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SYNTHESIS REPORT ON NATIONAL POLICIES TO SUPPORT ECO-INNOVATION

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NOTE BY THE SECRETARIAT

This document and the three annexes were posted on OLIS in October 2010 for declassification.

Comments received before 31st October 2010 have been taken into account. There was no objection for declassification.

An edited version of the synthesis report and Annexes 2 and 3 will be released as a book in the OECD Studies on Environmental Innovation series.

FOREWORD

This report was developed in the context of the OECD Programme of Work and Budget on eco-innovation. One objective of the programme is to identify best practices to support the development and the deployment of eco-innovation. This work builds on the OECD Innovation Strategy which was released in May 2010. It complements other work done on eco-innovation at the OECD, including on assessing the role of the mix of policy instruments in national policies on eco-innovation and the role that this will play in pursuing green growth strategies.

The report builds on analytical work developed over the last two years, which includes:

- a review of eco-innovation roadmaps developed by European countries under the aegis of the European Commission's Environmental Technology Action Plan; this complements country profiles on policies to support eco-innovation, developed by the OECD Secretariat on eight non European OECD members [see ENV/EPOC/GSP(2008)12/FINAL]; the review was undertaken by a team of WIFO experts, managed by Andreas Reinstaller and Daniela Kletzan-Slamanig.

- case studies on selected technologies. They were developed to explore how certain policies interfere with the production and diffusion of eco-innovation. The following technologies have been selected: electric cars (in Canada and Germany), micro combined heat and power (in Germany), combined heat and power generation (in Canada and Germany), carbon capture and storage (in Canada), solar tiles (in Portugal), biopackaging (in France). The case study on micro combined heat and power was developed by Philippe Larrue and Nicolas Turcat, Technopolis Group. The case study on solar tiles was developed by Jon van Til, Technopolis Group. The case studies on carbon capture and storage, combined heat and power, electric cars and biopackaging were developed by Gilles Le Blanc, CERNA / Mines Paris Tech.

- case studies on selected public-private partnerships. The outcomes of the studies are lessons learned for policy makers on the design of innovative and efficient forms of public private co-operation. Two partnerships have been selected: the Carbon Trust in the UK, Sustainable Development Technology Canada (SDTC), in Canada, based on suggestions received from delegates after the May 2009 meeting. The case study on the Carbon Trust, UK, was developed by Michal Miedzinski and Nelly Bruno (Technopolis Group). The case study on SDTC was developed by Gilles Le Blanc (Cerna / Mines Paris Tech).

- a Global Forum on Environment focused on eco-innovation, organised in November 2009; all relevant information, including proceedings and papers released in the OECD Environmental Working Papers series (Popp, 2009; Ockwell, 2010), is available at www.oecd.org/environment/innovation/globalforum.

The various streams of analytical work benefitted from the generous support of the European Commission (Life+ and ENRTP grants). Xavier Leflaive co-ordinated the whole project and developed the synthesis.

An informal technical workshop was organised in June 2010, with the authors of the case studies, external experts (Carlos Montalvo, TNO; Jens Horbach, University of Applied Sciences Anhalt), the European Commission (Aurelio Politano, ETAP) and the OECD secretariat (Tomoo Machiba, DSTI; Ivan Hascic, ENV). Messages coming from the case studies were discussed and refined.

The report benefitted from comments received from delegates of the OECD Working Party on Global and Structural Policies and Working Party on National Environment Policies at various meetings in 2009 and 2010 and through written procedure thereafter.

The synthesis report and the case studies will be published in the OECD Environmental Innovation series under the title *Better policies to support eco-innovation*.

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EXECUTIVE SUMMARY

This project takes account of the conditions under which eco-innovation policies are developed and operate in OECD countries. It focuses on the linkages between technical and non-technical innovation; the ways in which technological trajectories develop and may eventually segment markets; contextual features that influence the development and diffusion of eco-innovation (*e.g.* market structures); and consistency between instruments developed over time to support eco-innovation. The report also considers timing as a factor in deploying and diffusing particular innovations, as well as co-ordination needs across policy domains (including environment, innovation, competition and industry policies) and levels of government (local, regional and national). This report complements previous OECD work on eco-innovation which has generally focused on the impact of market failures that can impinge on the quantity of environmentally relevant inventions and on the instruments and well-designed policy packages that can remedy those failures.

How to strengthen the policy relevance of national strategies for eco-innovation

Most OECD countries have developed national strategies to support eco-innovation. In Europe, the Environmental Technology Action Plan (ETAP) has invited EU members to develop eco-innovation roadmaps and to report initiatives taken at national and/or local level to support eco-innovation. Outside Europe, a number of OECD countries have similar initiatives; in particular, Korea and the United States have designed explicit strategies to stimulate eco-innovation.

In Europe, national strategies to support eco-innovation have been used to assemble initiatives taken by a number of agencies at national and local level. They have generally not stimulated new initiatives in this area. Nor have they facilitated the emergence of clear policy objectives. The case studies presented in this report show that eco-innovation policies in Europe have sought to address a variety of objectives: bridging the gap from the demonstration phase to commercialisation (*e.g.* in the field of carbon capture and storage, or for micro combined heat and power generation), improving consumer awareness (*e.g.* in the area of biopackaging), defining the most relevant technical trajectory (see Box 1) and standard (*e.g.* for electric cars), and building a critical mass (*e.g.* combined heat and power generation).

As such, European roadmaps are best regarded as benchmark documents. They highlight the diversity of tools and initiatives taken to support eco-innovation, from support for research and development (R&D) to market creation and export promotion. They also highlight the extensive scope of policies with an impact on eco-innovation (from environment to science and technology, industry, transport, competition, and energy policies). Initiatives are taken by public authorities at both national and local levels, and lessons can be learned on how responsibilities are best split between these levels of government. Roadmaps provide a framework to assess the coherence of these policies.

The roadmaps would be even more relevant if they were improved in three ways. First, they could compile more systematic information on the contextual features of the country, including industry structure and domestic market size, key environmental challenges, the knowledge base as regards eco-innovation, and the strength of the domestic venture capital industry. Second, they would be even more informative if they included qualitative information on the design of instruments that underpin eco-innovation policies. Third, benchmarking would be even more relevant if standardised measurement references could be used to assess the impact of specific eco-innovation policies in national contexts. Improvements along these lines would encourage countries to update their eco-innovation roadmaps.

National strategies in non-European countries share a number of features with European roadmaps. However, as the case of Korea illustrates, some tend to be endorsed at the highest political level and have a genuine strategic character.

One issue remains: it is not clear how roadmaps support the development of eco-innovations in areas in which alternative technological trajectories abound. There is a risk that a roadmap, when too narrowly or strictly focused, restricts the scope of technological options that will be explored and impinges on the development of alternative trajectories.

Box 1. Technological trajectory, defined

The concept of technology trajectory refers to a single branch in the evolution of a technological design of a product or service, with nodes representing separate designs. Movement along the technology trajectory is associated with research and development.

The economic literature argues that only a small fraction of the possible directions a technology could have taken materialises. Owing to the institutionalisation of ideas, markets and professions, development of a technology can get "stuck" in one trajectory, and firms and engineers are unable adapt to ideas and innovation from outside. Alternatively, technological trajectories for a given product or service may proliferate, eventually fragmenting markets into segments which substitute poorly for one another. Independent technological trajectories are characterised by limited demand substitution and R&D scope economies.

The concept is useful for analysing the pattern of linkages across submarkets on the demand (substitution) and technological (R&D scope economies) sides. To address this issue, Sutton (1998) suggested introducing the notion of distinct technological trajectories, each associated with a distinct submarket. When products in submarkets are close substitutes, a firm advancing along one trajectory with a large R&D effort will manage to win market shares from firms operating on other trajectories and submarkets. Alternatively, when products in different submarkets are poor substitutes, the market becomes separable into a number of independent submarkets, and a superior R&D effort in one will have little impact on the others.

Sutton illustrates the two cases with the aircraft industry (escalation in the 1920-30s along the technical trajectory defined by the DC3 design from a very diverse landscape of plane types) and the flow meter industry (specific applications for particular types of buyers limit the scope of demand substitution and, despite high R&D intensity, allow for a large number of submarkets, specialised firms, and fragmentation of the industry).

The concept usefully allows for a distinction between markets in which innovation progresses along a single trajectory, and those marked by a continuous proliferation of technological trajectories. This distinction has significant implications for the analysis of the respective roles of market forces (demand, supply) and public policies. Moreover, it is an invitation to take account of the customer side, to evaluate the potential benefits offered by an eco-innovation, in light of existing substitutes and the nature of market competition. The concept has methodological consequences as well: to assess competition between distinct technological trajectories as well as the potential for product substitution and R&D economies of scope, empirical investigations should not be restricted to a particular eco-innovation, but should consider other alternatives and the associated industries.

Source: Adapted from an unpublished methodological note developed by Giles Le Blanc for the Global Forum on Environment focused on eco-innovation, November 2009.

Intertwining technical and non-technical eco-innovation

Eco-innovation is not purely technological; it covers non-technical innovation, including new business models, or adjustments to existing technologies. The case studies examined in this report highlight the long history of selected eco-innovations (such as combined heat and power generation and electric cars) and note that they very often originate outside the environmental domain. For example, carbon capture and storage combines a set of component technologies from the oil, chemical and power generation industries which already exist and are commercially available. Furthermore, a number of eco-innovations are not regarded as particularly "high-tech": for example, biopackaging can improve the environmental performance of the food, drink, cosmetics and pharmaceutical industries, using only mundane resources and mature techniques.

A number of policy messages derive from this. From an environment policy perspective, the issue is not solely to produce new knowledge, although this is obviously important. It is also important to try and make mature technologies more market-friendly, and to support technical and non-technical innovations that can benefit the environment. Capturing innovations originating in non-environmental domains but which potentially benefit the environment as well opens a large spectrum. This means that dedicated eco-innovation policies need to interact with policies developed in other domains, and raises issues of consistency, governance and monitoring across the various policy domains. In particular, from an environmental policy perspective, monitoring could focus more on the environmental potential of innovation-in-use than on the production of new knowledge.

Eco-innovation policies and technical trajectories

When considering the trajectories along which eco-innovations are developed and brought to the market, two opposing patterns tend to emerge in innovative industries, each of which may require policy makers to consider different concepts, instruments and indicators when developing eco-innovation policies.

The first pattern is one of R&D economies of scope and market substitution, which lead to escalation along a single technical trajectory and potentially to a high level of concentration. Typically, only one combined heat and power generation (CHP) technology is used in the market for a given size of applications. In such cases, public R&D expenditure benefits all players in the field; similarly, all firms potentially benefit from market creation mechanisms (*e.g.* performance standards, labels, green procurement). The second pattern emerges when there is no economy of scope for R&D and when demand is split among non-substitutable goods and services. This combination can lead to fragmented and independent submarkets. For instance, electric cars may be characterised by the coexistence of separate trajectories (*e.g.* hybrid, full electric), by specific technologies with little (if any) economies of scope, and by non-substitutable market segments. In such a context, there is a risk that public R&D expenditure will only benefit one trajectory (and one cluster of industries), and that market creation mechanisms will encourage one set of industries at the expense of others.

This links eco-innovation policies to industrial and competition issues. When facing a proliferation of possible technical trajectories, should a government concentrate R&D efforts and budgets on one technological trajectory or encourage a diversity of solutions by simultaneously supporting alternate routes? The first option focuses public support but may generate lock-in effects. The second option fragments R&D efforts and markets, potentially delaying diffusion. The CHP case study shows that Germany and Canada implement different strategies in this area, driven by different policy priorities in specific contexts.

Each pattern generates specific information needs in order to anticipate R&D economies of scope and demand substitution. Monitoring needs to be disaggregated at the level of trajectories. For instance, in the case of electric cars, where technological trajectories proliferate, it is misleading to consider public R&D expenditure at an aggregate level since, in practice, some trajectories (and related market segments) will benefit from public support at the expense of others.

Co-ordination needs, across policies and across time

The case studies make it clear that eco-innovation policies need to be co-ordinated in many ways: instruments accumulate along long time spans; initiatives are taken at national and local levels; co-operation between research and industry is a must; co-operative research can help, within the limits of competition rules.

