GLOBAL FORUM ON ENVIRONMENT FOCUSED ON ECO-INNOVATION
PARIS, OECD CONFERENCE CENTER
NOVEMBER 4-5, 2009

PROCEEDINGS

Drafted and compiled by Xavier Leflaive, OECD Environment Directorate

FOREWORD

The OECD Environment Directorate organised a Global Forum on Environment, focused on eco-innovation, November 4-5, 2009, at the OECD Conference Centre in Paris, France. The Global Forum on Environment is part of the OECD Global Forums, which aim to deepen and extend relations with a number of non-OECD economies in the fields where the OECD has particular expertise and where global dialogue is important.

The objective of the Global Forum on Environment focused on eco-innovation was to share experience on policy issues related to the development and diffusion of eco-innovation, and to fine-tune messages on how to make environment and innovation policies mutually supportive in the current economic and policy context. A special focus was on emerging and developing countries.

Participation was open to policy makers in the field of environment, science and technology, industry and innovation, to business firms involved in developing, financing and deploying green technologies and related innovations, and to non-governmental organisations active to promote eco-innovation. A total of 165 delegates from 35 countries participated in the Global Forum.

All information and documentation related to the Global Forum on Environment is available at www.oecd.org/environment/innovation/globalforum. This includes three papers that have been commissioned in the context of the preparation of the Global Forum on Environment. The papers benefited from comments received during and after the event:

- "Policies for the Development and Transfer of Eco-Innovations: Lessons from the Literature", by David Popp;
- "A methodology to develop case studies on eco-innovation", by Gilles Le Blanc[1];
- "Difficulties Developing Countries Face in Accessing Markets for Eco-Innovation", by David Ockwell.

The paper by David Popp has been released as OECD Environment Working Paper n°10. A revised draft of David Ockwell's paper will be released as an OECD Environment Working Paper as well.

The webpage also features additional papers released by the OECD and partner institutions on related issues, such as country profiles of selected OECD countries and China on policies to support eco-innovation, research papers on measuring eco-innovation, and empirical analysis of selected policy instruments.

[1] The methodology has been further refined and used to develop a set of case studies on the development and diffusion of eco-innovations, namely carbon capture and storage, solar tiles, combined heat and power generation (CHP), fuel cells for micro CHP, electric cars, and bio packaging; the case studies are published separately

The Proceedings include:

- A synthesis of key messages heard at the Global Forum on Environment. The synthesis was developed by the Secretariat and is not intended to be a Chair summary;

- A summary of each session. Each summary recalls the main objective of the session and summarises the main messages presented by the speakers.

Annexes include the final agenda of the Global Forum on Environment focused on eco-innovation and short biographies of the speakers and chairs. They also include a methodological note by Gilles Le Blanc (Mînes Paris Tech and CERNA) on how to develop case studies on eco-innovation to take account of some of their most salient features. Case studies on particular eco-innovations are being developed separately and will be released as a companion report to the Proceedings.

ACKNOWLEDGEMENTS

The OECD Global Forum on Environment focused on eco-innovation was organised by the OECD Environment Directorate. It benefited from the financial support of the World Bank and the European Commission's thematic programme for environment and sustainable management of natural resources (ENRTP). These supports are gratefully acknowledged.

The OECD would like to thank the Chairs of the different sessions who helped steer and summarise the discussions: Mr. Jan Boom (Danish EPA), Mr. Hervé Martin (EC/DG Environment/Environmental Technology Action Plan), Mr. Kerry Rhoades (Industry Canada/Environmental Industries Directorate), Dr. Jyoti Prasad Painuly (UNEP Risoe Centre in Denmark), and Mr. Pier Carlo Padoan (OECD Deputy Secretary-General).

The OECD would also like to thank the twenty speakers and discussants who generously shared their expertise and experience during the Global Forum. Their biographies are appended. All participants who took active part in the discussions at and after the Forum are acknowledged as well.

These proceedings were prepared by Xavier Leflaive of the Environment Directorate.

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SYNTHESIS BY THE SECRETARIAT

Rationale for a Global Forum on Environment, focused on eco-innovation now

The crisis is not an excuse to delay tackling urgent environmental challenges, such as climate change or unsustainable water management. Recent OECD analysis shows that ambitious policy in these areas makes economic sense and that delaying action could be costly. The *OECD Strategic Response to the Financial and Economic Crisis* is supporting countries to recover from the crisis and to create a stronger, cleaner and fairer world economy.

For the environment, the crisis can provide an opportunity and an incentive to improve efficiency in the use of energy and materials, to move towards more sustainable manufacturing, and to develop new green businesses and industries. Investing in the environment is an important element of many of the stimulus packages being put in place by governments in OECD and emerging economies.

In that context, policy makers and industry leaders look at innovation as one of the keys to making radical environmental improvements for tacking global challenges. New green technologies can help to cut the future cost of addressing environmental challenges such as climate change.

Governments can take a number of approaches to help spur environment-friendly innovation (eco-innovation) in the context of economic recovery. The OECD has inventoried policies in place in member countries to support the development and deployment of eco-innovation. In parallel, the OECD Innovation Strategy is looking in-depth at how government policies can best support innovation to address key challenges, including environmental ones.

Measures that can support eco-innovation in the context of economic recovery include:

- provide a clear price signal to internalise the cost of environmentally harmful activities in order to encourage innovation towards greater efficiency in the use of energy and natural resources and the reduction of waste;
- develop proactive policies to support innovation and environment-related technological development and uptake, including investment in basic R&D, where there are market barriers which lead to under-investment by the private sector;
- apply technological impact assessments to assess the potential gains and risks of new technologies, including for the environment;
- identify the infrastructures needed to facilitate a move to a low-carbon and environmentally sustainable economy, and develop policies to encourage the necessary investments (both public and private);
- develop international co-operation and collaboration for large-scale projects on clean technologies, as well as to facilitate international transfer and rapid uptake of new technologies, while taking account of the role of intellectual property rights (IPR);
- increase training and education to develop the new skill sets needed for green jobs, and raise consumer awareness to better reflect sustainability concerns in their daily decisions;

- ensure policy integration, benchmarking for performance, and evaluation of the approaches applied to check that they effectively help to develop and diffuse green technologies, while contributing to economic growth.

Based on its extensive knowledge base and empirical resources, the OECD has identified policy issues that have to be tackled to support eco-innovation efficiently. These include:

- How can the performance of eco-innovation policies be monitored and measured? Should the focus be on the inventions induced by policies, or should policy analysis consider such results as the development of markets for environmental goods and services, the environmental performance of the economy, or the timeliness of innovations to meet urgent challenges?
- How should policy instruments be designed to effectively and efficiently support eco-innovation, taking account of a variety of technologies and contexts? How can a variety of instruments be combined and coordinated? How can competition issues be avoided or addressed?
- How to best organise partnerships between public and private actors? What lessons can be learned regarding the structure, the mode of operation, the value added of the partnerships? How to make the best use of public funds?
- How to lower barriers to the diffusion of eco-innovation in developing countries? What are the lessons learned from ongoing experience in the environmental domain and in other areas (e.g. vaccines)?

The Global Forum on Environment focused on eco-innovation was designed to shed light on these issues.

Key messages heard at the Global Forum on Environment focused on eco-innovation

Key speakers at the Global Forum noted that eco-innovation is not only an instrument to foster environmental performance; it may be a new engine for sustainable/green growth and it can promote competitiveness as well. Governments need to support eco-innovation to ensure it can make a timely contribution to policy objectives. At the same time, this support needs to be carefully assessed. A robust policy on eco-innovation relies on a national strategy, requiring a whole-of-government approach and a combination of policy instruments. Therefore, governance is the key, and innovative institutional arrangements may be required.

The key messages from the Global Forum revolved around the need to ensure that policy makers take a holistic approach to eco-innovation, addressing the range of issues from invention and transfer through to adaptation and diffusion. These can be summarised as follows:

- A broader perspective on eco-innovation is required. Eco-innovation is not restricted to invention. It covers incremental innovation and systemic, transformative change. It also includes retrofitting, adaptive innovation, and behavioural/organisational innovations (e.g. car sharing), as well as the critical issue of diffusion. Policies to support eco-innovation need to be tailored to address these various aspects.

- Policy makers would benefit from more robust measurement of eco-innovation. Innovative approaches are needed to capture the different dimensions of eco-innovation and the way it develops in the current context, characterised by new channels to convey resources to research, open (non patented) innovation, and transfers. The quantity of invention is not the only issue. Eco-innovation policies aim at delivering tangible impacts on environmental challenges, rather than at stimulating new technologies per se. This could be better reflected

in policy analysis: for example, how can environmental policies make eco-innovation more timely and appropriate? What are the costs and benefits of alternative policy approaches to reach the same purpose? There is a need for indicators on co-benefits (including the impact of eco-innovation policies on sustainable development and poverty alleviation in a developing country context).

- Policy instruments interact over time to influence eco-innovation direction, pace and timing. Eco-innovation results from a variety of drivers, including an accumulation of policies which build on each other over time. Such accumulations generate synergies and/or inconsistencies and the impact of an instrument needs to be addressed with respect to its interactions with other instruments over time. Governments need to coordinate and manage such accumulations (e.g. how a green procurement policy interacts with public R&D initiated five years earlier, a fiscal incentive put in place two years earlier, and with the development of an energy efficiency standard). Process matters: there is a political economy of these instruments and engaging stakeholders, including the private sector, is a key factor of success.

- Public-Private Partnerships may create synergies, reduce costs (including transaction costs), mobilise private resources. Depending on the main objective of the partnership, a variety of structures can be used (contracts vs partnerships); modes of operation can differ, as regards "coproduction" and consensus building between public and private actors, risk sharing arrangements, decision making, or criteria used to select projects. Partnerships operate in the context of larger policies and should be considered with other policy instruments (e.g. public R&D, financing, creation of markets for eco-innovation).

- Technology transfer to developing countries is a key to meeting many environmental challenges but there is room for improvement. OECD countries can best achieve their own objectives if they engage with emerging and developing countries. Empirical experience suggests that technology transfer is more likely if the "recipients" have significant indigenous innovative capabilities themselves. This means that there is scope for reviewing existing frameworks for environmental cooperation (e.g. multilateral environmental agreements, Clean Development Mechanism) to ensure they provide the appropriate incentives and policy frameworks.

