising activities. The Landfill Tax provides a sound example. Perhaps the UK Climate Change Levy may also be a useful example depending on the goals to which dedicated revenues are addressed.

q. **Environmental management systems** – Environmental management systems (EMS) are an emerging feature of environmental control in some countries/companies. EMS and environmental audits should be amended to consider SI dimensions rather than mere regulatory compliance or product promotion. Both bottom-up and top-down EMS should have as a specific feature of review processes the opportunity to improve sustainability and economic efficiency through SI.

r. **Consumer environmental/ethical education –** This category is self-explanatory. At some point sustainability performance should feature in the labelling of goods in the same way as ingredients must be identified for our food products.

s. **Integrated product policy –** This is both a process and an instrument. As such, its implementation and effectiveness should be promoted and tracked in SI policy-making processes.

From the outset, each process should review and address potential inconsistencies in policies that touch upon the future policy objective. However, it is recognised that inconsistencies will inevitably occur, and hence, processes of policy learning and review are also needed, as discussed in Section 5.

We recognise that some instruments work well together and others do not. For instance, a voluntary agreement with targeted product recyclability content supported by backdrop legislation work together as the firm will know that it must innovate or otherwise face court action if the voluntary agreement fails. As another example, combining an economic instrument with a regulatory standard will promote both efficiency and effectiveness. As Kemp (1997) reminds us, the United States corporate automobile fuel economy (CAFÉ) standards supported with strict system of fines constituted an effective and efficient policy. An emissions trading scheme along side enforceable targets in an environmental permit for installations does not work as it removes the incentive to participate in the emissions trading scheme.

For an example of how this mix concept might evolve in the European Community, it is instructive to examine an existing policy and regulatory process for the instrument mixing potential that it possesses, even though the "mix" concept is embryonic in nature. At present, the Batteries Directive (91/157/EEC) is in the midst of a European Commission-led consultation process (BDC, 2002). This consultation process is of particular interest for two reasons. First, it is entirely possible that in part, a combination or mix of instruments will be agreed for implementing the revised Directive. At the 15 July 2003 stakeholder consultation, voluntary agreements featured as one of the items on the agenda. It is also noted that economic instruments have been discussed as well as traditional command and control measures. This excellent potential for a mix of instruments is evidenced in the European Commission Consultation Document on the Revision of the Batteries Directive (Consultation, 2003). It is possible that, in the revised Directive, legislative targets will be expressed at both the EC and Member State level, as well as voluntary agreements which can also now be agreed at the EC level. Economic instruments such as deposit return systems and charging systems could also be mandated as a solution to be implemented at the Member State level.

Combinations of instruments will be likely and some may even be integrated. For instance, a Member State legislative instrument may be established which mandates a voluntary agreement, to be contractually negotiated between a Member State and batteries industry trade association. The voluntary agreement would mandate new waste stream monitoring techniques and technologies as well as collection targets to be implemented by firms. The voluntary agreement could feature an economic instrument such as a charging system being put in place to determine battery company contributions to the scheme. In turn, the scheme could be reinforced with backdrop command and control legislation to punish free riders (non-participants) or non-compliant parties. This combination approach is deliberately described, not merely to illustrate the variety of possibilities for instruments selection strategy but also to highlight one of the key proposals that is on the table at present in the negotiations over the revision of the Batteries Directive (Makuch, 2003).

While technology forcing standards will likely continue to be important in creating technology demand-pull scenarios, it may be advantageous to give innovators a window of opportunity to best adapt to emerging standards before they are written into law (Ashford, et al, 1985), so as to allow for appropriate market adjustments and to allow for the emergence of substitute technological systems. Regulatory certainty about standards will be a key factor in generating the demand-pull phenomenon though other supporting instruments are of considerable importance. Normal business reasons, social reasons, pressure from stakeholders, the visibility of an environmental problem, user and other performance benefits should also be considered and are often not best met through command and control regulation (Makuch et al, 2003). Economic instruments, grants and subsidies, environmental agreements, environmental targets, permits, covenants and provisional phase-ins of standards all have a role to play in defining the mix (Kemp, 1997). Equally, it should be noted that, at any point or snapshot in time, the complex interaction of stakeholders, their interests and relative influence, the stages of development and market penetration of competing technological systems as well as competing policy and regulatory priorities cause the modulation of policy development such that instruments mixes must be sufficiently flexible to adapt to these conditions. This is why regular policy review and policy learning activities are important.

5. Role of policy learning and review

In the twin interests of providing a highly responsive tool for modulating paths of sustainable technological systems evolution and removing unintended consequences of adverse policies, it is important to incorporate 'policy learning' as an integral part of SI policy process. This would involve the development of integrated policy review, learning and correction mechanisms as a "looped" process appropriate for the evolution of long term SI policy. This follows from the inherent uncertainties and path dependence of innovation processes and the 'bounded rationality' of actors, including policy-makers, which mean that an 'optimal' mix of policies cannot be identified. Policy learning would improve the evaluation of policy effectiveness, enable correction of the unintended consequences of policy measures, and encourage appropriate responses to new information and knowledge.