First, policies to support eco-innovation generally develop and evolve over relatively long periods of time, and coherence among various instruments that are put in place over time can be difficult to maintain. In addition, priorities and needs evolve over time and instruments may have to be revised and adapted. For instance, CHP was initially developed to produce heat and is now seen as a technology to abate carbon emissions and ensure energy security; this shift in priorities is reflected in support policies. Similarly, policies to support micro-CHP in Germany have developed over 30 years; the initial emphasis of policy support was on R&D and has led to important developments and a fragmented marketplace, such that, since 2005, the major instrument is NOW, a joint initiative of several federal ministries, which mainly aims to develop applied research and field tests. Policy makers would benefit from a better understanding of when and how to introduce an instrument, and when and how to phase others out, so as to find a more effective way to introduce sequential policies and ensure an efficient policy mix.

Second, sub-national authorities actively support eco-innovation because they have developed capacities to address environmental concerns at their level, and because they consider environmental goods and services as new engines for growth (see Ontario's initiatives to support manufacturers of electric cars). Co-operation is needed across levels of government and the respective roles of the different layers of government need to be fine-tuned.

Third, co-ordination between research and industry is essential. Deployment matters just as much as development of new knowledge. The main vehicle for deployment, both domestically and internationally (through trade and foreign direct investment), is the private sector. Three issues arise: first, demonstration is an essential step, and governments can bridge the gap between research and industry when markets fail; second, the roadmaps confirm that knowledge transfer networks, incubators and other forms of partnerships can help to circulate information between research and industry; third, some of the case studies (*e.g.* on the Carbon Trust in the United Kingdom) illustrate how public-private partnerships can contribute to effective governance to support eco-innovation and the need to co-ordinate with other policy instruments.

Finally, a high degree of market uncertainty can create an incentive for increased co-operative research in order to pool development risks and share information. The roadmaps identify a number of initiatives in this area. Some of the case studies illustrate concrete co-operation mechanisms; for instance, in Germany, NOW is involved in international co-operation; similarly, the case study on carbon capture and storage identifies opportunities for international co-operation (*e.g.* on common regulation and policy to transport and store carbon in neighbouring countries; on R&D and demonstration subsidies). A lot must be learned about the best vehicles and the limits of alternative co-operation mechanisms, from the perspective of environmental, science, industrial and competition policies.

New models for technology transfer

For reasons alluded to above, technology transfer is essential in the field of eco-innovation. OECD analyses based on patent data measure the international diffusion of green technologies, across OECD countries and with selected emerging economies (China).

Transfers to developing countries topped the policy agenda on climate change mitigation, at COP 15 (Conference of the Parties 15) in December 2009. Discussions at the Global Forum on Environment in November 2009 suggested that international co-operation mechanisms in this area may be misconceived, as they tend to focus on hardware.

Recent research shared at the Global Forum suggests that international co-operation mechanisms are more effective when they strengthen indigenous capacities to develop and/or adjust eco-innovations in developing countries. Building up eco-innovation capabilities in developing countries requires approaches that emphasise flows of underlying knowledge (know-how and know-why) and tacit knowledge. This is not limited to higher education: low-skill jobs may be required to deploy and maintain some green innovations (which are not necessarily high-technology).

It follows that current international policy processes could be complemented by institutional and funding structures that achieve maximum leverage from public investment, both in terms of maximising the impact on indigenous eco-innovation capabilities, and maximising the potential to attract sustained private-sector investment in eco-innovation as opposed to conventional innovation. Precedents currently exist, which provide potentially viable models for a more focused, needs-based approach to building eco-innovation capabilities in developing countries.

THE VALUE OF A STRATEGIC APPROACH: ECO-INNNOVATION ROADMAPS

Most OECD countries have developed national strategies to support eco-innovation. These and related instruments are reported in a series of reference documents. In Europe, the Environmental Technology Action Plan (ETAP) has invited EU members to develop eco-innovation roadmaps to account for initiatives taken at national level to support eco-innovation. Similarly, the OECD Secretariat has compiled country profiles for eight non-EU OECD members (Australia, Canada, Japan, Korea, Mexico, New Zealand, Turkey and the United States) and for China.

Lessons can be learned from the systematic comparison of these policy documents. A project has been undertaken, with the financial support of the European Commission, to assess the ETAP roadmaps with regard to their eco-innovation potential. Country profiles of non-EU members have been used as a benchmark. This section reports on the messages that emerge from this project. The methodology is presented in Annex 1.

Characterisation of roadmaps

Roadmaps can be characterised along three dimensions: governance, steering role and balance.

Governance

Governance describes the structure and processes in place in each country to set priorities, co-ordinate the initiatives of the various agencies involved in policies to support eco-innovation, monitor and assess the initiatives, and revise the roadmap.

The analysis of the ETAP roadmaps shows that countries differ in many respects with regard to governance. The data show that in most countries the two ministries principally in charge of the measures listed in the ETAP roadmap are the ministries in charge of environmental policy and the ministries with economic affairs, innovation and technology policy in their portfolio. This reflects the dual character of the ETAP roadmaps as an instrument of the industrial policy embedded in the Lisbon agenda, and as an instrument to address environmental policy issues.

The country profiles of eight non-EU OECD members made it clear that public resources are increasingly channelled via departments not directly in charge of environment policies (*e.g.* those in charge of energy, agriculture and transport), making inter-agency co-operation even more necessary.

In several OECD countries, ministries dealing with regional development or public works are in charge of measures to support eco-innovation. This is often the case in the new EU member states. Depending on the design of the national innovation system, research support agencies are also often in charge of measures listed in the national eco-innovation strategy. This is the case in the Nordic countries.

Thus, different governance models exist across OECD countries. It is not clear whether the observed patterns are related in any meaningful way to a country’s eco-innovation potential and performance.

Steering role

The question is whether national eco-innovation roadmaps are used as reference documents to steer eco-innovation policies. A roadmap can be compared with the main initiatives taken since it was devised and made public. The question is only relevant for well-developed roadmaps.

The review of ETAP roadmaps indicates that they have usually not spurred new policies: rather, they have been a vehicle to gather and share information and to reorganise measures. For new EU member states, they have also been a way to initiate a policy dialogue on eco-innovation policies.

Some roadmaps are being assessed (Germany) or updated (Austria, Romania, Sweden, possibly Cyprus,[1] Denmark, Hungary, Ireland, Poland and Portugal).

Balance

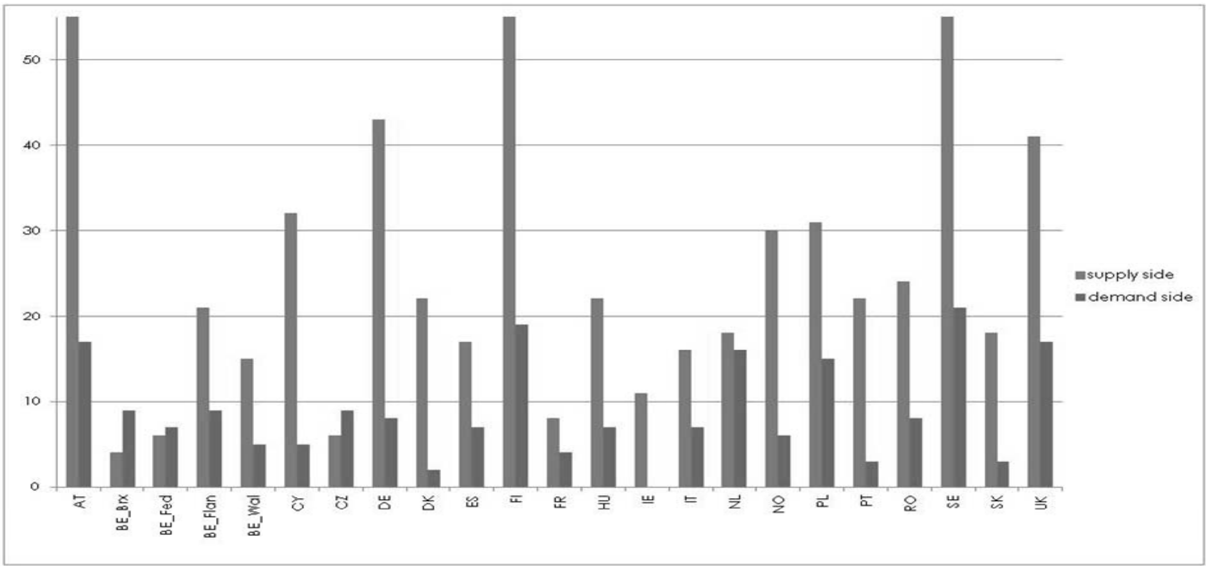
There is growing recognition that effective and efficient policies to support eco-innovation combine investment in innovation activities (technology-push or supply-side measures) and incentives to create markets for innovative products and services (market-pull or demand-side measures; see the following section). It follows that eco-innovation roadmaps can be characterised according to their ambition to combine supply-side and demand-side measures.

The balance of instruments reported in ETAP roadmaps indicates a bias towards supply-side instruments. They emphasise R&D support, the support of networks and partnerships, demonstration and commercialisation; among demand-side measures, information services are most common. The only exceptions are two regions in Belgium and the Czech Republic. Austria, Denmark, Germany, Finland, Norway, Sweden and the United Kingdom are the countries with the greatest difference between the number of supply-side and demand-side measures (Figure 1). At the same time, Austria, Finland, Sweden and the United Kingdom have also deployed quite a sizeable number of demand-side instruments. The Netherlands reports a more balanced policy portfolio.

[1] **Footnote by Turkey.** The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the “Cyprus” issue.

Footnote by all the European Union Member States of the OECD and the European Commission. The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

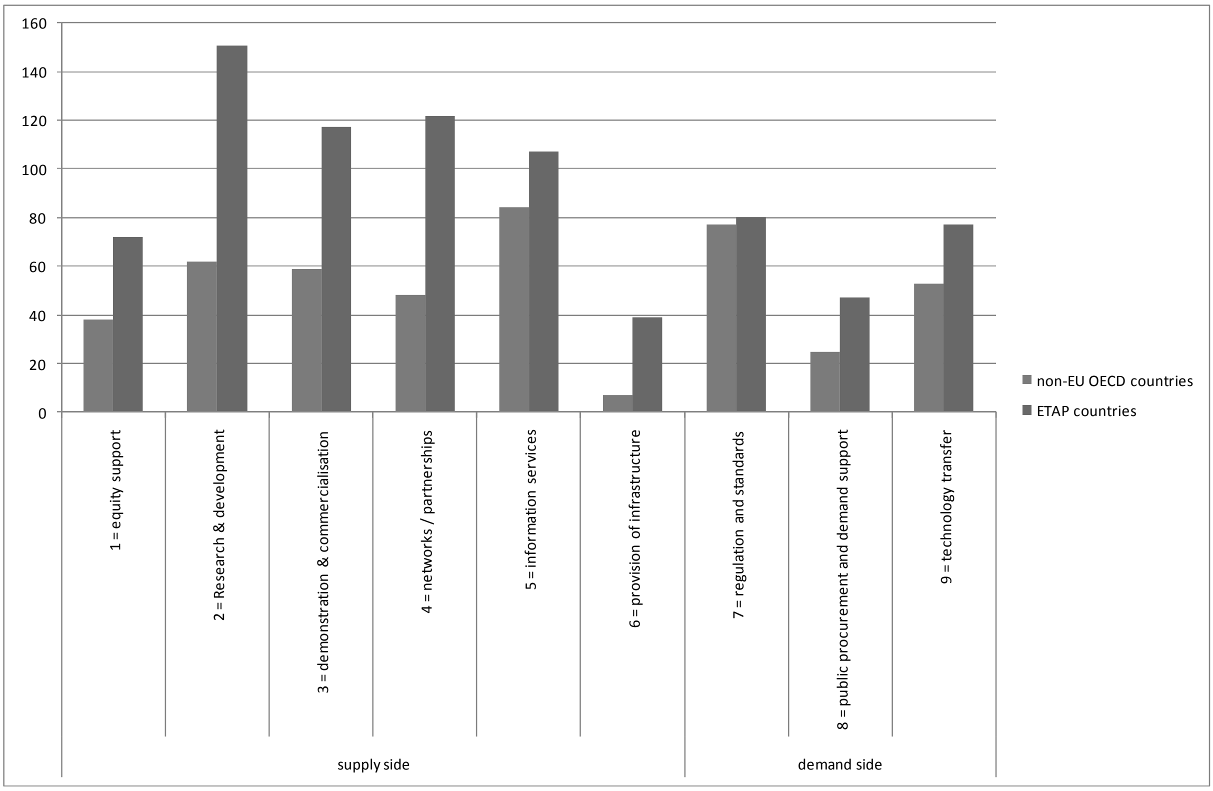
Figure 1. Balance between supply and demand side instruments



Source: WIFO (2009), *Assessment of ETAP Roadmaps with Regard to their Eco-innovation Potential*.