OPENING SESSION: SETTING THE SCENE

Objective of the session

The objective of this session was to set the scene for the Global Forum on Environment focused on eco-innovation. The main topics discussed include:

- The features of eco-innovation (vis-à-vis other innovations) and their consequences on the policies needed to support its development and diffusion;
- What we know about what works and what does not work to stimulate eco-innovation;
- The role of eco-innovation in environmental policies (to achieve national and global environmental challenges) and in Green Growth policies; and
- The main issues that are faced by emerging/developing countries.

Speakers in this session included a leading scholar in the field who shared lessons from the literature, and speakers from two countries (one OECD member and one emerging economy) who shared their own experience on eco-innovation.

Main messages from the speakers

Policies for the Development and Transfer of Eco-Innovations: Lessons from the Literature (David Popp)[2]

Along with the recent success of economic growth in the developing world comes more pollution. Reducing these emissions while still enabling these countries to grow requires the use of new technologies in these countries. In most cases, these technologies are first created in high-income countries. Thus, the challenge for environmental policy is to encourage the transfer of these environmentally-friendly technologies to the developing world.

The paper reviews the economic literature on both the creation and transfer of environmental technologies, with an emphasis on how the development of new technologies in leading economies can lead to environmental improvements in developing countries.

The author begins by discussing the incentives for environmentally-friendly innovation, which occurs primarily in developed countries. He then reviews the literature on the transfer of these technologies to the developing world. A key point is that technology diffusion is gradual: early adoption of policy by developed countries leads to the development of new technologies that make it easier for developing countries to reduce pollution as well. Globalization also plays an important role in moving clean technologies to developing countries. Since clean technologies are first developed in

[2] The messages are developed in the paper drafted by David Popp. The paper has been released as OECD Environment Working Paper n°10

the world's leading economies, international trade and foreign investments provide access to these technologies. Finally, the absorptive capacity of nations is important. The technological skills of the local workforce enable a country to learn from, and build upon, technologies brought in from abroad. The author concludes by discussing the implication of these lessons for policy, focusing on three examples pertaining to climate change: the Clean Development Mechanism, the role of intellectual property, and government-sponsored R&D.

Korea's Vision for Green Growth and Policy Measures for Eco-Innovation (Moon-Seob Youn)

Background

The rapid industrialization and urbanization of Korea has raised a significant challenge on environmental sustainability since Korea is one of the world's largest greenhouse gas producers: it ranks ninth in the world and has one of the highest growth rates of emissions.

The Korean "low carbon, green-growth" strategy aims to attempt a fundamental shift in growth paradigm, from the extensive "quantitative growth" of the past to "qualitative growth" driven by creativity and technology innovation.

Korea is recognized for its adoption of a national Green Growth Strategy as the core paradigm of the nation's development vision, a world *première*. In order to achieve green growth and to reduce GHS emissions effectively, the strategy is pursuing eco-innovation in every sector of society, including organization, policy, regulation and taxation.

Goals and Strategies

The Korean Green Growth policy is the national long-term development strategy up to 2050, with its detailed action plans being based on a Five-Year Green Growth Plan. The policy aims to make the country as one of the world's top five green leaders by 2050 through implementing a set of three strategies, namely: 1) measures for climate change mitigation and adaptation and for securing energy independence; 2) creation of a new growth engine; and 3) improving the quality of life and strengthening the status of the country.

New eco-innovation policy measures for green growth

Pursuing the Green Growth policy has brought changes in the NIS (National Innovation System) and adoption of new policy measures to enhance eco-innovation. Most notably, Korea established the "Presidential Committee on Green Growth" under the authority of the President of Korea in order to oversee all green growth initiatives, to provide strong momentum, and to promote a new form of governance of green growth that will bring together all stakeholders from national & local governments and from the private sector.

In the next five years, the Korean government will invest 2% of GDP to support green growth. R&D investment is the most critical part of eco-innovation policies, and the government plans to more than double R&D investments from KRW 1.2 trillion (1.0 billion USD) in 2008 into KRW 2.8 trillion (2.4 billion USD) by 2012. Furthermore, the government has selected 27 key technological sectors that are recognized as potential new engines for economic growth. The paradigm of environmental policy has shifted from end-of-pipe treatment of discharges to pollution prevention and conservation of environment. Instruments have been diversified, from existing policies focused solely on regulations to comprehensive policies for fostering, supporting and attracting industry.

As the green industry can be subject to a high degree of uncertainty and a long-term investment return cycle, the government needs to expand investment and engage the private sector more. By introducing green certification systems, such as green technology, green project and green enterprise, the government plans to introduce policies for facilitation of green financing combined with tax incentives. Meanwhile, there are other policies to encourage a green lifestyle, such as the policies for carbon labelling, carbon points, green purchasing. Global diffusion of eco-innovation achievements will also be addressed through dedicated and targeted cooperation plans.

A number of challenges remain. One is related to the establishment of monitoring systems. The National Green Growth Index aims to compare the national level of green growth by evaluating items related to input, process and output. The Degree of Greening of Technology (DGT) index assesses how much a specific technology is conforming to the low carbon paradigm and is socially sustainable over the long run; it can be used to make the existing R&D programmes greener.

Policies to support eco-innovation in Brazil (Ronaldo Seroa da Motta)

The centralized R&D system in Brazil is based on the Ministry of Science & Technology (MCT) that relies upon two major institutions (CNPq and FINEP) to deliver most of the resources. CNPq funding is mainly targeted at researchers, while FINEP targets firms. This system has showed good results but not enough to match the ones reached by other emerging economies. In addition to MCT, innovation takes place in other major centres and programmes related to agriculture, forestry, energy and aviation.

R&D is an important agenda for both government and private sector and resources have increased in the last years showing the positive effects of 2004 changes on policy goals (PITCE) attempting to increase targeting on priority areas. Later in 2008, the Productive Development Policy was launched aiming to enhance Brazilian exports by financing fixed capital and R&D, particularly in medium and small enterprises, with annual credit incentives of about 40 billion dollars until 2010.

Expenditures on R&D come 37% from federal funds, 15% from state funds and 48% from firms, indicating that Brazil has lower public funding share than the OECD average. Although Brazil´s R&D expenditures on GDP ratio has increased overtime, the current ratio of 1.13 indicates that much remains to be done. Nevertheless, researchers and research centres take 25% of total expenditures, equivalent to US$172,000/researcher (mean OECD level), against US$ 120/per capita (much below OECD level). Both federal public and private R&D expenditures were constant during the recession years of the beginning of the decade and have grown steadily since 2005 with the economic recovery (about 15%) and not slowed down in 2008. State budgets, perhaps due to their stronger constraints, instead, have a cyclical movement.

Instruments such as fixed-price and prizes are not considered in the agenda and cost-plus ones are usually the norm. In addition, reliance on public funds and lack of innovative financing instruments (e.g. bank loans, venture capital) reduce private sector capability to develop innovations.

R&D policies are mainly committed to increase the country´s competitiveness through innovation and technology efforts. However, the concepts of environmental conservation and clean technology are easily identified in the agenda as a mean to achieve such competition goals.

Studies show that the nature of the firms and international trade are relevant to motivate Brazilian firms to invest in eco-innovation but such trend has decreased in the period 2000-2005, perhaps due to the recession. Recent data are not available to update these findings.

Management of tropical forest, energy conservation and renewable energies are successful cases of eco-innovation in Brazil based on good targeting, consistent budgetary allocation and technology transfer. Climate Change mitigation actions through CDM has also made a great contribution to these areas. Future Brazil´s commitment on the Climate Convention if based on market mechanisms may be a unique opportunity to address directly eco-innovation with power incentives.

SESSION 1. MEASURING ECO-INNOVATION

Objective of the session

The objective of this session was to highlight the difficulties policy makers face in accessing the data/information they need to inform their decisions regarding the development and deployment of eco-innovation. Adopting a policy (i.e. non-technical) perspective, this was an opportunity to reflect on the broad objectives of eco-innovation policies.

Two sets of questions arose. One related to the metrics used. A variety of metrics are being used, which measure inputs (i.e. budgets, researchers), or outputs (e.g. in terms of patented inventions). Policy makers may need additional information, focused on the quality of innovation: For example, is it timely? Does it respond to environmental or other objectives?

Another set of issues related to knowledge gaps. What are the gaps between the needs of policy makers and the available information and indicators? Are additional indicators needed?

Emerging and developing countries face particular challenges in this regard as they may have different priorities (e.g. economic development and poverty alleviation), and they may be confronted with particular knowledge or information gaps.

Two experts involved in policy making reported on their experience and signalled their support for multidimensional monitoring and reporting. An Indian expert stressed the need for multidimensional approaches and for the measurement of co-benefits. One leading scholar in the field updated participants with the outcomes of a major research on the measurement of eco-innovation in Europe.

Main messages from the speakers

Results-Based Innovation at the U.S. Environmental Protection Agency (David Widawsky)

Depending on who is employing the term, "environmental innovation" or "eco-innovation" is used to describe a wide range of phenomena ranging from new technologies to new ways of enforcing environmental laws – and everything in between. At the U.S. Environmental Protection Agency (U.S. EPA), environmental innovation can be described as a portfolio of approaches - regulatory and non-regulatory, technological and behavioural – which share a common goal: promote improved environmental performance.

Effective environmental public policy demands that one establish a link between policy directives or assistance programmes and the environmental outcomes these policies/programmes are intended to achieve. Because the road from public investment to public good can be riddled with gaps and pitfalls, it is almost impossible to overstate the importance of carefully constructing measurement systems for environmental innovation. These measurement systems are intended to provide not only a measure of whether investments are achieving their intended outcomes, but how to improve and refine

systems of environmental innovation. The latter is critical because environmental innovation is, by its very nature, an iterative learning process of discovery, piloting, testing and diffusion.