Policy review and learning activities might take account of the following steps:

a. **Monitoring and evaluation of policy implementation**. Policy review rounds (content, process, dynamics and knowledge evaluation) could be focused upon an evaluation of the following six elements measured against interim sustainable innovation policy objectives:

- Content of the policy;
- Policy implementation and market dynamics;

- Knowledge gathered;
- Compliance successes;
- Compliance failures;
- Linking policy learning to technology learning, particularly as regards niche development and management.

At this stage, policies or programmes instruments that are failing and cannot be corrected to achieve long term targets should be abandoned in favour of resource reallocation to more successful policies.

b. **Review policy impacts on the process of sustainable innovation itself for the particular sector**. Examine impacts on competing and emerging technological systems to determine whether they have the following features:

- The technological systems that are most favoured are emerging along sustainable pathways;
- They are not dominated by few parties and so represent healthy competition;
- They are not leading to new and unsustainable lock-in situations;
- The strategic paths to sustainable innovation are consensual vis-a-vis civil society;
- Key actors are not missing in the process of moving towards more sustainable technological systems;
- Other forms of participation have been considered.

c. **Learning and policy enrichment** – On the basis of policy programme experiments, case studies or pilot projects:

- What were the most important learning moments/stages/events?
- Was new knowledge generated?
- Were there any unintended consequences and how can they be corrected?
- What are the implications of new knowledge gained for future policies[10]?

Other lessons of policy learning are as follows: In learning how best to address a policy challenge policy makers should familiarise themselves with **approaches in other countries,** particularly competitor's jurisdictions so that best regulation becomes base lines for improvement. This will push forward first mover advantage concepts using the "policy/regulation leap-frog" approach in which, rather than starting from policy point zero, policies leap frog ahead as each new policy process starts from the policy point of the most policy advanced jurisdiction. If implemented, this practice might also end adverse situations in which regulatory outcomes are already behind technological systems evolution as was the case with the phasing out of chlorine in the pulp and paper industry or the phasing out single hulled versus double hulled oil tankers.

Policy learning and review processes could seek to set levels of policy and regulatory stringency aimed at encouraging and stimulating innovation. Stringency levels must be designed to incentivise and reward first movers (tax breaks or whatever else regarding economic instruments). Three points are worth recognising here: a. Treat *status quo* techniques on a level playing field; b. Punish free rider behaviour; c. Advance sustainable innovation through technological system substitution or first mover rewards. Treat locked in unsustainable and

[10] This learning and review methodology is informed by Kemp's ongoing work on "transition management" in the Netherlands (Kemp and Rotmans, 2001).

locked in sustainable technologies/technological systems differently. Be aware of and measure to the extent possible the "sustainable innovation chilling effect" in determining policy stringency levels. This chilling effect can occur where locked-in technologies are unduly rewarded in regulatory processes.

In policy learning and review processes, a check on **policy harmonisation is critical** and should be addressed in the first instance through an institutional co-ordinating/integrating policy body (unit). Policy integration should be the win-win aim, though a minimum task should be to guarantee that there are no policy contradictions. This can be addressed through an institutional body/unit such as the UK's Regulatory Impact Unit (RIU). Areas for policy harmonisation must be identified and evaluated as standard practice [environment, industry, health and safety, intellectual property, consumer, competition, state aids, trade, employment, (environmentally damaging or lock-in technology support) subsidies, WTO-compatibility] in policymaking ventures.

Finally, within policymaking institutions themselves, there is a need to ensure that professionals are familiar with the theory and practice of sustainable innovation from relevant political and civil service leaders through to policy researchers. In this regard, training is required in order to implement sustainable innovation as a concise and clear overarching objective of Government policy. The creation of a compatible disciplinary skill set in the body of the civil service will enhance its capacity to integrate the information and analysis necessary to conducting evidence-based policy making towards sustainable innovation.

6. Conclusion

In this conference paper, we have set out the rationale and some developing ideas for an improved approach to policymaking towards sustainable innovation. We have also presented and analysed in detail four key themes linked to the practical advancement of sustainable innovation policy in an EU and Member State context: *role of public-private and other institutional structures and activities; forms of stakeholder participation; a coherent and integrated mix of instruments;* and *the role of policy review and learning*.

It is hoped that the paper will stimulate discussion and debate during this conference, and will contribute towards making sustainable innovation the subject of more detailed academic and policy scrutiny. We argue that, though policy processes have an inertia and tradition that has evolved roughly evenly with the pace of contemporary society, there is a need to focus the methodology of policymaking on the advancement of sustainable technological systems innovation. While we recognise that there are other key areas, such as sustainable consumption, that need to be addressed within the larger sustainability debate, we hope that this work will contribute to the debate and, more importantly, to informing future policymaking towards socially desirable ends.

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