In the profiles of the eight non-EU OECD countries, policies supporting eco-innovation focus on supply-side measures as well, even though the emphasis differs slightly (Figure 2). Information services are quoted more often than R&D support or measures to support demonstration and commercialisation. Another major difference with ETAP roadmaps is the importance of regulations and standards: in terms of the absolute number of reported measures, such instruments play a less prominent role in ETAP countries.

Figure 2. Contrasted profile between EU and selected non-EU OECD countries



Source: WIFO (2009), *Assessment of ETAP Roadmaps with Regard to their Eco-innovation Potential.*

Of course, the number of measures or instruments is not correlated with effectiveness.

Assessing the fit between national roadmaps and contextual features

A preliminary analysis of policies to support eco-innovation in EU and selected non-EU OECD countries (OECD, 2008) has suggested that the context in which these policies evolve can be described in terms of three dimensions which are relevant from a policy perspective:

- The size of the domestic market for environmental goods and services. A large domestic market can be attractive for investors; in such a context, a policy (*e.g.* a standard) may be geared towards satisfying the needs of that particular country; smaller markets may not offer strong enough incentives for technology developers to invest in tailored innovations.

- The knowledge base of a particular economy as regards eco-innovation. The knowledge base of a particular economy is a key capacity on which policies to support eco-innovation can build. Countries with a smaller knowledge base may be more likely to adopt innovations developed abroad.

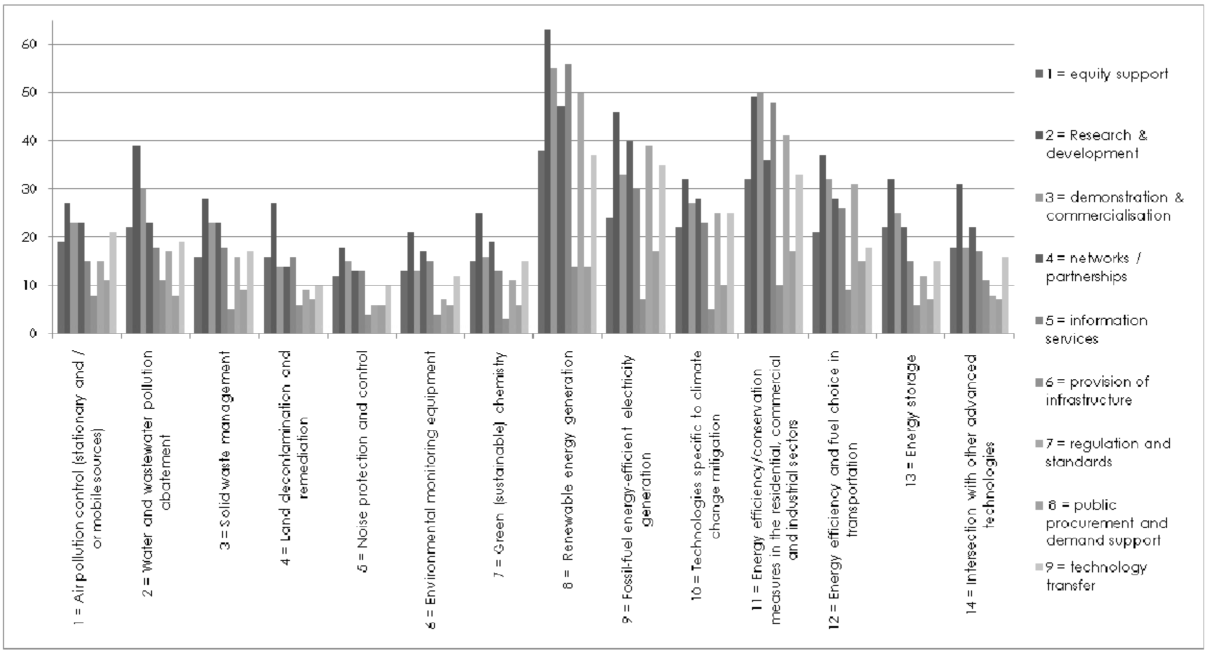
- The vigour of the country's venture capital industry. Venture capital (VC) is a key resource for developing green technologies. Among non-EU OECD countries, the United States is a particular case in point; Korea has taken specific action to stimulate VC for green technologies.

Additional contextual features can be considered, *e.g.* the environmental context of the country; environmental priorities (*e.g.* air, water, waste, etc.); policy areas that receive more attention.[2]

In the project on the assessment of ETAP roadmaps, a classification of countries was developed based on indicators of innovation potential, environmental challenges and framework conditions; a summary list of the countries that reported an ETAP roadmap is appended.

The systematic review of ETAP roadmaps indicates that environmental policy priorities are well reflected in the eco-innovation priorities reported in the roadmaps. Nevertheless, there is a strong bias towards climate change mitigation and (renewable) energy generation. For some countries, environmental priorities in air emissions, waste management, or wastewater treatment are less well reflected in ETAP roadmaps (Figure 3).

Figure 3. Instruments reported in the roadmaps, by technological area



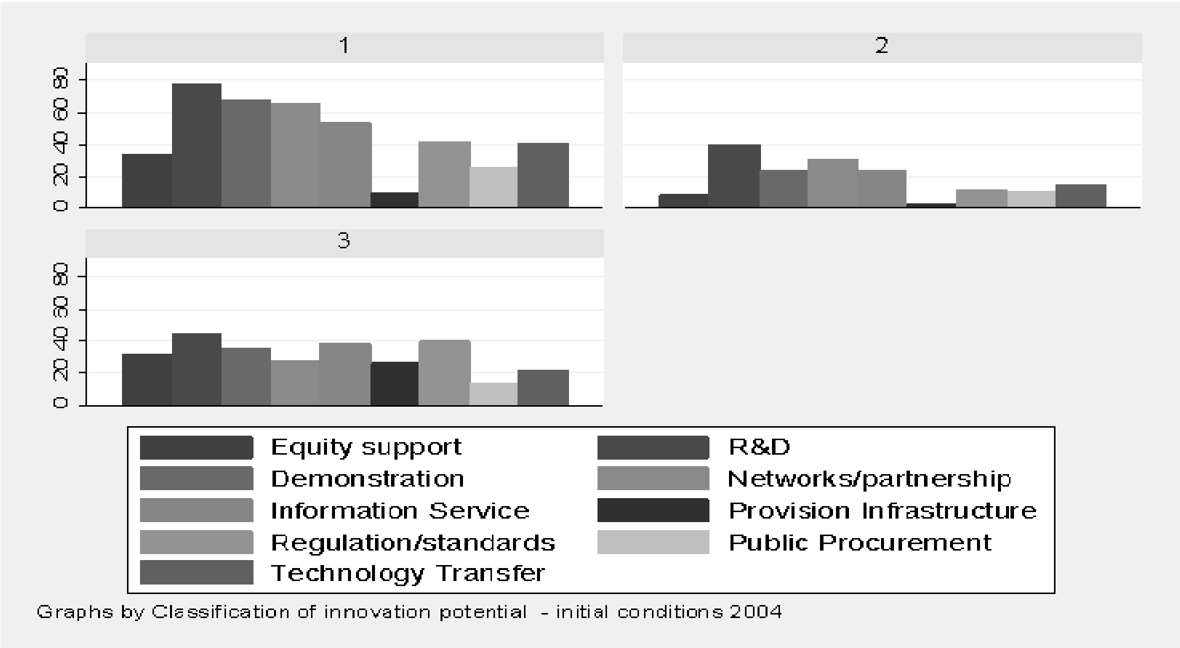
Source: WIFO (2009), *Assessment of ETAP Roadmaps with Regard to their Eco-innovation Potential.*

The review indicates that the choice of instruments to support eco-innovation is related to a country's innovation potential and level of development. Countries with a higher potential for innovation (Group 1, in Figure 4) tend to focus mostly on supply-side measures to support eco-innovation and favour R&D support. Less advanced countries (Group 3 in Figure 4) tend to rely more on demand-side instruments, such as standards and regulations or technology transfer. This reflects their technological capability and their emphasis on the diffusion and adaptation of technologies developed abroad (spillover effect, when regulations in one country spur innovation in other countries). This also suggests that eco-innovation policies will not bridge technological gaps.

[2] See for instance the EU country profiles developed by DG Environment, summarising the environmental situation of different member states, the *OECD Environmental Performance Reviews*, or the *OECD Environmental Outlook to 2030*.

The OECD Innovation Strategy also suggests that countries with small domestic markets or less innovation/knowledge capacity could also develop targeted strategies and focus on specific areas of innovation, such as wind industry in Denmark or water technologies in the Netherlands. They do not need to adopt innovations developed elsewhere.

Figure 4. Principal instruments in ETAP roadmaps by innovation group

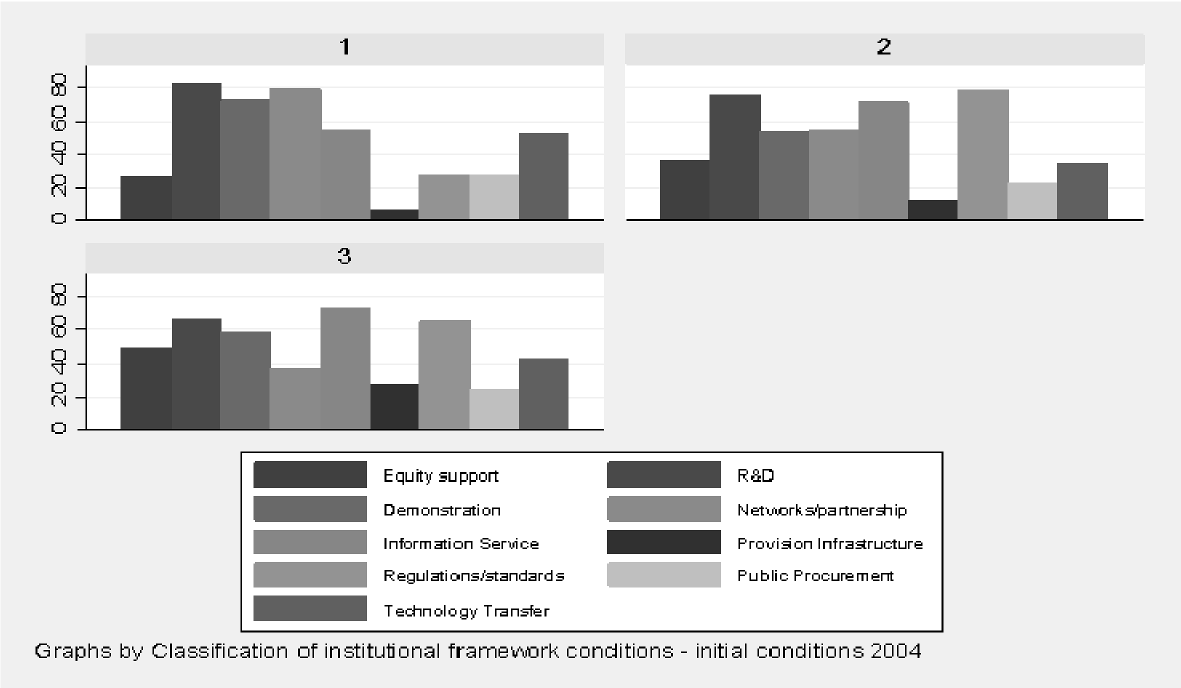


Source: WIFO (2009), *Assessment of ETAP Roadmaps with Regard to their Eco-innovation Potential.*

Finally, the review suggests that countries with the most stringent, most flexible and most transparent environmental regulations (Group 1 in Figure 5) rely more heavily on supply-side measures, whereas countries with less stringent environmental policy regimes and less developed financial markets (Group 3 in Figure 5), on average, more frequently use information services, the provision of infrastructures, and regulations and standards to support eco-innovation. The countries in Group 2 have a more business-friendly, competitive institutional environment with more sophisticated financial markets; they predominantly rely on R&D support, information services, standards and regulations.