The American Recovery and Reinvestment Act of 2009 (ARRA, the so-called "Recovery Act") makes historic investments in energy efficiency, renewable energy, and environmental protection. Indeed, by some calculations, more than $100 billion of the $800+ billion Recovery Act funds are directed to projects and programmes that can be characterized as "green." Measurement of programme activity under ARRA, as well as outcome measurement are central and are reported on an ongoing basis through public venues (i.e., a U.S. government website: www.recovery.gov). One important consideration is that investments in environmental innovation, in general, and under ARRA, in particular, are intended to satisfy multiple policy objectives. For example, economic growth and job creation are critical outcomes for all the programmes being funded under ARRA. Therefore, measurement systems need to be flexible, robust, and multi-dimension to be useful in managing environmental programmes under ARRA.

One environmental innovation currently under development is the Recovery Through Retrofit initiative, which is intended to reduce energy costs for middle class families through residential weatherization and energy efficiency, while creating jobs and reducing greenhouse gases. Integrating the programmes of several U.S. Government agencies, the initiative will establish standardized methods of measuring and reporting home energy efficiency, develop financing mechanisms to stimulate demand for weatherization activities, and standardize 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 $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 realize economic revitalization and environmental sustainability. These gaps exist because many organizations investing in environmental innovation were not set up to measure environmental outcome. Analyses of market demand and penetration, linking behaviour change to environmental outcomes, and ex ante/ex post estimation of environmental impacts will all be important investments in supporting a robust system of environmental innovation.

Research and Innovation for a Green Economy (Michael Lehane)

The development of a smart and resilient green economy can make a significant contribution to economic recovery and growth by creating employment and export opportunities in green enterprises. It can also help existing companies in all sectors to improve their competitive position though adopting innovative environmental goods and services. The global market for environmental goods and services is vast and it continues to mature quickly and in particular, the environmental technologies' sector is one of the fastest growing markets internationally. The Irish Environmental Protection Agency (EPA) is one of the main bodies in Ireland fostering growth in this area through the provision of funding for research and innovation.

The 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.* The report profiles a range of successes and impacts of research and innovation undertaken to date. Indicators used in the report reveal the interests of policy makers and the many dimensions of policies which support eco-innovation.

Impacts include high-value products from waste, energy from sewage treatment, smart filters that can remove metal ions from water, pollution sensors and a sustainable, ecological high-performance computer. The examples stem from the investment made through the EPA Science, Technology, Research and Innovation (STRIVE) programme. Since 2005 the EPA has funded 190 research and innovation projects in the technologies area, representing an investment of €30 million. This has led directly to the engagement of 200 new researchers in full-time roles.

Aside from the demonstrated academic excellence of this work and its contribution to building Ireland's reputation as a centre for research and innovation, the investment is also yielding wider economic benefits. A survey of 18 large-scale projects funded by the EPA in 2005 and 2006 found that the research investment had led to wider benefits including: the filing of five patents with seven additional patents in preparation; nine non-disclosure agreements; one licence agreement; and one new spin-off company.

This return on investment compares very favourably to similar investments elsewhere in the EU and in the USA. The EPA sees a strong need to continue to prioritise environmental research and innovation investment in Ireland with the aim of:

- Supporting the continued development of the environmental goods and services sector;
- Contributing to environmental protection by delivering applicable and relevant solutions, information and knowledge;
- Promoting the integration of eco-innovation into all relevant sectors

The EPA environmental technologies report is available on the website www.epa.ie/downloads/pubs/research.

About data collection and research about eco-innovation (René Kemp[3])

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 benefits and motivations for it. Attention should be broadened to include innovation in or oriented towards resource use, energy efficiency, greenhouse gas reduction, waste minimization, reuse and recycling, new materials (for example nanotechnology-based) and eco-design. The drivers are related but different and the patterns of eco-innovation activity are likely to be different as well.

The subject of eco-innovation is a rich and untapped field of research. One area for future research (besides measuring what companies do in terms of eco-innovation) is the macro-effects of eco-innovation, to complement studies on the micro-effects. Measuring the greenness of national systems of innovation (green taxes, education, collaboration, venture capital, subsidy schemes, environmental standards, education relevant to green issues) constitutes another important avenue for research.

For measuring eco-innovation, no single method or indicator is likely to be sufficient. In general, one should therefore apply different methods for analyzing eco-innovation – to see the "whole elephant" instead of just a part. In particular, more effort should be devoted towards direct

[3] based on joint work with Anthony Arundel

measurement of innovation output using documentary and digital sources. The advantage is that they measure innovation output rather than innovation inputs (such as R&D expenditures) or an intermediary output measure (such as patent grants). Innovation can also be measured indirectly from changes in resource efficiency and productivity. These two avenues are underexplored and should be given more attention, in order to augment our rather narrow knowledge basis.

It would be of interest to develop a scoreboard for eco-innovation. A first attempt was made in the Measuring Eco-Innovation (MEI) project, which came up with a list of 24 indicators for five categories: i) firms, ii) conditions, III) linkages, IV) radical/incremental innovation indicators, and V) overall performance.

To get a better understanding of the different biases of various innovation measures, it is proposed to undertake a research programme into measuring eco-innovation activity in a particular domain (automobile manufacturing, electricity production, waste management) using different methods: patents (citations), government-funded R&D, private R&D, innovation expenditures, eco-efficiency improvements and direct innovation output measures (such as innovation announcements) – to see whether the methods lead to similar results.

In addition, a pilot project on company environmental performance data and eco-innovation activities is proposed as well. Panel data would be very suited for this.

National surveys on pollution abatement and control expenditures could inquire into R&D and other innovation expenditures and differentiate between investments on innovation and line extensions. Such surveys could also examine motivations, such as to reduce resource costs, improve products so that their use leads to lower environmental impacts and innovation offsets (gains from the introduction of environment-saving measures). Additions to the OECD Pollution Abatement and Control (PAC) surveys would provide a relatively easy way of augmenting the international knowledge base on eco-innovation. This could offer information for benchmarking nations and sectors within nations, such as on the degree to which nations are shifting to cleaner production and waste reduction.

Finally, it is proposed that invention should 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 for invention, which may or may not lead to innovation. Moreover, the majority of innovations are not based on inventions that were developed within the innovating firm itself.

SESSION 2. STRENGTHENING THE DESIGN OF POLICY INSTRUMENTS

Objective of the session

The objective of the session was to share experience on how instruments are best designed to support eco-innovation. A number of practitioners with hands-on experience shared the lessons they have learned working with a selection of instruments. This was an opportunity to better understand what works best, under what conditions.

Two issues have to be kept in mind to put this session into perspective. First, the traditional taxonomy of instruments (market-based instruments vs. direct forms of regulation) may be misleading. It might be more helpful to think in terms of attributes of instruments, and what effect each of these attributes has on innovation. Preliminary work by Johnstone and Hascic [ENV/EPOC/WPNEP(2009)2] suggests that relevant attributes include s*tringency (*how ambitious is the environmental policy target, relative to the 'baseline' trajectory?), *predictability (*what effect does the policy measure have investor uncertainty; is the signal consistent, foreseeable, and credible?), or f*lexibility* (does it let the innovator figure out the best way to meet the objective, whatever that objective may be).

The second issue relates to the fact that instruments do not operate in a vacuum. They operate in combination and are embedded in the policy context with other drivers including market forces, corporate strategies, etc. The impact of specific instruments depends on a variety of interactions between these drivers. The European Commission and the OECD are jointly commissioning a number of case studies to trace the history of selected green technologies, to situate the policy instruments in the context of other drivers. The objective of the case studies is to trace how policy instruments (if at all) interfere with the development and diffusion (or lack thereof) of selected green technologies. The following technologies are covered: electric cars, carbon capture and storage, combined heat and power generation, fuel cell micro CHP, solar tiles and bio packaging. A methodological note has been drafted to steer work on these case studies. This research is published separately.

Main messages from the speakers

A methodology to develop case studies on eco-innovation (Gilles Le Blanc)[4]

Eco-innovation exhibits a number of distinctive economic features, which a comprehensive and insightful case study must consider. Academic research on environmental innovation usually considers three types of explanatory variables: regulation, market and firm-internal conditions. The vast empirical literature then builds an ad hoc framework to test relations between environmental innovation and a set of factors aimed at capturing the various forces at work in each field.

Several methodological insights from the literature are worth considering to organize the case studies. They can be grouped under three categories: the technological innovation system and its

[4] The messages are developed in the appended paper by Gilles Le Blanc

"failures", the dynamic view of markets and public intervention, the diversity of policy instruments and goals.

The first approach uses the concept of technological innovation system (TIS) to pin down some "system failures" hampering innovation. The systemic picture sees technological innovation as arising out of the interplay between different actors and involving both knowledge flows and market interactions. This framework allows a more accurate analysis of barriers and incentives to innovate and the potential room for public policy.

A second line of research insists on the time frame and dynamics of both eco-innovation and public policy. Most studies on the effects of environmental policy on environmental innovation neglect policy accumulation, or only focus on short time periods. It is suggested investigating the policy accumulation, i.e. the implementation of "a mixture of policy instruments with a variety of underlying mechanisms to enable the achievement of policy goals". Attention should then 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).

Finally, several papers emphasize the variety of policy instruments used (fiscal incentives, direct subsidies, norms design, public procurement…) and argue that 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.

Gilles Le Blanc suggests a pragmatic and empirical way to reconcile these different approaches. The case studies will take account of various dimensions and descriptive variables introduced to specify the TIS functions, the market dynamics, the variety and time accumulation of policy instruments. This will allow a richer and more accurate picture of the institutional and market features as well as the nature of public policy.

In addition, the competitive environment and market structure will be taken into account. Here, it is proposed to use Sutton's notion of distinct technological trajectories[5], each of them associated with a distinct submarket. 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 on other trajectories and submarkets. Applying the same logic, when products in different submarkets are poor substitutes, the market becomes segmented into a number of independent submarkets, and a superior R&D effort in one of them will have little impact on the others. This framework could bring insightful results in the case of eco-innovation, allowing a distinction between markets where an escalation mechanism prevails and those marked by a continuous proliferation of technological trajectories. This context will have significant implications for the analysis of the respective role of market forces (demand, supply) and public policies. This line of reasoning requires a definition of the overall utility in the market considered, a comprehensive identification of the various technical solutions available to answer this need, including the environmental ones, and a careful examination of the substitution and scope for R&D economies between them.