These features can explain why particular policies may be appropriate and effective in particular contexts and why some policies may be irrelevant or difficult to replicate in other contexts. Although objectives are not explicitly stated in roadmaps, the analysis of contextual features suggests that eco-innovation policies have a variety of objectives, which do not necessarily coincide, *e.g.* addressing a domestic environmental challenge or building a competitive industry (which may be export-driven). The case studies illustrate some objectives of eco-innovation policies: bridging the gap of the demonstration phase (carbon capture and storage, micro-CHP), improving consumer awareness (biopackaging), defining the most relevant technical trajectory and standard (electric car), or building a critical mass (CHP). These objectives relate to choices in timing and instruments for public intervention.

Figure 5. Principal instruments in ETAP roadmaps by regulatory framework conditions group



Source: WIFO (2009), *Assessment of ETAP Roadmaps with Regard to their Eco-innovation Potential.*

How to make the most of national roadmaps

National strategies to support eco-innovation provide opportunities to co-ordinate a policy dialogue on this complex and multifaceted issue in a whole-of-government approach. Typically, in Europe, ETAP has been a vehicle for systematising and reorganising existing measures in the participating countries. For countries that have been exposed to the European convergence process more recently, ETAP has also been a means to start a policy debate on issues related to eco-innovation.

National strategies are useful as benchmark documents. The knowledge base made from roadmaps (for EU members) and country profiles (for non-European OECD members) has proven very useful. However, some information is missing on policy measures that would make the assessment and benchmarking even more useful. For instance, more qualitative information on the status and design of instruments would be needed to characterise them further and assess their potential impact on eco-innovation; additional information on target, budget (annual or total when appropriate) would be useful as well. In addition, it would be useful for countries to report on policies that were successful and lessons that have been learned from the use of particular policies.

OECD countries could benefit from updating these reference documents and completing the missing information.

INTERTWINING TECHNICAL AND NON-TECHNICAL INNOVATION: FROM CLEAN TECHNOLOGIES TO ECO-INNOVATION

Like innovation in general, eco-innovation is a multifaceted term, which cannot be subsumed under environmental technologies. A more systematic coverage of its scope and focus is of consequence from a policy perspective. In the vein of the discussions at the Global Forum on Environment, this section proposes a balanced approach and emphasises the importance of the pace of diffusion and of alternative patterns of technological trajectories. Policy messages derive from these considerations.

Issues of scope and focus

Two points are emphasised here. First, enhanced environmental performance may derive from innovations in other domains. The case of carbon capture and storage shows how eco-innovation combines a set of component technologies from the oil, chemical and power generation industries that already exist and are commercially available. According to René Kemp, who led the project Measuring Eco-Innovation in Europe, eco-innovation research and data collection should not be limited to products from the environmental goods and services sector or to environmentally motivated innovations but should cover all innovations with an environmental benefit, with research inquiring into the nature of the benefit and motivations for it. Attention should be broadened to include innovation in or oriented towards resource use, energy efficiency, greenhouse gas reduction, waste minimisation, reuse and recycling, new materials (for example nanotechnology-based) and eco-design. It follows that eco-innovation potentially covers generic technologies, which may not be directly acknowledged as environmental technologies. From a policy perspective, a broad portfolio of investments is required.

Box 2. Take-home messages from the study of policies to support biopackaging

Biopackaging is a business-to-consumer sector in which products have a short life cycle. The denomination masks a proliferation of techniques.

This area attracts very little public intervention. Development in this area essentially relies on initiatives from industry, *i.e.* retailers and agro and liquid producers.

The deployment of biopackaging technologies requires high upfront investment in stores and in logistics. In such a competitive market, replacing existing products hardly makes business sense, as higher production costs can neither be reflected in final pricing nor be recouped through revenues from recycling. Return depends on a long-term perspective.

Incentives are very few, except in specific cases where the packaging contributes to product definition, or when the industry anticipates regulation.

In the short term, the most appropriate government initiatives relate to the recycling stage and enhance the business case for biopackaging.

Source: OECD case studies on selected eco-innovations

Second, enhanced environmental performance may derive from a range of complementary changes and investments, new production processes, systems or organisations. In a contribution to the Global Forum on Environment, René Kemp proposes that invention be carefully differentiated from innovation. Too often the two are used as synonyms, especially in innovation studies that rely on patents as the only source of information. Patents are a measure of invention, which may or may not lead to innovation, whereas the majority of innovations are not based on inventions that were developed within the innovating firm itself.

Bleischwitz *et al.* (2009) present three categories of eco-innovations:

- A process innovation is the implementation of an improved production or delivery method; it includes organisational innovation but can also involve tweaking configurations of existing equipment or experimenting with existing processes. It is closely linked to learning. It is associated with such concepts as cleaner production, zero emissions or waste, or material efficiency.

- A product innovation leads to a significantly improved product or service. It may involve eco-design, environmental technology and the dematerialisation of products.

- System innovations are concerned with technological systems, disruptive technologies, as well as all types of system changes. It is associated with life-cycle analysis, cradle-to-cradle, material flow analysis, integrated environmental assessment, closed loop, factor 4 or 10, user-oriented systems, etc.

Many of these innovations are usually not patentable. In the case of carbon capture and storage, the required skills are not all new but derive from skills in a variety of fields. The issue really is to build on such existing skills to meet additional need for carbon capture and storage.

Issues of scope and focus are of some consequence from a policy perspective. Some considerations follow.

Impact, diffusion and pace as features of eco-innovation policies

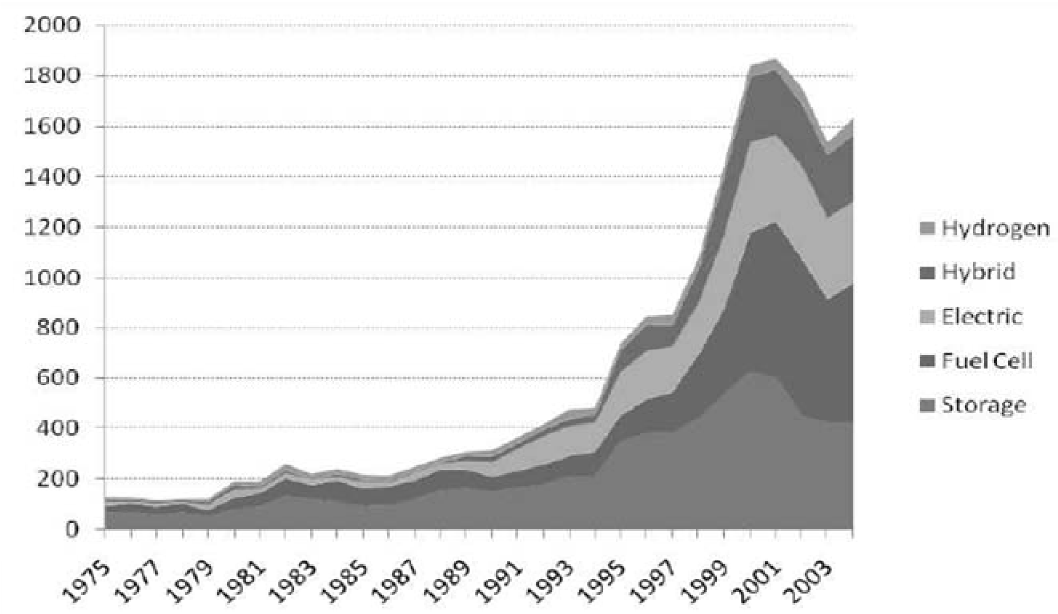
Reid and Miedzinski (2008) claim that eco-innovations should aim to reduce material flows. This may be restrictive (qualities of the flows matter just as much), but points at a feature of eco-innovations and policies that support them: the objective is not to spur new technologies (eventually measured through patents), but to accelerate the improvement of environmental performance (through innovation). The benefits of innovation for the environment only materialise when the innovation is taken up by users and delivers the expected performance.

An implicit assumption made in much of the innovation literature is that more innovation-related activity is always better than less. This may not necessarily be true, especially if it means unnecessary duplication of research efforts. It is at least as important to ask whether optimal use is being made of the existing stock of knowledge as it is to ask how that stock can be expanded (Jaumotte and Pain, 2005). In the current economic context, budgetary constraints and fiscal consolidation add power to this view. It is even more important in the case of eco-innovation, as more eco-innovation does not necessarily lead to improved environmental performance; for instance, Doornbosch and Steenblick (2007) show how eco-innovation can have unintended negative environmental consequences (*e.g.* growing crops to make biofuel can lead to deforestation and increased greenhouse gas emissions). The case of carbon capture and storage also illustrates how the deployment of this technology may conflict with policies to support renewables in Germany.

Also, research outputs are not all of equal value. This is particularly true from an environment policy perspective. What is important is to obtain adequate environmental benefits from the resources being used in the research process and to address any market or policy failures that may be holding back the level of research that takes place. As an illustration, recent OECD research on patents for alternative fuel vehicles (AFVs) indicates that there are more patents on fuel cells (Figure 6), although hybrid vehicles dominate this market segment. This shows that the number of patents is an indication neither of policy relevance, nor of market success or environmental benefit.

Figure 6. Development of Invention with respect to AFVs

Claimed priorities worldwide, 1975-2003



Source: Johnstone, N. and I. Hascic (2008), “Preliminary Indicators of Eco-innovation in Selected Environmental Areas”, ENV/EPOC/WPNEP(2008)7, internal working document, OECD, Paris

In other words, when it comes to eco-innovation, the issue is not so much to stimulate innovation, but to make sure that new technologies will deliver a certain level of environmental performance, on time. In a number of environmental areas (water, climate, eco-system services), time matters and there is some urgency. The pace of eco-innovation diffusion may be critical, in particular when countries face precise deadlines, *e.g.* access to safe water supply according to the Millennium Development Goals (MGDs) or emission reduction targets under the Kyoto protocol, or when urgent action is required.

Time is thus an issue: How much time does it take to develop an innovative process, product or service, deploy it, and see the environmental benefit? From a policy perspective, the issue then is: What policy mix can best shorten that delay? Time here does not necessarily refer to the creation of new knowledge. It more aptly refers to the deployment and diffusion of eco-innovations. This explains why policies to support micro-CHP in Germany have shifted from long-term perspectives to closer-to-market applications.

Two policy issues derive from these considerations:

- Effective eco-innovation policies deal with speeding up innovation delivery and the uptake of innovative technologies; diffusion and delivery of environmental performance are key dimensions of eco-innovation policies. In many areas, innovative technologies are already available and need to be brought together in appropriate demonstration projects (*e.g.* Smart Energy Home, F3 Factory for the future for sustainable chemistry in Europe).

- Policies to support eco-innovation must be evaluated against tight timelines for delivering solution and achieving enhanced environmental performance.

These considerations are explored below.

Policy mixes that induce the diffusion of eco-innovation

Very little is known about induced innovation diffusion. Diaz-Rainey (2009) defines it as any intervention that aims to alter the speed and/or total level of adoption of an innovation, and notes that the concept remains elusive. The literature is sparse, although it is mostly focused on environmental innovation.

From a theoretical perspective, induced diffusion may not be desirable. For instance, as reported by Diaz-Rainey, subsidies for technology adoption may not increase welfare. Therefore, it is only desirable to accelerate the diffusion of eco-innovations that will increase welfare for the wider community.

Empirical research indicates that diffusion can be induced. This may be of importance from an environmental policy perspective, as the environmental benefit of eco-innovation will depend on the pace and level of diffusion. Case studies of selected eco-innovations point at several factors which hinder the deployment of mature technologies: conflict of interests (in the case of combined heat and power generation), market uncertainties and network externalities (in the case of electric cars). Here, policy makers can mobilise a broad array of instruments to induce the diffusion of eco-innovation. Empirical evidence reviewed by Diaz-Rainey suggests that command and control instruments may be just as effective as market-focused instruments in terms of speeding up eco-innovations.

Box 3. Take-home messages from the study of policies to support combined heat and power generation (CHP)

CHP is a proven technology that has been on the market for more than four decades. It is an example of technological variety, segmented by size and users. The alternative technologies do not compete with one another.

The main challenge in this area is return on investment. The latter is essentially driven by input and output prices, hence the uncertainty that derives from erratic oil prices and the relevance of feed-in tariffs as a policy instrument.

CHP is at the crossroad of a number of policy goals: development of renewable energy sources, reduction of carbon emissions, and development of business opportunities (typically for biogas CHP technologies). It was initially developed to produce heat and now is seen as a technology for reducing carbon emissions and ensuring energy security. This can lead to possible contradictions, unintended consequences or inconsistencies.

CHP is a cost-effective technology, the diffusion of which is hindered by a market failure. There is a conflict of interest between energy users and suppliers *vis-à-vis* CHP. Command and control (*i.e.* make the use of heat mandatory when energy is produced) may be appropriate to remedy this market failure.

Canada supports CHP at a generic level, through wide, non-specific instruments; the absence of a targeted federal policy leads to fragmentation of the field and suboptimal arrangements. In Germany, CHP benefits from a variety of instruments, in combination with incentives for renewables (biomass). Germany uses precise and targeted instruments (*e.g.* feed-in tariffs tailored to the size of the equipment, the fuel used). This requires additional information.

Source: OECD case studies on selected eco-innovations

To decide on the most appropriate mix, one needs to take account of the heterogeneity of adopters of the innovations and to better understand their environment. Exploratory methods, including case studies, may be best suited to discover the non-economic barriers to adoption and the detailed interaction between instruments that support the diffusion of eco-innovation. A refined analytical framework may help to cluster technologies into homogenous types and to adjust policy responses.

Looking for a complex combination of indicators

As flagged by an expert from the US Environmental Protection Agency (USEPA) at the Global Forum on Environment on eco-innovation, investments in environmental innovation are intended to satisfy multiple policy objectives. For example, economic growth and job creation are critical outcomes for all programmes being funded under the American Recovery and Reinvestment Act of 2009 (ARRA, the so-called “Recovery Act”). Combined heat and power generation contributes to heat production, reduction of carbon emissions and energy security.

One environmental innovation currently under development in the United States is the Recovery through Retrofit initiative, which is intended to reduce energy costs for middle class families through residential weatherisation and energy efficiency, while creating jobs and reducing greenhouse gases. Integrating the programmes of several US government agencies, the initiative will establish standardised methods of measuring and reporting home energy efficiency, develop financing mechanisms to stimulate demand for weatherisation activities, and standardise workforce and entrepreneurial training to support implementation of the initiative. The measurement and reporting components of this initiative are central to achieving the multi-goal objectives. With more than USD 100 billion of green investments contained in the Recovery Act, there are many other examples of multi-objective environmental innovations.

At the same time, there remain many gaps in the measurement system that will need to be filled in order to realise economic revitalisation and environmental sustainability. These gaps exist because many organisations investing in environmental innovation were not set up to measure environmental outcomes. Analysis of market demand and penetration, the linking of behavioural change to environmental outcomes, and *ex ante/ex post* estimation of environmental impacts will all be important investments in support of a robust system of environmental innovation.

The Irish Environmental Protection Agency (EPA) has echoed this view. Stated objectives of eco-innovation policies in Ireland include: supporting the continued development of the environmental goods and services sector; contributing to environmental protection by delivering applicable and relevant solutions, information and knowledge; and promoting the integration of eco-innovation into all relevant sectors. This suggests that measurement systems for eco-innovation can only be useful if they are flexible, robust and multi-dimensional. The Irish EPA has outlined some practical outcomes in the areas of environmental technologies and innovation in its recent report *Innovation for a Green Economy – Environment and Technology: A win-win story.* Indicators used in the report reveal the interests of policy makers and the many dimensions of policies that support eco-innovation.

In a similar vein, Environment Canada is developing and assessing environmental performance indicators used (or to be used) by federally supported environmental technology programs.

For measuring eco-innovation, no single method or indicator is likely to suffice. In general, different methods need to be combined. In particular, more effort could be devoted to direct measurement of innovation output. The advantage is that it measures environmental performance rather than innovation inputs (such as R&D expenditures) or an intermediary output measure (such as patents). Innovation can also be measured indirectly through changes in resource efficiency and productivity. These two avenues are underexplored and could receive more attention, in order to augment the existing knowledge base (see OECD, 2010, in particular Chapter 4). The way the UK Carbon Trust reviews and communicates its results is interesting as it covers some of these dimensions, including the reduction in carbon dioxide (CO_2) emissions (see Box 4).

Box 4. Measurement of the impact of eco-innovation policies by the UK Carbon Trust

According to the Carbon Trust's assessments, the organisation has contributed to saving over 23 Mt CO_2 as of 2009, delivering costs savings of around GBP 1.4 billion (Carbon Trust, 2009). It has helped drive around GBP 1 billion of additional investment into the development and deployment of low-carbon technologies, markets, products and services. The organisation supported the development of over 250 new low-carbon technology projects and companies in the United Kingdom. The Carbon Trust Footprinting Company has certified the carbon footprints of over 2 500 products and awarded the Carbon Reduction Label to more than 2 000.

Over the financial year 2008/09, the Carbon Trust has supported 30 000 customers, saving companies up to GBP 227 million in direct costs and cutting up to 2 million tonnes of CO_2 from their annual emissions. The Trust leveraged some GBP 300 million of private investment in carbon reduction and low-carbon technology projects and delivered carbon savings cost effectively at GBP 4-6 per tonne of carbon saved. The organisation has offered GBP 22.3 million in interest-free energy efficiency loans to businesses and the Carbon Trust Standard Company has certified 71 companies to the Carbon Trust Standard.

The Carbon Trust also launched three major projects to accelerate the deployment of low-carbon energy technologies, including a GBP 30 million flagship project with the offshore wind industry (Technology Accelerator) to cut the cost of offshore wind energy by 10%. It has signed a contract with the China Energy Conservation Investment Corporation to set up a joint venture company to help businesses that have decided establish a presence in Chinese low-carbon technology markets.

The satisfaction of clients is taken into consideration as well. Out of all Carbon Trust customers who received specific guidance or advice between April 2005 and March 2006 80% were satisfied with the service received (NAO, 2007). Over three-quarters of respondents considered that they had received sufficient advice to reduce their CO_2 emissions. Among respondents, 76% said that they would not have implemented the same level of energy or carbon savings without the intervention of the Carbon Trust, while 20% said they would have made the same changes anyway.

Source: OECD case study on the Carbon Trust.

Technological trajectories and market fragmentation

The technological landscape of eco-innovation is quite complex and often covers a large variety of distinct technical solutions. Two opposing patterns emerge in high-technology and innovative industries. The first combines economies of scope for R&D and demand substitution. It is a pattern of R&D escalation along a single technical trajectory, leading to a high level of concentration. The second involves the impossibility of demand substitution. It is a pattern of proliferation of technical trajectories and their associated submarkets. Sutton illustrates the two cases with the aircraft industry (escalation in the 1920-30s along the technical trajectory defined by the DC3 design from a very diverse landscape of plane types) and the flow-meter industry (specific applications for particular types of buyers limit the scope of demand substitution and, despite a high-level of R&D intensity, allow for a large number of submarkets and of specialised firms, and fragmentation of the industry). Among the case studies developed in this project, micro-CHP tends to follow a single trajectory; carbon capture and storage follows three trajectories, with some common elements; in the case of combined heat and power generation, technological variety is segmented by size and users; the electric car and biopackaging are marked by technology proliferation, with no (or very few) common elements.

Box 5. Take-home messages from the study of policies to support electric cars

This is a business-to-consumer industry, marked by the proliferation of vehicles and technological trajectories (hybrid, fully electric cars). It is characterised by large uncertainties on a variety of dimensions: technological, regulatory, consumer behaviour and economic. In addition, the sector faces high network externalities; in such a context, the winner takes all and the losers lose heavily. This results in suboptimal levels of innovation.

A number of consequences follow, from a policy perspective:

- experimentation is required to produce some of the missing information and real innovation;
- a balance has to be found between inertia and the costs of switching from traditional combustion to electric cars;
- the electric car relates to smart grids (because it takes a smart grid to access the sophisticated pricing system needed);
- a critical size is required, to generate positive network externalities.

The case highlights how initial conditions drive the ways in which experimentation is organised. In Canada, provincial and municipal authorities are demonstrating leadership to stimulate the development of demand and infrastructure for electric vehicles, often in close collaboration with industry (e.g. car manufacturers and utilities). This is leading to experimentation and demonstration at the local and regional scale that could later be applied more broadly. In Germany, initiatives are taken by car manufacturers, including newcomers. In France, initiatives follow a national plan, co-ordinated by the central government; the plan sets domestic targets and essentially supports one manufacturer.

The case highlights timing issues as well. Because of uncertainty and the variety of competing trajectories, standardisation is required, which may generate positive externalities. The question is: When is the best time to set standards? Setting standards too early can raise competition issues; setting standards too late may lead to irreversible effects, wastage of financial resources and duplication of efforts.

Source : OECD case studies on selected eco-innovations.

These patterns are of consequence from a policy perspective. When products in submarkets are close substitutes, one firm advancing along one trajectory with a large R&D effort will manage to win market shares from firms operating with other trajectories and submarkets; similarly, public support for R&D will benefit a wide community. According to the same logic, when products in different submarkets are poor substitutes and R&D efforts in one area do not benefit other submarkets, fragmented and independent submarkets develop, and a superior R&D effort in one submarket will have little impact on the others; this raises irreversibility issues for public support or for firms' R&D effort. Among other things, it calls for a qualification of the indicator for public R&D expenditures. In some contexts, it may be too aggregate to be meaningful from a policy perspective; for instance, in the case of electric and hybrid vehicles, an aggregate figure for R&D efforts may be misleading, as expenditures in one technology area do not benefit others. This reflects Sutton's notion of distinct technological trajectories, each associated with a distinct submarket (Sutton, 1998).

This framework potentially has significant implications for the analysis of the respective roles of market forces (demand, supply) and public policies in the development and deployment of eco-innovations. The development of alternative technologies may lead to a suboptimal level of innovation, as it adds to the uncertainty firms have to cope with. The case of electric vehicles suggests that policy responses may include experimentation (to produce information and real innovation) and standardisation (to reduce uncertainty). Timing is crucial, as too early a response may generate competition biases, and too late a one may result in irreversible effects and the duplication of efforts.

As suggested by Le Blanc in a contribution to the Global Forum on Environment on eco-innovation, this line of reasoning requires a definition of overall utility in the market considered, a comprehensive identification of the various technical solutions available to answer this need, including environmental ones, and a careful examination of substitution and scope for R&D economies between them. It calls for a refinement of demand-side measures to support eco-innovation: the structure of markets, based on more or less substitutable technologies and market segments, is important. Governments would benefit from a better understanding of what drives the development patterns identified above as this may condition the effectiveness and costs of policies to support eco-innovation.

JOINING UP AN ARRAY OF POLICIES: CO-ORDINATION NEEDS

This section analyses the need for co-ordination to drive the effectiveness and efficiency of eco-innovation policies. It first emphasises policy accumulation during long periods of time. It looks next at the combination of national and local initiatives. It then turns to the joining of research and industry; particular attention is paid to policies to support new firms, as they play a particular role in the development and deployment of eco-innovation. Finally, it considers the role of public-private partnerships.

From the design of policy instruments to the review of policy accumulation

ETAP roadmaps and country profiles developed by the OECD Secretariat confirm that countries implement a variety of policies to stimulate eco-innovation. This is justified on two grounds. First, different policies are needed at different stages of the innovation process; for instance, pricing mechanisms and taxes are more likely to stimulate market-ready innovation (OECD, forthcoming). Second, different policies are needed to address different market failures; for instance, basic R&D provided by public research institutions can be used when the outcome cannot be appropriated by a private firm.

This makes the design of eco-innovation policies complex. Optimising the design of individual instruments makes more sense in the context of policy packages. Moreover, as eco-innovation policies accumulate over long periods of time, one cannot presume that such accumulation is consistent. This vein of reasoning is explored below.

Combining policy instruments into effective packages

Recent modelling work on endogenous directed technological change confirms that the most efficient policies to spur a low-carbon economy combine a portfolio of instruments, involving carbon pricing, R&D support for green innovations, removal of non-market barriers to ease the shift from dirty to green technologies, and subsidies for transfers of clean technology to developing countries (Acemoglu *et al*., 2010). Typically, pricing the externality should be combined with long-term investment by governments and firms if technological change is too costly, too risky, too-long term or cannot be appropriated by firms.

The case studies on selected technologies reveal the diversity of policy instruments in use. For instance, policies to support micro-CHP in Germany combine research programmes, demonstration projects, field tests, feed-in tariffs, regulations, upfront investment and financial support, planning, and governance. This diversity should be comprehensively reviewed to evaluate the impact of public policies on innovation creation and diffusion. One size does not fit all and the final outcome crucially depends on the composition, relevance and coherence of the policy mix implemented in each case.