The discussion above suggests several methodological points for rigorous empirical case studies of eco-innovation. Four key elements can be successively underlined: overall utility definition, innovation patterns, demand characteristics, competition.

[5] See Sutton, J., 1998, *Technology and Market Structure. Theory and History*, Cambridge, MA: MIT Press.

Supporting eco innovation through sustainable public procurement (Wiana Partakusuma)

Ms. Wiana Partakusuma presented the Dutch experience on sustainable public procurement and the potential of this policy instrument to encourage eco innovation.

The presentation took a closer look at using public procurement as a stimulus for innovation and sustainability, the policy rationales to support eco-innovation and the various Dutch initiatives in place to do so. A short overview of the Dutch experience with sustainable public procurement and the capacity needed to effectively support this was highlighted.

Over the past two years the main focus of the programme has been on developing sustainability criteria for product groups and ensuring implementation at all levels of governments. More recently an additional focus has been to create room for this policy instrument to encourage eco-innovation.

The presentation elaborated on three ways through which sustainable public procurement has the potential to encourage eco-innovation, through:

- award criteria,
- multi stakeholder eco innovation focussed projects, and
- future goal setting.

The Swedish charge on NOx emissions from stationary combustion sources (Lena Höglund Isaksson, Frida Gavelin)

The Swedish charge on nitrogen oxides (NOx) emissions from stationary combustion plants was introduced in 1992 as part of a broader strategy to bring down overall NOx emissions to meet environmental targets for acidification and eutrophication. The charge currently targets over 400 boilers producing at least 25 GWh useful energy per year and covering several different sectors from power and heat production, waste incineration, and chemical, metal, pulp- and paper, food and wood industries. Exempt from the charge due to e.g., concerns about unfeasibly high costs, are some industrial processes like iron and steel, cement and lime production processes as well as certain boiler types e.g., recovery and black liquor boilers.

The charge has successfully brought down emissions by 50 percent in terms of NOx per unit of useful energy produced by targeted plants. It has managed to decouple increases in energy output from increases in emissions. The charge was initially meant as a complement to quantitative emission limits for NOx introduced at a plant level already in 1988. After a few years, it was apparent that the charge had effectively pushed down emission intensities well below the quantitative emission limits.

Two crucial features for the success of the charge are the refund mechanism of the charge and the compulsory continuous monitoring of emissions. Targeted plants pay about 5 Euro/kg NOx emitted and revenues are refunded almost entirely to the targeted plants based on each plant's fraction of total energy output produced by targeted plants. This creates a system where polluters compete for the lowest emissions per unit of energy produced relative the other polluters in the system. Polluters with emission intensity exceeding the group average pay a net contribution to the system, while polluters with emission intensity below the group average receive a net refund from the system. Due to the refund mechanism it has been possible to set a high charge level and attain considerable emission reductions, while keeping polluter resistance to the charge at a minimum. Another important feature of the charge is that polluters are obliged to monitor NOx emissions continuously, which provides full

flexibility in the choice of abatement strategies and allows for exploiting technical as well as non-technical abatement options.

The high charge level creates strong continuous incentives to invest in innovation of abatement technology. A survey of actual costs for NOx abatement conducted on targeted plants in 1996, showed statistically significant downward shifts in the marginal abatement cost curve for targeted power plants over the period 1991-96. An analysis of emission intensity levels in targeted plants from 1992-2007 shows that these have been falling by almost three percent per year when controlling for the direct effect of technology adoption, hence suggesting effects of innovations.

Output-based refunding has the advantages of combining an ambitious environmental target with low polluter resistance and low administration costs. In contrast to a conventional emission tax or tradable permits, output-based refunding shifts the "proof burden" from a regulatory authority to the polluters as it becomes in the interest of the polluters to prove that low emission intensity levels have actually been attained (and higher refunds can then be claimed). Important prerequisites for output-based refunding are that there exists a single output upon which refunds can be based and that the output is independent of abatement. Other important prerequisites are a polluter community large enough to create a competitive situation and that technologies for continuous and careful monitoring are available and affordable.

Use of Standards and Other Measures to Prevent Salinization of Aquifers in Israel (Yael Mason)

Israel is experiencing a severe water shortage as a result of its location in a semi-arid area with both a rapidly growing population and economy, diminishing natural freshwater supplies and five consecutive years of drought. Salinization of surface water and groundwater is occurring as a result of interference with the hydrological balance, as well as from industrial, domestic and agricultural practices.

Policies and programmes have been introduced to provide long-term solutions for both the decreasing quantity and quality of water resources. Foremost amongst these are the introduction of desalination plants and extensive reclamation of sewage effluents for use in agriculture as well as encouraging the efficient use of water for irrigation.

Reducing the salt content of sewage effluent requires the reduction of the salt concentration at source. The Israeli Ministry of Environmental Protection has identified the sources of salt inputs in wastewater and introduced various instruments to reduce their levels. Four instruments are being used: i) legislation - stringent regulations have been introduced regarding sea disposal of brines or disposal into evaporation ponds instead of sewage systems; discharge of brines from water cooling towers into sewage systems is prohibited, just as marketing water softeners based on ion exchange to households. Also part of the legislative measures, a more flexible requirement for industry to use reverse osmosis (RO) for water softening instead of ion exchange has been enacted. New technologies have been developed to enable industry to meet these requirements. New regulations set new stringent effluent limits requiring also the reduction of salinity in supply water. These regulations were one of the triggers for the implementation of desalination plants based on innovative technologies as well as the development of novel technologies for tertiary wastewater treatment; ii) sea discharge permitting - setting discharge limits encourages the development of novel technologies for saline wastewater treatment at source; iii) introduction of new standards for detergents used in dishwashers and washing machines – it resulted in a dramatic reduction of Boron concentration in wastewater from the domestic sector; iv) economic incentives – they have motivated industry to implement the switch from ion exchange to RO and from water-cooling towers to air cooling systems and substitutes to salts are being sought.

Implementation of measures: In 2007, 740,000 m^3 of brines containing 40,000 tons of salt (about a third of total salt consumed in Israel) were disposed of at sea rather than into wastewater treatment plants, 65% of cooling systems sold today are air cooling systems and a large portion of the industry has changed to RO water softening process. In 2009 140 MCM of seawater as well as 30 MCM brackish (saline) groundwater wells were desalinated and mixed with potable water in the national water supply system, contributing to a reduction of salt (chloride, sodium, boron) content in supply water. Boron concentration has been reduced as a result of reducing boron salts in detergents from 0.7 to 0.2 mg/l, complying with new stringent effluent standards.

Effectiveness: Salinity of effluents used for irrigation is gradually decreasing contributing to the reduction of salinization of aquifers. This is a result of the measures implemented to reduce total salts consumed, total salts supplied in potable water and of the disposal at sea and into evaporation ponds of one third of the salt produced.

Conclusions: Introduction of stringent legislation and new standards accompanied by economic incentives for viable alternative practices, as well as other measures, have contributed to the reduction of salinization of aquifers and encouraged development of technological improvements and innovation.

SESSION 3. PUBLIC-PRIVATE PARTNERSHIPS FOR ECO-INNOVATION

Objective of the session

Previous sessions have highlighted that the private sector plays a particular role in the development and diffusion of eco-innovation. Indeed, public-private partnerships are acknowledged as a major mechanism to promote environment-friendly innovations.

The objective of this session was to shed some light on what should be expected from these partnerships (what objectives can reasonably be achieved) and how they should be organised (which structure, modalities, or criteria to select projects and make decisions). Particular attention was paid to SMEs and how they can be engaged.

A number of practitioners shared their experience on Green Tech incubators, Science Parks, Knowledge Transfer Networks, and clusters.

It should be noted that the OECD and the European Commission are jointly studying selected partnerships to shed some additional light on these and related issues.

Main messages from the speakers

Korea's Incubation Policy for Environmental Venture Companies (Soung-An Kwon)

In 2008, President Myung-Bak Lee declared the "Green Growth" policy as the new national development paradigm to create the national growth engine and jobs with new green technology and clean energy. With this policy, various types of policies and measurements to promote the green industry and technology in Korea have been strengthened and the movements of government and civil sectors for eco-innovation have been activated.

The presentation explored the incubation policy and current status of the environmental ventures that have been promoted since 2000. In addition, information has been shared on the projects for the environmental venture incubation and its direction, which has been strengthened since 2009 based on the "Green Growth" policy in 2008.

The presentation presented the concept of environmental industry in Korea as compared with the definition used in the OECD and in Europe. Through the trend of GDP and R&D investment in Korea, the status of the total venture companies and of environmental venture companies in particular has been assessed. In addition, the problems of the incubation policy up to 2008 have been highlighted. The endeavour to improve the incubation policy and new direction were presented.

The presentation was an opportunity to present Korea environmental venture incubation projects from 2003 to 2009. These included "Environmental Technology R&D Project: Eco-Technopia 21" and its results through the support of 800 million USD to develop environmental technology. The presentation covered the venture incubation fund as well, which was created for the environmental venture companies. Finally, the Environmental Technology Business Incubator (ETBI) was presented,

a project operated by KEIT (former KIEST) to provide support for the environmental ventures; the presentation covered the purpose, mode of operation, process of selecting promising ventures at ETBI.

The presentation also covered the direction and operation plan of "the green industry complex cluster". This cluster has been set up to enhance the overseas market share and to create the new high value-added industry by strengthening the technology and competitiveness of the existing environment industry.

Knowledge Transfer Network programme and their Rationalisation in the UK (Arnold Black)

The Knowledge Transfer Network programme (www.ktnetworks.co.uk) came out of a previous UK programme called Faraday Partnerships. Established between 1998 and 2003 the Faraday programme was seen as a UK business assistance programme to encourage closer contact and exchange between the science base and industry. Funded by the Research Councils (RC) and Department of Trade and Industry (DTI)/ Department for the Environment, Food, Regulations and Agriculture (Defra) funding it was intended to correct a critical weakness in the exploitation of science, engineering and technology in the UK - the lack of coherence between researchers and new product developers. Faraday Partnerships were designed to be business friendly, knowledge base industry partnerships recognized nationally and regionally as centres of expertise and collaboration in their sector or technology.