A lot of attention has been paid to the design of the policy instruments that will best support eco-innovation. Less work has been devoted to the design of policy packages. Montalvo (2002) claims that policy packages are specific to the goal, subject and context and have a limited lifespan. Braathen (2007) considers how such mixes can stimulate environment-related innovation. While market-based instruments can provide important incentives for research and innovation, it may also be useful to introduce complementary measures to promote technological innovation directly. For example, in the area of non-point sources of water pollution, the provision of financial support to develop better feedstuffs for animals has played an important role in addressing nutrient run-off in Denmark and the Netherlands, in combination with their respective nutrients accounting systems. Similar conclusions derive from recent OECD research on environmental taxation (OECD, forthcoming): in cases of split incentives, it is necessary to know the impact of changes in taxes and additional measures such as regulation and/or information campaigns.

Braathen argues that the efficiency and effectiveness of instrument mixes depend upon proper targeting of financial support programmes. For instance, providing subsidies for R&D may undermine the environmental effectiveness and economic efficiency of the instrument mix, if these subsidies are not properly designed and targeted. It is important to ensure that financial support provides an incentive for technological innovations with a positive return for society as a whole, and that these innovations would not have occurred otherwise. It is noteworthy that the better targeting of measures can also entail significant additional administrative costs: there is a trade-off here.

Timing and policy accumulation as driving features of eco-innovation policies

Timing, a critical dimension

The case studies on selected eco-innovations suggest that timing is critical. The case study on micro-CHP in Germany provides a good illustration. In 2002, a CHP law introduced a feed-in tariff for electricity produced through CHP; the tariff includes a bonus supported by the government. According to Cames *et al.* (2005), as fuel cells are still at the stage of product development and field testing, this bonus will not be sufficient to lift fuel-cell-based micro-CHP technology over the breakeven point and facilitate market entry. On the contrary, some boiler developers claim that the current difference between feed-in tariffs (output) and the price of natural gas (input) is sufficient to cover the high acquisition costs over the expected lifetime of the system. The case studies of selected eco-innovations thus highlight a number of timing issues: When to shift from demonstration to market support (*e.g.* micro-CHP)? At what time should standards be introduced to generate positive externalities while avoiding competition biases and/or replication of efforts (*e.g.* electric cars)?

Box 6. Take-home messages from the study of policies to support micro-CHP generation

The case describes comprehensive policy mixes which may not be coherent: incentives may be inconsistent, and elements may be missing. Typically, poor governance has limited the development of the sector in Germany; the NOW programme reflects the new priority given to interactions between stakeholders.

Micro-CHP remains a risky technology. It is a case for a stable (and sustainable) policy framework: in Germany, CHP law and feed-in tariffs give long-term confidence to investors.

Policies in this area are marked by two shifts: from long-term to short-term (closer to market) applications; from a single stage to a multistage approach (looking for breakthrough technologies).

The case also shows the operational issues related to timing: When does the demonstration phase end and when does market support begin?

Source : OECD case studies on selected eco-innovations.

It follows that the effectiveness and cost efficiency of the tariff policy depends on its timing with the development of technological options. Inappropriate timing can increase the cost of public support. Green public procurement can be very costly and quite ineffective if there is only a limited supply of greener goods and services. The micro-CHP case study suggests that more work is needed to improve the co-ordination of policy packages over time.

Taking account of policy accumulation

Policy packages are supposed to be designed in a coherent way. They do not account for cases in which a variety of instruments accumulates over long periods of time. Chappin *et al.* (2009) suggest investigating policy accumulation and the implementation of "a mixture of policy instruments with a variety of underlying mechanisms to enable the achievement of policy goals". Attention should be paid to the growing variety of instruments, the (in)consistencies between the associated mechanisms, and the temporal aspect (continuity or change, potential clustering of instruments in a short period of time). Their empirical application to the case of CHP adoption in the Dutch paper and board industry over a 40-year period demonstrates the differentiated role of policies in different time periods. The results reveal different effects: some instruments reinforce each other, new instruments disturb situations originating from earlier policy instruments, and negative risk-adverse firm behaviour is triggered by several instruments implemented in a short time span.

The case study on micro-CHP in Germany indicates that policies have developed over 30 years. The initial emphasis was on R&D. It covered a wide array of topics and did not systematically focus on fuel cells and micro-CHP: systems analysis, analytics, production engineering, electrochemistry, modelling and simulation, catalysis and reaction engineering, or process and system engineering. At the turn of the century, micro-CHP benefited from a wider programme targeted at hydrogen technologies (ZIP programme); the programme facilitated fuel cell development, including for micro-CHP applications. This has led to important developments and a fragmented field: different norms, technologies and partnerships coexisted and hindered further development and market entry. In that context, developers and energy suppliers understood the need to have a large, co-ordinated programme: since 2005, the major instrument to develop the fuel-cell-based micro-CHP technology is NIP (National Hydrogen and Fuel Cell Technology Innovation Programme), a joint initiative of several federal ministries which focuses mainly on developing applied research and field tests.

Unintended consequences of policies are just as relevant as intended ones.

Combining national and local efforts

The country profiles flag the numerous initiatives taken at local, sub-sovereign level to support eco-innovation. Sub-national entities are involved, because some environmental problems require local responses. This is the rationale for Korea's regional environmental technology development centres. Universities, administrative agencies, research institutes, industries and non-governmental organisations constitute regional environmental technology development centres which attempt to solve unique local environmental problems collectively. The responsibilities of each centre include analysis and study of local environmental pollution, development of environmental technology, environmental education and technical support to enterprises coping with environmental management problems, dissemination of new environmental technologies, and promotion and education regarding new environmental technologies to local people.

Sub-national authorities also actively support eco-innovation because they have developed capacities to address environmental concerns at their level and because they consider the development of environmental goods and services as a new engine for growth. Illustrations abound: regional economic development is one of the rationales for public support for solar tiles in Portugal; the German *Länder* join with the federal government to fund R&D for fuel cells and micro-CHP; Ontario supports the development of electric cars by car manufacturers located in the province. In the United States, states take a number of initiatives with or without federal support: they have a (limited) capacity to finance R&D directly. They also take initiatives essentially to bridge the gap between research and markets, often in collaboration. Important measures, increasingly in use at local and state level, have to do with performance standards such as requirements for green buildings or portfolio standards for renewable energy.

Box 7. Take-home messages from the study of policies to support solar tiles in Portugal

Solar tiles are a niche of the solar photovoltaic domain. These products fit well into Portuguese traditions in architecture and construction, but still face a number of technical challenges. A specific type of tiles is being developed by a Portuguese consortium that comprises industry (ceramics), research (from the ceramics, photovoltaics and coating sectors) and the government. The Energy Agency initiated the consortium as part of a portfolio of initiatives to support renewables; it will see that knowledge produced by the consortium is disseminated at the end of the project. Users are imperfectly represented in the consortium (photovoltaic market).

Building on accumulated knowledge in related fields, the project aims to develop a proof of concept. This stage of the project benefits from generic innovation incentives (via the National Strategic Reference Framework of Portugal, the Ministry of Economy and Innovation, and the Energy Agency). At later stages, other instruments will be available, with a view to engaging industry further and to stimulating demand (including feed-in tariffs and tax exemptions). Current standards regarding renewable energy in buildings are technology-prescriptive and tend to favour alternative options; members of the consortium claim that the standards should be revised and become more flexible as regards the technology. The demand side of the market will need to be mobilised further.

The stakes are high as regional authorities see opportunities to stimulate the tiles industry, for domestic markets and exports in the Mediterranean.

Source: OECD case studies on selected eco-innovations

It is not clear when and how national and local initiatives come together. Additional research in this area would be useful, in particular in the context of fiscal consolidation (when public finance is particularly scarce) and of green growth policies: What is the role of central/federal governments *vis-à-vis* local initiatives? What national framework is particularly capable of inducing co-ordinated local action?

Joining research and industry

The eight country profiles of non-EU OECD members indicate that the role of research organisations is being redefined to intensify linkages with the private sector and stimulate the development of marketable outputs. In the United States, the Department of Energy runs the Technology Commercialization Fund (TCF) to complement angel investment or early-stage corporate product development. The Fund brings the DoE's national laboratories and industry together to identify technologies that are promising but face the "Valley of Death" of commercialisation. It makes matching funds available to private-sector partners who wish to deploy the identified technologies. Incubators in the United States and the National Institute of Advanced Industrial Science and Technology's (AIST) Technology Licensing Office in Japan illustrate innovative arrangements in this area.

Attracting private funds to finance environmental R&D is another major policy orientation. The main issue is to reduce risks for private investors investing in environmental R&D projects, while making sure that public money is used effectively and does not crowd out private initiatives. A variety of funds have been established to reduce risks to private investors (*e.g.* Sustainable Technology Development Canada), or incubators (*e.g.* The Clean Energy Alliance in the United States, the Environmental Technology Business Incubator in Korea). Measures are taken to stimulate the venture capital industry and to provide incentives for environment-related projects; this is the role of the Environmental Venture Fund in Korea (see below).

Knowledge transfer networks (KTNs) are an interesting way to bring research and industry together. In the United Kingdom, a knowledge transfer network is a group of individuals/organisations with a shared interest in an area of emerging technology. It provides an easy means of acquiring and sharing knowledge, and hence, participating in shaping the future of a strategically important technology in the United Kingdom. KTNs have been set up and are funded by government, industry and academia. They bring together diverse organisations and provide activities and initiatives that promote the exchange of knowledge and the stimulation of innovation in these communities. There are currently 25 KTNs with a membership of around 45 000, now funded by the Technology Strategy Board. KTNs are playing an increasingly important role in the development of the Technology Strategy Board's future direction with a view to improving the United Kingdom's innovation performance by increasing the breadth and depth, or the knowledge transfer, of technology in UK-based businesses and by accelerating the rate at which this process occurs. The Global Forum on Environment has been an opportunity to share experience on KTNs and the results of a recent review of their performance (see Box below).

Box 8. The performance of knowledge transfer networks in the United Kingdom

During 2008 a review of the knowledge transfer networks was carried out to assess their current effectiveness and scope. The comprehensive review, which obtained views from 2 100 KTN users and R&D-intensive businesses, strongly confirmed the value of the networks: 75% of business respondents rated KTN services as effective or highly effective. Over 50% have developed, or are developing, new R&D or commercial relationships with people met through a KTN and 25% have made changes to their innovation activities as a result of their engagement. The most highly rated functions of KTNs, according to the survey, are monitoring and reporting on technologies, applications and markets; providing high-quality networking opportunities; and identifying and prioritising key innovation-related issues and challenges. The review also emphasised the strong benefits brought to the KTN programme by links with a wide range of partners. KTNs engage with trade associations, technology providers, research councils, regional development agencies and devolved administrations to deliver benefits to businesses of all sizes.

The review highlighted an opportunity to refocus the work of the KTNs, by optimising the coverage of business and technology sectors and by creating a more targeted, comprehensive and accessible range of network resources to help accelerate innovation. Plans are also advanced to establish new KTNs in some areas, for example energy generation and supply.

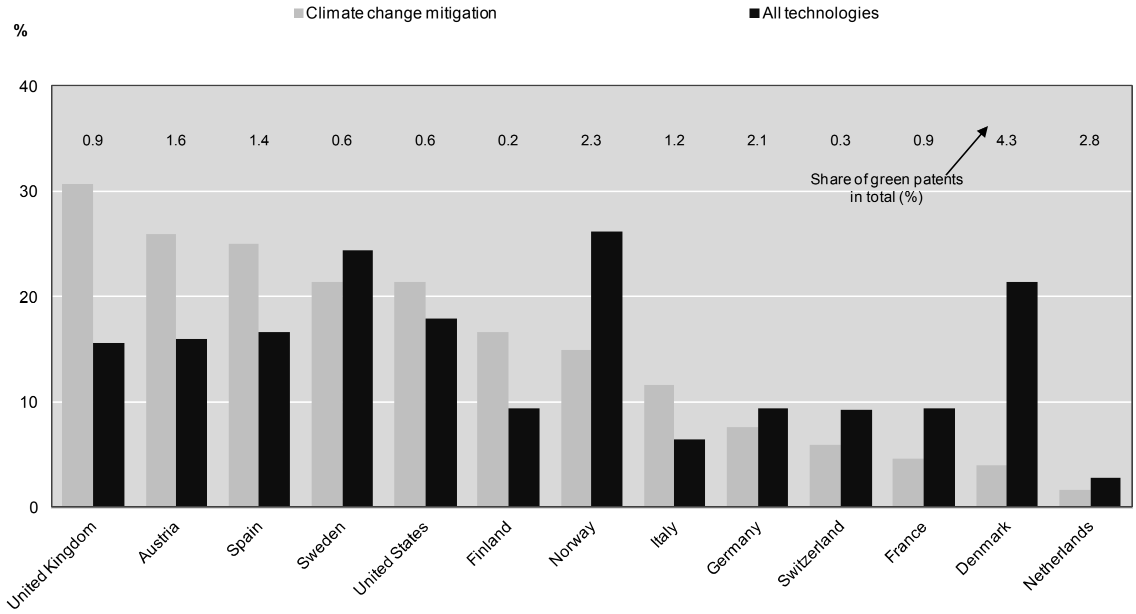
Source: Proceedings of the Global Forum on Environment on Eco-innovation, November 2009 (http://www.oecd.org/dataoecd/36/7/45375531.pdf).