Most Faraday partnerships transitioned into Knowledge Transfer Networks (KTN) between 2003 and 2005.

A Knowledge Transfer Network is a group of individuals/organisation that have 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 UK. 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 (TSB). KTNs provide many benefits including:

- **Networking** - frequent opportunities to network with other businesses and academics through targeted events, meetings and Special Interest Groups organised by the KTN;

- **Information and news** - free access to on-line services such as reports, newsletters, webinars/e-training, events diaries, e-conferencing and collaboration tools and general sector/application specific information;

- **Funding opportunities** -advice on Technology Strategy Board Collaborative R&D calls, Knowledge Transfer Partnerships and other sources of funding for innovation such as Framework Programme 7, Eureka, Venture Capital;

- **Policy and regulation** - a communications route between their community, Government and EU, giving members the opportunity to influence policies and regulation in the UK and abroad.

KTNs are playing an increasingly important role in the development of the Technology Strategy Board's future direction with the objective to improve the UK's innovation performance by increasing

the breadth and depth or the knowledge transfer of technology into UK-based businesses and by accelerating the rate at which this process occurs.

Optimising the KTN 'Family'

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 2100 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 through links with a wide range of partners. KTNs engage with trade associations, technology providers, research councils, Regional Development Agencies and the Devolved Administrations to deliver benefits to businesses of all sizes.

The review highlighted an opportunity to refocus the work of the Knowledge Transfer Networks (KTNs), optimising the coverage of business and technology sectors, creating a more targeted, comprehensive and accessible range of network resources to help accelerate innovation.

This process of optimising the range of KTNs is now under way, and will see the number of formal networks reduced to around 15 - yet all existing knowledge exchange communities will continue to be supported within the new structure. Plans are also advanced to establish new KTNs in some areas, for example financial services and energy generation and supply.

Eco-Innovation - The role of Science Parks (Klaus Plate)

The economy today and in the future will be knowledge based and driven by knowledge. The knowledge economy needs locales that stimulate and enable innovation, whether it is in ICT, Bio or Eco.

Innovation is one of the buzzwords of our time. There are countless definitions. Basically innovation is a culture, personally it’s a mindset. Regarding the market, innovation is the ability to deliver new value to the customer. In general it means new solutions to unsolved problems and challenges. At least innovation is to see what everybody sees and to think what no one has thought before. Innovation needs an environment that stimulates new ideas, an atmosphere of open minded collaboration. Science Parks have proved to be the place for it.

Science Parks create a culture of Innovation, including all relevant actors from the areas they are focused on, including Eco. They are centres of Eco-Innovation.

The Heidelberg Technology Park has set up an EcoPark. It´s companies vary from consultancy in energy saving and making use of renewable energies to biotech firms with products and services to eliminate pollution. All of them are members of the EcoPark and Technology Park community meeting Science, Business and Politics, forming and living a culture of innovation in a stimulating surrounding. It is no secret that the restaurant located in the Park plays a significant role in bringing people together and fostering innovation.

Innovation, and in particular eco-innovation is borderless. Therefore it is one of the challenges of Eco-Innovation to build a worldwide alliance of the leading actors in Eco-Innovation. The Heidelberg Technology Park has taken these steps but it needs many more.

It needs a policy that provides funding and co-funding for Science Parks focused on Eco-Innovation to make them more recognized centers of excellence. It needs a public support for a clustered development to create EcoClusters and for a worldwide alliance of Science Parks and EcoClusters. This does not mean just offering public support to everyone. The way is to find the best and to strengthen the strengths. International benchmarking and evaluation are key.

Setting up a Green Innovation Hub in Trento (Gianluca Salvatori)

Over recent years the Autonomous Province of Trento has developed a policy aimed at nurturing innovative enterprises. This policy has been supported by various resources: an internationally recognised local government research system, efficient public administration, a social context that welcomes entrepreneurial initiative, a series of legislation and incentives tailor made to support small and medium sized businesses who believe in innovation.

Manifattura Domani is a public company created by the Autonomous Province of Trento with the purpose of realising the Manifattura project. The task consists of reinvigorating the site "ex Manifattura Tabacchi", an icon of the industrial history of Trentino. Its goals are to develop a production system specialized in the branches of environmental sustainability and *cleantech*, having as a basis the area of the province of Trentino but conceived to serve a much larger area to start with the north-eastern Italian regions which characteristically host small and medium sized companies being rather dynamic on a national level and candidates for relationships with globally active international enterprises.

The Manifattura project is concerned with the field of "green innovation". The most important topics concern the construction sector and renewable energies. In this context the Manifattura project, consisting of the re-use of an abandoned industrial site in the municipality of Rovereto, is strictly connected to the technological cluster "Habitech", founded in Trentino – and of national interest – for the purposes of energy and the environment.

The concern of the Manifattura project is to evidence the relation network created through the activity of the technological cluster "Habitech" in order to accelerate the development of new entrepreneurial initiatives by the means of the sharing of a physical space in which businesses, innovation promoters, research and education organizations interact. A space in which it is easy and natural to experiment, produce and transmit knowledge and innovative practises.

The Manifattura project is intended to welcome initiatives of different natures and dimensions. The type of construction of the site – either in the existing parts to be reconstructed (the building is from the 19th century) or in the parts still to be built – allows the collocation of a plurality of entities. For general orientation, and without being exhaustive, there can be distinguished:

- companies in incubation period or start-ups with space requirements of variable dimensions from a single working position up to spaces of 100-200 sqm equipped to host new enterprises or temporary projects;

- companies, new or already existent, with space requirements up to 500 sqm for their offices to host functions such as research, planning and engineering, in cases connected to development labs and/or prototype labs;

- companies with light production requiring spaces with industrial equipment, sized from 500 to 3000 m2;

- management, coordination and networking organizations;

- professional studios, consulting services, service-companies specialising in the field of green economy (e.g. Esco);

- labs, publicly or privately owned, for applied research with equipments allowing activities up to the construction of prototypes with space requirements between 100 and 500 m2;

- organizations providing education mainly addressed to operators and practitioners, with specific training purposes, life-long learning, technical updating, also taking the form of the reproduction of real systems (e.g. for the installation and the maintenance of technical structures, the realization of construction technologies or the experimenting of prototypes).

The following activities will integrate with each other in the Manifattura project:

- activities of applied research, developed also in cooperation with universities and research institutes;

- activities of demonstration and of technological qualification such as the creation of prototypes;

- activities for the development of production chains in the field of "green innovation";

- activities of industrialization for innovative products and/or services;

- activities of support in the creation and the development of new enterprises;

- activities of ongoing education and the creation of new professional profiles;

- activities of spreading research results through networks, service developments, technological transfers and further distribution;

- activities aimed at raising awareness through entertainment regarding the topics connected to the green economy.

Public Private Partnerships for eco-innovation, an industry perspective (Gernot Klotz)

In the last past months innovation has become the subject of many political debates in Europe and has been declared as an essential tool for taking up the opportunities presented by the societal grand challenges. Innovation is also key to the future of the chemical industry. The European chemical industry is providing modern materials and enabling technical solutions in virtually all sectors of the economy – its products are indispensable to address some of the most pressing global issues.

To address the societal challenges, the industry has to overcome certain barriers such as:

- the simultaneity of the multiple societal challenges;

- the too strong focus on research both in policy and in funding (not enough support for innovative demonstration projects – example: the Smart Energy Home project);

- the fragmentation between central European institutions and the Member States;

- the difficult access to appropriate projects and programmes and the insufficiency of instruments to carry forward good ideas into practice in a timely fashion;

- the lack of sufficient cooperation with and within the value chain;

- the urgency of actions that require innovative ways of cooperation.

There are a couple of initiatives that have already been started and where the chemical industry has played its role such as the European Innovation Strategy, facilitation of access to grant information, improved work between the national branches of SusChem (Sustainable Chemistry Technology Platform), calls related the European economic recovery plan, concrete projects between different technology platforms (chemistry & water), etc.

There are still a number of areas that need to be strongly taken up in order to help overcome the barriers mentioned:

- Improve leadership and focus of resources. In order to implement a European strategy, high level leadership (industry and European Commission) is needed. For example, the EU innovation policy should be an overarching task for the European Commission President to drive the innovation needs, with implementation being coordinated through the various DGs in specific well-defined packages. Furthermore, innovation needs the timely development of appropriate skills and human resources in order to address the needs of the business of tomorrow and the needed change in mindset of society about the challenges ahead.

- Better cooperation. A better and more pragmatic cooperation between EC and national institutions needs to be made possible, that their functioning mechanisms are re-designed in order to use the full potential of Europe and its various specific strengths. The same goes for international cooperation. It is also crucial that a better alignment and involvement of and within the industrial value chain is ensured. For example, an existing instrument such as the European Technology Platforms could better deliver on their objectives if enhanced cooperation is implemented.

- Speed up innovation delivery through synchronised funding programmes and innovation support as well as for the uptake of innovative technologies, especially in the public sector. Any activity must be evaluated against the tight timelines of solution delivering. In many areas innovative technologies are already available and just need to be brought together in appropriate demonstration projects (i.e. Smart Energy Home, F 3 Factory for the future).

SESSION 4. PARTICULAR CHALLENGES FOR NON-OECD COUNTRIES

Objective of the session

The objectives of this session were to identify barriers to the diffusion of clean technologies in emerging/developing countries, to assess the existing mechanisms for international co-operation in this area, and to discuss new opportunities for further co-operation.

The focus was on:

- Barriers to the diffusion of eco-innovation and green technologies in emerging/developing countries (e.g. access to knowledge; capacity and indigenous; patent protection and intellectual property rights);

- Instruments to overcome these barriers (e.g. multilateral co-operation on environmental challenges and multilateral environmental agreements; responsible trade and investment; trade in environmental goods and services).

The discussion highlighted the critical importance of developing indigenous eco-innovation capabilities amongst developing country firms, the tools that can contribute to this, and the role international cooperation can play.

It relied on practical experience and on a draft scoping note, which was developed by David Ockwell.

Main messages from the speakers

Difficulties Developing Countries Face in Accessing Markets for Eco-Innovation (David Ockwell)[6]

The deployment of eco-innovations in developing countries is a key driver of their contribution to efficiently addressing global environmental challenges. It is also a key driver of markets for eco-innovation and sustainable economic development. Recent research by the author explores the barriers developing countries[7] face in accessing markets for eco-innovation, outlines the key considerations policy needs to address to overcome these barriers and discusses the extent to which selected existing policy mechanisms have achieved this. The existing mechanisms analysed in the report commissioned for this Global Forum on Environment are Multilateral Environmental Agreements (including the Montreal Protocol and the Expert Group on Technology Transfer (EGTT), Clean Development

[6] The messages are developed in the paper drafted by David Ockwell. The paper will be released as an OECD Environment Working Paper

[7] Note that the term "developing countries" is adopted for ease of use in this report to refer to both developing and emerging economies. This is not intended to obscure the important contextual differences between, for example, the BRICS countries and countries in Sub-Saharan Africa, and these differences are considered in detail in this report relation to the context specific nature of appropriate policy approaches to facilitating access to, and access to markets for eco-innovation.

Mechanism (CDM) and the Global Environment Facility (GEF) under the auspices of the UNFCCC), information sharing initiatives (including the Environmental Technology Verification Programme), and more targeted international collaborative initiatives along the research, development, demonstration and deployment spectrum (including the UK Carbon Trust's Low Carbon Technology Diffusion and Innovation Centres, and Fundacion Chile).

The key finding of the research is that the majority of existing policy mechanisms fail to recognise the critical importance of developing indigenous eco-innovation capabilities amongst developing country firms. Indigenous eco-innovation capabilities are essential to facilitating *both* the diffusion of existing eco-innovations within developing countries *and* sustainable economic development based on the adoption, adaption and development of environmentally sound technologies that fit with the bespoke conditions faced by developing countries. 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 the hardware aspects of clean technologies, towards approaches that emphasise flows of underlying knowledge (know-how and know-why) and tacit knowledge. Policy also needs to be improved to better respond to the context-specific technological and cultural requirements which vary inter- and intra-nationally.

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, both in terms of maximising the impact on indigenous eco-innovation capabilities, and maximising the potential to attract sustained private sector investment in eco as opposed to conventional innovation. Precedents do currently exist, such as the Carbon Trust's proposed network of Low Carbon Technology Innovation and Diffusion Centres, and Fundacion Chile (a not for profit organisation geared towards facilitating access to relevant international innovations and increasing indigenous innovation capabilities). These provide potentially viable models for a more focussed, needs based approach to developing eco-innovation capabilities in developing countries than can be achieved by the centralised, large project based approach that tends to characterise current international efforts. The analysis has been used to set out some guiding principles for informing the post-Kyoto approach to technology transfer to developing countries.

Training and technology transfer: the engines for eco-innovation and entrepreneurship in Africa (Paul Ginies)

Between 2005 and 2030, the African population will have grown by more than 60%, exacerbating current tensions. Growing scarcities of resources and environmental degradation coupled with food insecurity may well give rise to major social tensions. Research can help curb these pandemics by providing the tools and knowledge that tomorrow's decision-makers will need at both the local and the international level.

In that context, 2iE is a public-private partnership serving eco-innovation; it contributes to building the capabilities which are needed to efficiently develop and transfer technologies that will yield result in the African context.

2iE combines research and training activities. Its research activities, specifically aimed at a "post-oil" world of solar energy, biofuels, eco-materials, and water and environmental management, target this near future by fully embracing the sustainable development of Africa. 2iE's training courses are based on research focusing on a post-oil horizon year of 2030. This approach, which can be qualified as "everything except oil", 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 respectively in water, ecosystem clean-up and health, hydrology

and water resources, biomass energy and biofuels, solar energy and energy economics, and eco-materials.

The 2iE foundation has one of the most advanced research laboratories anywhere in the fields of biofuels and solar energy. This laboratory conducts research, in partnership with CIRAD, into all parts of the sector, ranging from plant production to the performance ratings of biodiesel-fuelled engines.

This laboratory is currently working in close co-operation with the French Atomic Energy Commission (CEA) and the National Institute of Solar Energy (INES Savoie Technolac) to develop a pilot scheme to promote the flexi-energy concept for use in rural areas. This technology combines several energy sources (solar photovoltaic energy without storage batteries, diesel and biofuels in particular) to provide increased and secure access to energy, to reduce the consumption of diesel fuel by generator sets and, in the short term, to eliminate the use of fossil fuels altogether. This laboratory is also working on solar concentration plants which could be used to exploit Africa's untapped potential in this area.

Another example of new technology is the Compressed Earth Block (CEB) developed by the Ecological Construction Materials Laboratory. Given the excessively high cost of energy, the cement currently used for construction in Africa adds considerably to the costs of building houses. Research carried out since 1990 has made it possible to stabilise earth with an 8-12% mix of cement to produce CEBs. This extremely cheap material offers a temperature gain of 3-7°C. 2iE is currently using these blocks in the construction of extensions to its facilities. This laboratory is also conducting research into the use of plant fibres to produce construction materials normally imported from outside the African continent.

Training and research focused on innovation and entrepreneurship have made 2iE a magnet for students from all over the continent. The number of students studying on campus has risen from 220 to 850, and the number of students enrolled on distance learning courses from 0 to 400, within the space of 5 years. The 2i3 Foundation has won the trust of a variety of investors. Its EUR 30 million investment plan is fully funded and will allow the Foundation to enrol 2,500 students in 2012 from over 40 African countries and worldwide.

The challenges faced by emerging and developing countries regarding eco-innovation and policies to remedy these challenges – the case of MEAs (Alfred Oteng-Yeboah)

The MEAs have made tremendous efforts to ensure that the basic elements of access to and transfer of technology are achieved at all levels of the implementation of their programmes of work.

Eco-innovation is addressed by the three conventions under review: UNEP-CBD, UNFCCC and UNCCD. Each convention has devoted specific articles for technology transfer (UNEP-CBD Articles 16-19 UNFCCC Articles 3 and 4 and UNCCD Article18) to promote access to and transfer of technology in order to implement the other articles and work programmes of the conventions. The understanding is that these technologies can be diffused to provide the basis for the promotion of eco-innovations at national and local levels.

The emerging and developing country parties recognize the need for and application and adoption of technologies, especially eco-innovation (both local and imported) and their diffusion at the national levels to support their efforts at overcoming harsh environmental conditions they face.

Many communities and individuals at the local level in emerging and developing countries have developed local knowledge and expertise about some technologies which they use whenever they encounter unusual situations of drought, salination, flooding, crop failure, etc.

The need to integrate these with modern technology cannot be over emphasized because of the advantages associated with recognition of traditional knowledge. There are many of such indigenous technologies waiting to be documented, studied and made available for integration and use, taking into consideration all aspects of intellectual property rights.

In all the MEAs, the implementation of the programmes of work makes reference to a mix of access to and transfer of technologies as the means to achieve the objectives of these conventions, recognizing the contributions that also come from local sources and the need for IPR recognition.

A lot of scientific and technological cooperation, including the transfer of technologies, is already being undertaken, albeit on a small scale. The obstacles associated with such access and transfers of technology are well known. They include: high cost of new technology and lack of access to finance; lack of awareness and access to technical information; inadequate or restrictive government policies and regulations; lack of institutions to promote and implement new technologies; and lack of skilled human resources.

Professor Oteng-Yeboah suggests that the following policies can be set in place to overcome these barriers. The most important and more beneficial approach, in addition to provision of access to finance, would be to re-examine national policies, especially as they relate to the following:

- Access to knowledge in technology issues and international markets;
- The links between these and the development of indigenous innovation capabilities;
- The ability at the local level to adapt to eco-innovations developed abroad.

The OECD and developed country parties to the MEAs have major roles in this and are entreated to re-examine the effectiveness of their technology aid packages.

Overcoming Barriers to the Diffusion of Clean Technologies in Developing Countries (Nuna E. Almanzor)

The Philippines, like other developing countries, is beset with numerous environmental problems and issues. Resolving these environmental problems requires technical solutions such as innovative technologies.

However, potential users of these clean technologies refrain to utilize them for fear that they will not work. A technology's performance in another country may vary when used in the Philippines. Working conditions in the Philippines definitely differ from those in other places. Conditions such as tropical temperatures and high relative humidity may affect the technology's performance. There are also instances where foreign and local investors promote market and distribute their technologies all over the country with insufficient information on their performance efficiency based in distributors' claims. Available information on technical and economic performance is only available from suppliers.

To address these problems, the Environmental Technology Verification (ETV) programme was created. The Philippine ETV Programme aims to streamline the deployment of environmental

technologies and provide partnerships with various stakeholders and with international linkages. It provides the safeguard to the country from outdated technologies and other technologies that can cause environmental problems.

A major issue is the mutual recognition among national ETV schemes: Canada, Japan, Korea, the Philippines and the US have ETV schemes in operation. The European Commission and China are considering setting up similar mechanisms. The ultimate objective of mutual recognition would be "verified once, accepted everywhere".

APPENDIX 1. AGENDA OF THE GLOBAL FORUM ON ENVIRONMENT FOCUSED ON ECO-INNOVATION

Wednesday, 4 November 2009	
9:00-10:30	**Opening session: Setting the scene** **Chair: Mr. Pier Carlo Padoan** (OECD Deputy Secretary-General) **Dr. David Popp** (Syracuse University, USA) will pinpoint the main issues regarding policies to develop and transfer eco-innovation today. A scoping note commissioned by the OECD is available on the website. **Mr. Moon-Seob Youn** (Executive Director for Environmental Technology, KEITI, Korea) will share Korean experience on eco-innovation policies and highlight the role eco-innovation plays in the stimulus package in Korea. **Mr. Ronaldo Seroa da Motta** (IPEA; Brazil) will share Brazil's experience on the need to access technologies to address environmental challenges and on the main policy issues regarding the development and diffusion of eco-innovation.
10:30–12:00	**Session 1: Measuring eco-innovation** **Chair: Mr. Jan Boom** (Danish EPA) The objective of this session is to highlight the difficulties related to assessing the impact of policies to support eco-innovation. Two sets of questions arise: 1. Is it enough to measure innovations induced by particular policies, or should the quality of these innovations be considered (e.g. in terms of market opportunities or environmental performance)? 2. What are the gaps between the needs of policy makers and the available information and indicators? Are additional indicators needed? **Dr. David Widawsky** (Associate Director of the National Center for Environmental Innovation, US EPA) will explain what needs to be measured from a policy perspective, what instruments are implemented by US EPA and what the gaps are. **Dr. Mícheál Lehane** (Programme Manager for Environmental Research and Assessment, Irish EPA) will share the vision of Irish EPA, with a particular focus on research and innovation to support the development of a green economy). **Pr. Shukla** (Professor, Indian Institute of Management) will share the perspective of an emerging country, building on ongoing Japanese international cooperation. **Dr. René Kemp** (Maastricht University/United Nations University-MERIT) will share the latest developments in indicators for eco-innovation, based on the OECD project on sustainable manufacturing and eco-innovation, recent OECD work on the development of patent-based indicators of environmentally sound technologies, and Measuring Eco-Innovation, a recent research project for the European Commission.