Eco-innovation comes from new firms as well

The ETAP roadmaps and the country profiles of non-EU OECD countries show that countries devote a lot of attention to the creation and development of new firms. In particular, a variety of initiatives encourages venture capital and direct it towards investments in green technology and eco-innovation. The United States paves the way. Australia, Korea and the European Commission have taken actions to stimulate (or compensate) less dynamic venture capital industries.

This is appropriate, as eco-innovation comes from new firms as well. Figure 7 gives an indication of green entrepreneurship: in most countries covered, the share of patents related to climate change mitigation held by firms born after 2000 is higher than the share of patents held by these firms for all technologies.

Figure 7. Share of patents held by firms born after 200

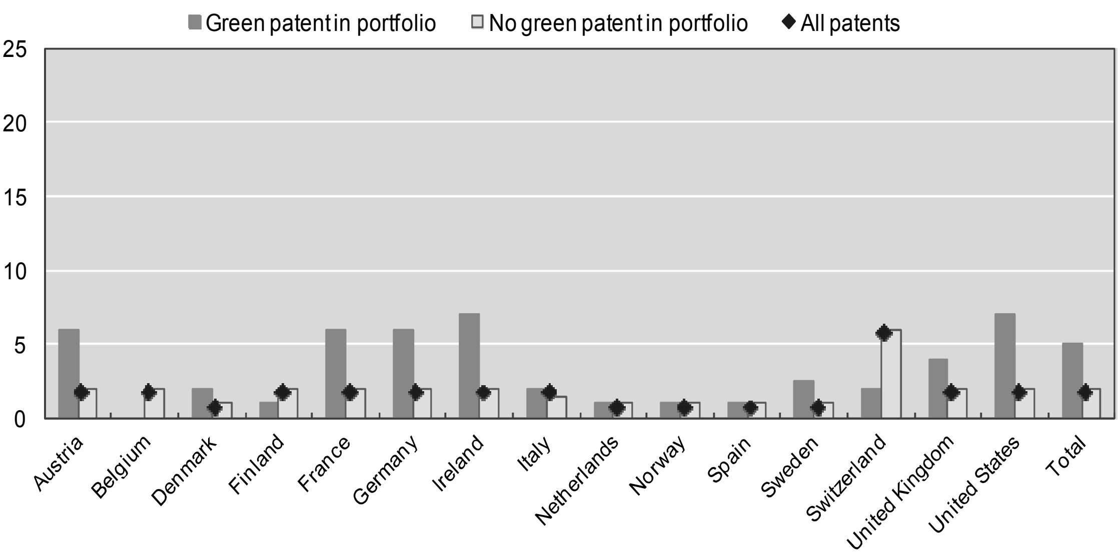


Source: OECD, Patent Database, March 2010; Bureau Van Dijk Electronic Publishing, ORBIS Database, August 2008.

In addition, Figure 8 suggests that young green firms are more inventive than young non-green firms.

The case studies on selected technologies confirm that new firms and newcomers play a role in the development and deployment of eco-innovation. In the field of micro-CHP, Hexis AG is a Swiss company which has its main market in Germany and Austria. Hexis is now an independent start-up, but formerly belong to the Sulzer Group. The company develops and integrates all the components; it is now a leading firm in the 1 kWe (kilowatt electric) segment. Newcomers (*e.g.* battery manufacturers) play a critical role in the development of electric vehicles, and may lead innovation and market development in this area.

Figure 8. Median number of patents in the portfolio of firms created after 2000



Source: OECD, Patent Database, March 2010; Bureau Van Dijk Electronic Publishing, ORBIS Database, August 2008.

The Global Forum on Environment has been an opportunity to review instruments developed in Korea over the last decade (2001-10) to stimulate new business ventures in the field of green technologies. These include:

- Eco-Technopia 21 is an R&D fund which supports the development of core environmental technologies to put Korea on a par with the most advanced countries in the field. The fund merges public and private resources. Turnover totalled USD 1.6 billion as of June 2009.

- The Environmental Venture Fund. Performance of the fund was plagued by a number of factors, including uncertainty about the profit rate of environmental industry, and the lack of management capacity in the field.

- ETBI, the Environmental Technology Business Incubator. ETBI selects high-potential environmental ventures and provides comprehensive incubation services to support commercialisation.

Building on lessons learned, Korea Environmental Industry & Technology Institute (KEITI) was established in 2009, to co-ordinate a comprehensive support system for environmental ventures. KEITI activities cover development of environmental technology, certification of environmental technologies and products, support to the promotion of Korea's environmental industry, including in foreign markets, and framework conditions (promoting green firms and green procurement).

The Korean Green Industry Complex cluster complements support to innovative firms. Its role is to enhance the global market share of Korea's environmental industry. It supports technology development through technical assistance and information sharing; it supports competitiveness; and it reinforces mutual co-operation through the Customised Technology Development Mechanism between large firms and SMEs.

Clustering and incubators for eco-innovation attract a good deal of attention in OECD countries, because they can stimulate the creation and development of new ventures, knowledge sharing and market opportunities. As an illustration, in the context of the strategy to develop carbon capture and storage for coal-fired power stations, the UK government says it will establish low-carbon economic areas (LCEAs) to create opportunities for firms in the carbon capture and storage supply chain and boost the industry in regions with existing assets. Concrete examples were reviewed at the Global Forum on Environment, such as Manifattura Domani in Trento (Italy), which focuses on the construction sector and renewable energies.

Discussion at the Global Forum on Environment called for public support to create eco-clusters and for a worldwide alliance of science parks and eco-clusters. The way forward requires identifying and strengthening the best clusters. International benchmarking and evaluation are crucial.

The role of public-private partnerships

Co-ordination needs have fuelled the governance of eco-innovation policies. For instance, German authorities have set up a dedicated organisation to steer and implement the NIP programme, which co-ordinates support for micro-CHP (see Box 3).

Box 9. Governance structure for micro-CHP in Germany

The *Nationale Organisation Wasserstoff und Brennstoffzellen Technologie Gmbh* (NOW) was founded in 2008 as a private organisation. It acts as a consultancy wholly financed by the government. Its task is to co-ordinate and implement the German NIP programme by 2016. This includes evaluation and selection of projects, in particular for field-test activities; linking research and development with demonstration; international co-operation; communication and knowledge management. NOW gathers actors from the entire micro-CHP value chain.

Prior to its creation, most stakeholders called for a comprehensive and co-ordinated public strategy. NOW is the direct answer to these demands and plays a central role in the structuring of the institutional landscape.

The NOW organisation, although still quite recent, is expected to be valuable in supporting the pre-commercialisation phases and market entry of the fuel-cell-based micro-CHP technology. It plays a structuring role by co-financing projects, notably the Callux field-test projects. The public and central positioning of the NOW organisation is applauded by most interviewees, even though some would like to see a more aggressive structuring role. The organisation has created high expectations. Its capacity to influence micro-CHP policy remains to be seen.

Source: OECD case study on micro-CHP.

More generally, public private partnerships are seen as an option for facilitating co-ordination and leveraging resources (knowledge, finance, co-ordination) among a variety of actors. Evidence from the roadmaps and country profiles shows that such partnerships may take the form of knowledge networks (*e.g.* in the United Kingdom, a KTN on Energy Generation and Supply is planned, to operate as a "one-stop shop" for various low-carbon initiatives), technology platforms (experience with the Sustainable Chemistry Technology Platform in Europe was shared at the Global Forum on Environment) or incubators for green start-ups, science parks specialised in green technologies, joint R&D, and venture capital funds.

The case studies on selected technologies identified a number of such partnerships. Callux is one: this programme supports field tests for fuel-cell-based micro-CHP in Germany; the target is to test 800 fuel cell units in Germany by 2012; the programme is jointly financed by public (48%) and private (52%) funds; beyond field-testing activities, the clustering and information exchange role of Callux is acknowledged by all stakeholders. Manufacturers claim that Callux has already had a significant impact, notably by setting technical requirements, performances, synergies and qualification.

Partnerships can have distinct structures (contracts or partnerships) and modes of operation (*e.g.* "coproduction" and consensus building between public and private actors, risk-sharing arrangements, decision making, criteria used to select projects). They can add value in different ways: *e.g.* synergies, cost reductions, transaction costs, mobilisation of private resources. They need to be co-ordinated with other policy instruments (*e.g.* public R&D, financing, creation of markets for eco-innovation).

A couple of case studies shed some light on concrete examples.

The UK Carbon Trust covers five areas: insights (informing key decision makers in the United Kingdom), solutions (advisory services to businesses and the public sector), innovations (more on this below), enterprises (creation and development of low-carbon enterprises in markets facing important barriers), and investment (co-investor in early-stage low-carbon technologies). A technology accelerator is a particular instrument for supporting innovation. The National Audit Office (NAO, 2007) noted that the accelerator is particularly well designed to fill what could otherwise be a barrier to the development of commercially viable low-carbon technologies. The NAO also noted that the Carbon Trust's co-ordination of businesses and researchers for collaboration on the accelerator projects appeared to be unique in the UK policy landscape and that the focus on applied research and commercial development rather than on basic research and academic achievement meant that the Carbon Trust supported a different range of projects from other sources of grants (such as those supported by Research Councils).

The Carbon Trust also supports the development of low-carbon technologies and companies that are further from market entry. Its business incubator scheme helps companies with promising low-carbon technologies to become attractive to investors. The incubator activity is a publicly funded activity and is not part of the investment portfolio *per se*. It is part of the continuum of innovation support that the Carbon Trust provides, from R&D through applied and directed research.

As regards governance, the Carbon Trust claims that delivering multiple interventions through one organisation integrating a number of functions reduces the operational costs typically carried by many separate bodies. This seems to be the case as regards close collaboration between investment and incubator teams which both benefit from expertise developed in the private sector.

Co-ordination with other bodies is improving: three of the main independent, publicly funded bodies – the Technology Strategy Board (TSB), the Energy Technologies Institute (ETI) and the Carbon Trust – created the Low Carbon Innovation Group (LCIG) in 2008, a strategic collaboration with a shared vision to reach the United Kingdom's low-carbon innovation goals. The Low Carbon Innovation Group meets regularly to review the strategic direction and content of their respective low-carbon technology programmes and initiatives. The group is to be expanded to include representation from the research councils, the Environmental Transformation Fund and, when relevant, regional development agencies and devolved administrations.

Sustainable Development Technology Canada (SDTC) operates one technological fund (plus one on next-generation biofuel). It bridges a gap in market finance at demonstration and development stages. SDTC interventions are designed to "de-risk" investment by partners (not other financiers) in technological eco-innovations.

SDTC differs from investment funds in a number of ways: it only provides grants and does not take equity or property rights in the projects it supports; it has a longer time horizon; selection criteria include sustainability; it covers a broad array of technologies, including competing ones.

The Carbon Trust and SDTC illustrate competing models. The Carbon Trust has been criticised for lacking a public dimension: it is fully financed by the public sector but has a high level of autonomy; some critics say it has lost its link to government. SDTC qualifies as a public-private partnership and operates as a not-for-profit foundation, established under Federal legislation, and incorporated under the Canada Business Corporations Act. Its private side is not obvious: it relates to the way it operates, in a very flexible and open-ended way (no pre-defined technology area).

Both organisations play a pivotal role in feeding the knowledge gap within government to develop evidence-based policies; dissemination of experience and lessons learned is essential. At the same time, in the current context, they are faced with the issue of sustainability: the UK government can cut the budget of the Carbon Trust, and SDTC has no sustainable mechanism to replenish its fund.