12:00–14:00	***Lunch break***
14:00–18:00	**Session 2: Strengthening the design of policy instruments** **Chair: Mr. Hervé Martin** (EC/DG Environment/Environmental Technology Action Plan) The objective of this session is to shed light on the rationale for public support for eco-innovation and to wrap up what we know about the most effective ways of inducing innovation that serves the objectives of environment policies. The discussion will: 1. Assess the cost-effectiveness of selected policy instruments. Discuss the impact of *specific attributes* of policy instruments (e.g. flexibility, stability, stringency). 2. Discuss the impact of the design and implementation *process*, as it can build trust, help share information, build partnerships and make necessary adjustments; 3. Identify the capacities needed to operate specific instruments. **Dr. Gilles Leblanc** (Research fellow at CERNA – Mines Paris Tech) will set the scene, emphasizing that instruments have to be bounded in packages and that policies interact with other drivers to spur eco-innovation. He will build on ongoing case studies undertaken jointly by the OECD and the European Commission. A methodological note is available on the website. Participants are invited to send written comments at gfsd.eco-innovation@oecd.org by the end of November. **Ms. Wiana Partakusuma** (Director of the Interdepartmental Programme for Sustainable Procurement, VROM) will present the Dutch experience on public procurement and how it promotes eco-innovation. **Ms. Frida Gavelin** (Naturvårdsverket, Sweden) and **Dr. Lena Höglund Isaksson** (International Institute for Applied Systems Analysis, Austria) will present the innovation effects of the Swedish charge on NOx emissions. **Dr. Yael Mason** (Ministry of Environmental Protection, Israel) will discuss the benefits of standards vis-à-vis other instruments to prevent salination of aquifers. **Dr. Herman Vollebergh** (Netherlands Environmental Assessment Agency) will act as a discussant and put each presentation in perspective, to kick-off discussion.
18:00	***Cocktail***

Thursday, 5 November 2009	
9:00–12:00	**Session 3: Public-Private Partnerships for eco-innovation** **Chair: Kerry Rhoades** (Industry Canada/Environmental Industries Directorate) Partnerships between public and private actors are key to promote eco-innovation. A number of questions arise, regarding their organisation and the best use of public resources. Issues to be tackled include: 1. Rationale for public-private partnerships: when to set them up, what are the risks associated with them (e.g. crowding out)? Should public support be focused on early *vs* late technologies? How to optimise the allocation of public funds and the coordination of instruments? Are there competition issues and how can they be tackled? 2. What mechanisms work to stimulate private sector investment in eco-innovation? How to support SMEs as both technology suppliers and buyers? Focus on innovative partnerships (e.g. the role of governments as buyers of eco-innovation). **Mr. Soung-An Kwon** (Environmental Industry & of Technology Institute, Seoul; former Director of Environmental Technology Business Incubation, KIETI) will share experience with Korea's incubator for environmental industries. **Mr. Arnold Black** (Deputy Director, The Environmental Sustainability Knowledge Transfer Network, UK) will explain recent developments in the organisation and management of knowledge transfer networks in the UK. **Mr. Klaus Plate** (CEO of Technologiepark Heidelberg GmbH, Germany) will discuss the role science parks can play and the features of green technologies (as compared with ICT and biotechnologies). **Mr. Gianluca Salvatori** (President, Manifattura Domani) will share experience with the Green Innovation Hub in Trentino, Italy. **Mr. Gernot Klotz** (Executive Director for Research & Innovation, the European Chemical Industry Association) will give a business perspective based, *inter alia*, on the experience with the EU High-Level Group on Chemicals Competitiveness. **Dr. Herman Vollebergh** (Netherlands Environmental Assessment Agency) will act as a discussant and put each presentation in perspective.

12:00–14:00	***Lunch break***
14:00–17:30	**Session 4: Particular challenges for non-OECD countries** **Chair: Jyoti Prasad Painuly** (UNEP Risoe Centre in Denmark) The objectives of this session are to identify barriers to the diffusion of clean technologies in emerging/developing countries, to assess the existing mechanisms for international co-operation in this area and to discuss new opportunities for further co-operation. Issues to be debated include: 1. Barriers to the diffusion of eco-innovation and green tech in emerging/developing countries (e.g. access to knowledge; capacity; patent protection and intellectual property rights); 2. Instruments to overcome these barriers (e.g. multilateral co-operation on environmental challenges and multilateral environmental agreements; responsible trade and investment; trade in environmental goods and services; the Green Commons Initiative). **Dr. David Ockwell** (University of Sussex, SPRU) will scope the barriers to the diffusion of eco-innovation in developing countries, based, *inter alia*, on research commissioned by the UK and Indian governments on the transfer of low-carbon technologies. A draft paper commissioned by the OECD, with the support of the European Commission, is available on the website. Participants are invited to send written comments at gfsd.eco-innovation@oecd.org by the end of November. **Dr. Nuna E. Almanzor** (Director of the Industrial Technology Development Institute, Department of Science and Technology, the Philippines) will share her views about the opportunities and challenges regarding eco-innovation in the Philippines. She will explain the role Environmental Technology Verification can play in this context. **Mr. Paul Ginies** (International Institute for Water and Environmental Engineering, Burkina Faso) will discuss the role of education as a driver for the diffusion of eco-innovation in African countries. **Prof. Alfred Oteng-Yeboah** (Deputy Director General, Council for Scientific and Industrial Research, Ghana) will discuss the impacts of the Convention on Biological Diversity on innovations in the sustainable use of biological resources.
17:30–18:00	**Concluding session** The OECD secretariat will highlight some of the things that have been heard during the sessions, and how they will be integrated in further OECD work.

APPENDIX 2. BIOGRAPHIES OF THE SPEAKERS

Dr. Nuna ALMANZOR is the first lady Director of the Industrial Technology Development Institute, Department of Science and Technology, Government of the Philippines; she has been working with that Department (previously National Science and Development Board) since 1972. Dr. Almanzor is an active member of the Philippine National Consultative Committee for Standards and Quality, the Philippine Panel of Experts from AEC-International Quality Assurance System. She has authored technical papers and books in selected fields. She was awarded several distinctions such as Outstanding PhilJapa Fellow for Public Administration, Outstanding Personality and Socio-Civic leader by Asia-Pacific Youth Outreach Development Inc.; she is a British Council Fellow.

Arnold BLACK is Director of the Resource Efficiency Knowledge Transfer Network in the UK. After nearly 25 years in the Design, Operation and Maintenance of chemical plants in the UK and abroad, Arnold joined C-Tech Innovation in 2002 as a Project Manager. This partnership eventually evolved into a much larger Knowledge Transfer Network in Resource Efficiency funded by the UK government. Arnold is currently the Director. Arnold reports to an Industrial Steering committee, which includes different Ministries, the Confederation of British Industries, and key industrial collaborators. In his spare time Arnold is very involved in his local Church and has been to Africa recently with an international charity to offer project manager/funding advice for training/resource centre they are trying to build in Kenya and Uganda. Arnold will share the outcomes of a recent review of Knowledge Transfer Networks in the UK.

Frida GAVELIN has been working with the Swedish Environmental Protection Agency with the oversight of the Swedish NOx charge since April 2006. She holds an MSc in Environmental Engineering. Dr. **Lena HÖGLUND ISAKSSON** holds a PhD in Environmental Economics from Gothenburg University, Sweden, and is since January 2004 employed as a Research scholar at the International Institute for Applied Systems Analysis (IIASA) in Austria. Lena has developed the methane module in the GAINS model for air pollutants and greenhouse gases and coordinates policy applications of the GAINS model to non-CO_2 greenhouse gases. This work has included producing projections and mitigation cost-curves for future emissions of non-CO_2 greenhouse gases for the European Commission. Her research interests include empirical analysis of abatement behaviour and design of policy instruments. Previous employments include research and teaching positions in environmental economics and microeconomics at Gothenburg University, Skövde University College and University of Vienna, consultancy work for International Atomic Energy Agency (IAEA), and short-term employments by the Swedish International Development Agency (Sida) and the World Bank.

Mr. Paul GINIES has been appointed Executive Director of the 2iE Foundation in September 2004. Previously, he has been working on water, food and rural development issues in Africa for more than twenty years. At his instigation, major transformations have been decided and are being implemented such as the opening of the 2iE toward the private sector and toward English speaking countries, and the setting up of innovative and appropriate governing rules both on the financial and the academic sides. Since October 2009, Mr. Ginies is President of French-Burkinabe business men club. He is foreign trade advisor for the French government. He has a very good experience of international organizations and his one of the main actors of the connection with the African Initiative for Science and Technology/Nelson Mandela process. He can rely on a very motivated African team which he succeeded to bring together around himself and a common project.