NEW MODELS FOR TECHNOLOGY TRANSFERS

The transfer of environmental technologies, both between OECD members and between developed and developing countries, increasingly receives policy attention. This section explores selected issues related to opportunities and appropriate ways to stimulate and co-ordinate such transfers.

Spillovers and international co-operation on eco-innovation

An important theme is the increasing "mismatch" between policy with a domestic focus and economic activity with an international reach. Particularly challenging is the question of capturing national benefits from the spillovers of the ecosystems of innovative firms that span national borders. This is acute in the case of eco-innovation, as environmental goods and services are considered by OECD governments as a growth sector, with potentially significant employment opportunities.

The Global Forum on Environment and the case studies provide instances in which spillover effects are acknowledged. In Canada, the possibility of spillover effects has been identified and discussed at federal level. The general view is that Canadian industry will also benefit from projects and innovations even though foreign suppliers may benefit first. For instance, the pulp and paper industry imports German equipment and machinery, but improved environmental performance will benefit the Canadian industry as well. In Germany, the Callux project, which supports field tests for micro-CHP, allows for testing fuel-cell-based micro-CHP plants based on foreign fuel cell technologies.

Different instruments exist to take account of spillover effects and mitigate their potential negative impacts on policies to support eco-innovation. Cost-sharing and reciprocity agreements, as well as joint development and public-private partnerships, can help. The potential national benefits must be communicated and demonstrated to public stakeholders.

Similarly, there is room for international co-operation in the field of public research. Joint investment in pre-competitive research, mapping of R&D needs, multilateral science and technology co-operation and pooled knowledge make it possible to share costs and effectively and efficiently stimulate eco-innovation at world scale. Such co-operation potentially facilitates outreach and access to funding and can contribute to technology transfer and capacity building. A number of examples are reported in the eight country profiles of eco-innovation policies; they take many forms and are supported by a variety of institutional arrangements, *e.g.* the International Partnership for the Hydrogen Economy (IPHE), the Carbon Sequestration Leadership Forum (CSLF), the Generation IV International Forum (GIF), and the International Thermonuclear Experimental Reactor (ITER). Building on this experience, it might be useful to identify principles and best practices for further co-operation in this area.

Similarly, the case study on carbon capture and storage illustrates how international co-operation can contribute to the development of an international standard that will facilitate technology development and deployment.

Box 10. Take-home messages from the study of policies to support carbon capture and storage

Carbon capture and storage (CCS) has a long history. It is a cluster of technologies, which are at the demonstration phase. It combines technologies developed in non-environmental fields which require adaptation to local conditions. The main clients are power utilities and large manufacturers. There are therefore only a few tens of potential clients in the world, in two market segments: developed countries (where CCS can be retrofitted to existing plants) and emerging economies. This is important when considering which policy instrument to implement to support the development and deployment of CCS.

Three technological trajectories compete. Governments face the choice of promoting all of these routes or selecting one. Among other factors, the deployment of CCS depends on the existence of downstream infrastructure (to transport and store captured carbon); Canada is considering building a collective carbon transport infrastructure.

The financial model depends on how reductions in carbon emissions are monetised (*e.g.* guaranteed CO_2 prices for CCS plants, feed-in tariffs for CCS-equipped power plants). Including CCS in emission trading schemes and in clean development mechanisms seems preferable to subsidising R&D.

Different industry contexts lead to different policy goals and interventions. In Canada, CCS is used by the oil and gas industry to enhance operating efficiency; this leads to the deployment of more mature technologies. In Germany, where energy producers predominantly use coal, more advanced technologies are being developed by other industries Rennings *et al.* (2009) argue that, should R&D on CCS be left to energy suppliers, radical technologies would not materialise. In France, the main incentive derives from prospects to export the technology (because Alstom is a global manufacturer of power plants); this led to R&D subsidies and to one demonstration site (Lacq).

A norm might be an appropriate way to plan the deployment of the technology, when information about the technological, environmental and economic benefits is available. In the meantime, a transitory standard is being considered at international level, forcing new fossil-fuel plants to be “CCS compatible”.

One unintended consequence of the development and deployment of CCS is that it competes with investment in renewables. In Germany, feed-in tariffs become a problem because, when CCS is cost-effective, it may crowd out renewables. From an analytical perspective, this suggests a distinction between policy mix (designed and implemented consistently) and policy accumulation. The analysis of policy accumulation requires monitoring and raises the issue of governance and the capacity to adjust or phase out overlapping or inconsistent policies.

Source : OECD case studies on selected eco-innovations.

Intellectual property rights

Intellectual property is often mentioned as a barrier to the diffusion of eco-innovation. On the one hand, technology vendors claim that more stringent protection in emerging economies can only stimulate innovation and its wider diffusion. On the other, technology takers remark that intellectual property rights (IPRs) increase the cost of technology and make access to eco-innovation more difficult. The debate is particularly vivid in the field of environmental technologies as eco-innovation has some public good characteristics: it is assumed that the diffusion of environmentally superior products benefits the wider community.

Recent research sheds some light on this hotly debated topic. A report by Maskus (OECD, 2009) addresses the question of whether particular changes in patent rules would effectively induce innovation and diffusion of environmentally sound technologies to address climate change. Quantitative and qualitative analysis finds that patents have not yet amounted to a significant barrier to access in developing countries. Johnson and Lybecker (2009) argue that a variety of technologies exist (including unprotected ones) and that protected technologies are not systematically more costly than unprotected ones. Econometric evidence on general licensing behaviour finds that multinational firms tend to increase the availability of new technologies when patent rights are strengthened, at least as regards transactions with partners in the middle-income and larger developing countries (OECD, 2009).

The analysis suggests that there is some scope for adjustments of intellectual property regimes for environmental technologies. For instance, it may be beneficial to expedite applications for environmental technologies. The Patent Prosecution Highway in Japan illustrates this route: it ensures that applications for which patents have been granted in a first country will be eligible for accelerated examination through simple procedures in a second. Similarly, Japan has initiated the APEC Co-operation Initiative on Patent Acquisition Procedures, which sets out to enable applicants to obtain a higher-quality patent in the APEC region more quickly; the initiative was endorsed by APEC Ministers in September 2007. Another option is to encourage patent pools. The Eco-Patent Commons paves the way. This is an initiative to create a collection of patents on technology that directly or indirectly protects the environment. The patents are pledged by companies and other IPR holders and made available to anyone free of charge. The World Business Council for Sustainable Development (WBCSD) and IBM are initiating this effort in partnership with Nokia, Pitney Bowes and Sony. The pledged portfolio is available on a dedicated public website (www.wbcsd.org) which is hosted by the WBCSD. The actual impact of this initiative on the diffusion of eco-innovation and on environmental performance remains to be assessed.

Adjustments of intellectual property regimes require additional resources, *e.g.* in patent offices. They need to be accompanied by enforcement capacities in the recipient countries and by measures unrelated to IPRs. As mentioned, international research co-operation and domestic innovative capabilities play a role.

Technology transfers in developing countries

The deployment of eco-innovations in developing countries is a key means of addressing domestic and global environmental challenges efficiently. It is also an important driver of markets for eco-innovation and sustainable economic development. In the photovoltaics industry, research indicates that the main benefit of transferring technologies to emerging economies was not abatement in these countries but increased competition in global markets and thereby reduced abatement costs.[3]

Johnson and Lybecker (2009) identify a number of barriers developing countries face for accessing eco-innovation: lack of scientists and researchers, brain drain, small market size, lack of infrastructure (notably telecommunications infrastructure), quality of the business environment and governance conditions, bureaucratic climate and the formal/informal regulations regarding economic transactions, cash-strapped governments unable to make public investments in research and infrastructure. Most of these barriers concern indigenous eco-innovation capabilities. These are essential for facilitating both the diffusion of existing eco-innovations in developing countries and sustainable economic development based on the adoption, adaptation and development of environmentally sound technologies that fit the specific conditions faced by these countries. This echoes OECD analyses which demonstrate that strong technological capacity in the recipient country is a key factor in encouraging transfers.

The paper by D. Ockwell for the Global Forum on Environment (Ockwell, 2010) argues that the majority of existing policy mechanisms[4] fail to recognise the critical importance of developing indigenous

3 See the presentation by Mathieu Glachant at COP15 (2009), “Beyond Patents. Competition, innovation and international technology flows in the photovoltaic industry”, www.cerna.ensmp.fr/images/stories/PV_Copenhagenfinal2.pdf .

4 The mechanisms analysed are multilateral environmental agreements (including the Montreal Protocol and the Expert Group on Technology Transfer – EGTT; the Clean Development Mechanism – CDM; and the Global Environment Facility– GEF, under the auspices of the United Nations Framework Convention on Climate Change – UNFCCC); information sharing initiatives (including the Environmental Technology

eco-innovation capabilities. Building up eco-innovation capabilities in developing countries requires a shift away from the current focus on large project-based approaches, which emphasise the transfer of hardware aspects of clean technologies, towards approaches that emphasise flows of underlying knowledge (know-how and know-why) and tacit knowledge. This is not limited to higher education: low-skill jobs may be required to deploy and maintain some green innovations (which are not necessarily high technology). Policy also needs to respond better to the context-specific technological and cultural requirements which vary inter- and intra-nationally.

The paper argues that there is a need to address the shortfall of current international policy processes by putting in place institutional and funding structures that achieve maximum leverage from public investment, in terms both of maximising the impact on indigenous eco-innovation capabilities and of maximising the potential to attract sustained private-sector investment in eco-innovation as opposed to conventional innovation. Precedents exist, such as the Carbon Trust's proposed network of Low Carbon Technology Innovation and Diffusion Centres, and Fundación Chile (a not-for-profit organisation which facilitates access to relevant international innovations and seeks to increase indigenous innovation capabilities). These provide potentially viable models for a more focused, needs-based approach to increasing eco-innovation capabilities in developing countries than can be achieved by the centralised approach based on large projects that tends to characterise current international efforts.

Co-operation is this area can be South-South. The *Institut international d'ingénierie de l'eau et de l'environnement* (2iE) illustrates South-South green technology transfers. It is a public-private partnership serving eco-innovation; it contributes to building the capabilities needed to develop and transfer efficiently technologies that will yield results in the African context. 2iE combines research and training activities. Its research activities are specifically aimed at a "post-oil" world of solar energy, biofuels, eco-materials, and water and environmental management. 2iE's training courses are based on this research. The approach is designed to promote innovative technologies in the main sectors of activity contributing to the sustainable economic development of Africa and draws on the work of five research laboratories specialised in ecosystem clean-up and health, hydrology and water resources, biomass energy and biofuels, solar energy and energy economics, and eco-materials. [5]

Verification Programme); and more targeted international collaborative initiatives (including the UK Carbon Trust's Low Carbon Technology Diffusion and Innovation Centres, and Fundación Chile).

5 A more detailed presentation was made at the Global Forum on Environment.

ANNEXES

Annex 1. Assessment of ETAP roadmaps: a methodological note

1. The general aim of this study was to carry out a policy mapping exercise in order to assess the performance of ETAP countries as regards their eco-innovation potential. The questions guiding the enquiry were:

1. Do countries with similar contextual features develop similar policy patterns?
2. Are EU member states addressing the environmental priorities and needs of their countries?
3. How do EU member states compare with non-EU OECD countries in terms of the balance of their policy instruments in the field of eco-innovation?

2. The main sources of information to address these questions were the national roadmaps and data gathered in a survey of national ETAP correspondents. Data from public sources have been collected in order to characterise the national context of each roadmap in terms of the country's innovation potential, the important environmental challenges it faces, and some key institutional framework conditions that typically affect innovation in general and eco-innovation in particular.

3. The first step in this study was to classify ETAP countries in a number of dimensions that are relevant for their eco-innovation potential using statistical cluster analysis. Classifications were developed for three fields. The first country classification concerned its level of development and its innovation potential. A second classification related to the principal environmental challenges faced and the third captured regulatory and market conditions favourable to innovation in general and to eco-innovation in particular. Overall about 30 indicators were used to classify countries.

4. The next step was to characterise the ETAP roadmaps using the information available from the ETAP roadmaps and from the survey conducted among ETAP correspondents. The data collected cover additional information for the measures listed in each national ETAP roadmap in terms of the policy instruments they combine, the environmental policy priorities they address, the principal types of environmental technologies supported by each measure, the principal public entities in charge of each measure and whether the planning of the measures was initiated by the ETAP process. These data were used to characterise ETAP roadmaps on three dimensions: governance, the balance between supply-side and demand-side instruments and the steering role of ETAP roadmaps.

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