Dr. René KEMP is professor of innovation and sustainable development at ICIS, Maastricht University and professorial fellow of UNU-MERIT in Maastricht (NL). He studied econometrics in Tilburg and worked as a visiting researcher at Harvard (US), Foscari University in Venice (Italy), IPTS (Spain), STEP (Norway), SPRU (UK) and EAWAG in Switzerland. René Kemp is well known for his work on eco-innovation, environmental policy, and governance for sustainable development. His research interests are: environmental policy and technical change; sustainability transitions; green innovation policy; evolutionary theories of technical change; reflexive governance. For the Dutch government he developed the steering model of transition management, together with Jan Rotmans. This model is currently used by the Dutch government for its innovation policy for sustainable development. For the Environment Council of July 2004 he wrote a policy note on strategies for eco-innovation, which fed into the Council's conclusions. Before that, he advised the European Commission on the RTD implications for climate change policy (in the framework of an ETAP project).

Gernot KLOTZ is the Executive Director for Research and Innovation at the European Chemical Industry Council (Cefic). He coordinates and steers the innovation-related activities of the organisation: technology development, innovation policies, societal acceptance of new technologies and products, emerging science/policy issues and the Cefic Long-range Research Initiative (LRI). He is also responsible for the EU Technology Platform for Sustainable Chemistry. Prior to joining Cefic in 2007, he held various research and business positions in Bayer. Gernot Klotz currently sits in various advisory and steering committees at OECD, WHO and EU Commission level in areas such as innovation, technology development, impact on environment and health.

Dr. Soung-An KWON is currently the team leader for the International Business Cooperation Team of Korea Environmental Industry & Technology Institute KEITI (former KIEST). Formerly, he was the director of Environmental Technology Business Incubator Center in KIEST. In addition, he was also executive programme manager of national environmental technology R&D project (Eco-Technopia 21) operated by KIEST. He is specialized in the promotion of the environmental industry, especially in the environmental venture company and also specialized in the planning of the international cooperation projects between countries such as international joint research, establishment of national environment management master plan and development of human capability for the developing countries. He has a Ph. D. in science from Nagoya University in Japan.

Gilles LE BLANC is professor of economics with Mines ParisTech and senior researcher in Cerna. His teaching, research and consulting interests are in the areas of industrial economics, competition dynamics, innovation, and public policies. From a theoretical perspective, his research deals with theories of market structure and their empirical application (to public policies and corporate decisions such as mergers, R&D, differentiation, or geographical location). Current research focuses on three main topics: the dynamics of the industry in France and Europe and the definition of an efficient industrial policy; competition, innovation, and regulation in emerging industries

(environmental, digital goods and services); agglomeration externalities, clusters, and the firm's location decision.

Dr. Mícheál LEHANE has a PhD from the National University of Ireland. He worked initially in the UK as a geologist supporting the North Sea exploration programme of Conoco Oil. Later he took up a position as a pollution control inspector in what is now the Environment Agency (England and Wales). In the mid 1990s, he joined the Irish Environmental Protection Agency (EPA) and has since held a variety of roles. He is now Head of Programme in the EPA's Office of Environmental Assessment and has responsibility for a range of functions. These include the EPA's environmental research and innovation programme, State of Environment assessment and reporting, Strategic Environmental Assessment, bathing water, noise, soil and the EPA's informatics and Geographical Information Systems. He is the Irish National Focal Point for the European Environment Agency.

Dr. Yael MASON received her PhD from the ETH- Zürich where she worked for the Swiss Federal Institute for Water Resources and Water Pollution Control under Prof. Werner Stumm, the Godfather of aquatic chemistry. She also worked for two years in Environmental Engineering at UCLA. After returning to Israel Yael joined the Ministry of Environmental protection where she was in charge of the Municipal wastewater section and was responsible for establishing national policy regarding aspects of secondary and tertiary wastewater treatment, reuse of wastewater for agricultural irrigation. Yael is currently head of the Department for Industrial Wastewater, Fuels and Soil Pollution and is responsible for determining national policy regarding professional and regulatory aspects of Industrial wastewater discharge limits of anthropogenic as well determining BAT (best available technologies) to improve Industrial wastewater quality, reduce its quantities, reduction at source and internal recycling, waste minimization and monitoring of industrial effluents. In addition Dr. Mason is responsible for treatment, risk assessment, and remediation of contaminated soils.

Dr David OCKWELL is a Lecturer in the Geography Department at the University of Sussex. He is also a Research Fellow in the Sussex Energy Group and an Honorary Fellow of the Tyndall Centre for Climate Change – both cutting edge research organisations providing policy advice on transitions to a low carbon economy. As well as leading work oriented towards understanding how to engage the public in low carbon behaviour change, for the last three years David has also led a collaborative UK-India study for the UK and Indian governments that provides an empirical basis for policy negotiations on low carbon technology transfer to developing countries. He now plays an advisory role to the UK Department for Energy and Climate Change on technology in the context of the United Nations Framework Convention on Climate Change and is about to commence a new study for the UK and Chinese governments mirroring UK-India work on technology transfer in a Chinese context.

Professor Alfred A. OTENG-YEBOAH is a Professor of Botany currently based at the University of Ghana. Before he retired from active Ghanaian public service in August 2006, he was the Deputy Director-General of the Council for Scientific and Industrial Research (CSIR-Ghana) with special responsibility towards national research co-ordination of issues of the Ghanaian environment and health. He has served as board/council member of a number of Ghanaian public institutions, including the Environmental Protection Agency (EPA), the Government of Ghana Scholarship Review Committee, the University of Ghana College of Health Sciences and the Centre for Scientific Research into Plant Medicine, the Ghana National Commission for UNESCO. He has chaired the Ghana National Biodiversity Committee since its inception in 1996 and has contributed in awareness creation of issues of biodiversity as a national heritage. At the international level, he serves on a number of high profile bodies and committees such as the Council of the Global Environment Facility (GEF) where he represents 8 coastal West African states. Previously he served as a member of the Millennium Ecosystem Assessment (MA) and its follow-up Scientific Advisory Body.

Ms. S.W. (Wiana) PARTAKUSUMA has been the director of the interdepartmental Programme for Sustainable Procurement at the Dutch Ministry for Environment since October 2007. Jacqueline Cramer, the Minister of Housing Spatial Planning and the Environment, who is the coordinating Minister responsible for the implementation of sustainable procurement, asked Mrs. Partakusuma to take on this role for the duration of the mandate of the current Cabinet. Before this Wiana was director General and Technical Services Management and CPO at the Ministry of Education and Culture. Her previous posts include deputy director of the Auditing Department, deputy director Information Service and head International Relations.

Dr. Klaus PLATE has been the CEO of Heidelberg Technology Park, the first Biopark in Germany, since 1994. A lawyer by training, he is the former International President of the International Association of Science and Technology Parks. His experience spans over a range of countries (including Germany, the US and China) and different industries (biotechs and green technologies). He is able to pinpoint the features of eco-innovation and the role science parks can play in this industry.

Dr. David POPP is an Associate Professor of Public Administration at the Maxwell School of Citizenship and Public Affairs at Syracuse University (USA), where he is a Senior Research Associate in the Center for Policy Research. He also is a Research Associate at the National Bureau of Economics. He is an economist with research interests in environmental policy and the economics of technological change. Much of his research focuses on the links between environmental policy and innovation, with a particular interest in how environmental and energy policies shape the development of new technologies that may be relevant for combating climate change. He holds a Ph.D. in Economics from Yale University. Dr. POPP has been commissioned by the OECD to develop a scoping note on things we know and major issues regarding policies to support eco-innovation in the current context. This note is available as background documentation on the webpage of the GFENV and was released as an OECD Environment Working Paper.

Mr. Gianluca SALVATORI has been focusing on research management and innovation policy for the last 15 years. For ten years, he has been in the managing team of an Italian leading research centre, working on ICT, material science, micro-technology. In the last five years, he was Commissioner in charge of research and innovation in the government of Trentino, one of the two Italian autonomous provinces. In this role, he has launched several major initiatives in the area of renewable energies and sustainable building (as the Italian Green Building Council and the "Habitech" cluster of green companies). In 2009, he was appointed President and CEO of *Manifattura domani*, a company established by Trentino's government with the mission of re-developing an old industrial site to host an "innovation hub" on green and clean technologies. Mr. Salvatori is CEO of Euricse, European Research Institute on Cooperative and Social Enterprises and Senior Enterprise Fellow, School of Entrepreneurship and Business, University of Essex. He used to chair the Advisory Board of the OECD LEED Trento Centre. He has experience working with emerging economies, as a former Chair of ITPAR, Indian-Trento Programme for Advanced Research.

Dr. Ronaldo SEROA da MOTTA is a Former Director at the Brazilian Ministry of the Environment and the Civil Aviation Authority. He currently is a Senior Researcher on Economic and Environmental Regulation at the Research Institute for Applied Economics (IPEA), Rio de Janeiro, Brazil. He has been working as a consultant on Economic Regulatory Issues for the World Bank, IADB, GTZ and UNEP. His recent publications include *Macroeconomic Policies for Sustainable Growth: Analytical Framework and Policy Studies of Brazil and Chile*, Edward Elgar Publishing, Cheltenhan, 2006 and *Economic Instruments for Water Management: The cases of France, Mexico and Brazil*, Edward Elgar Publishing, 2004. He works on environmental performance and competitiveness issues. He holds a Ph.D. in Economics from University College London.

Dr. Herman VOLLEBERGH is a Senior Fellow at the Netherlands Environmental Assessment Agency and visiting Research Fellow of the Smith School of Enterprise and the Environment from Oxford University. His teaching, research and consulting interests are in the area of environmental and public economics. His current research covers a broad range of topics including the design and effects of market based incentive mechanisms, like taxation, subsidies and tradeable permits in the energy or waste market, (environmental) cost-benefit analysis, long run relationship between emissions and income, and the effect of environmental policy on technological change. Finally, he has always been strongly involved in applying his academic work to the policy community including the OECD, European Union and the Dutch government. Recently he completed a study for the Organisation for Economic Co-operation and Development (OECD) on the differential impact of policy instruments like motor vehicle emission standards and fuel taxes on patents related to fuel-efficiency and emission abatement technologies of motor vehicles.

Dr. David WIDAWSKY serves as the Associate Director in the National Center for Environmental Innovation at the U.S. Environmental Protection Agency, where he leads several initiatives to identify and promote opportunities for enterprises to improve economic performance through improved environmental performance. Among many diverse roles, David serves on the Executive Council of an interagency workgroup (the Interagency Network of Enterprise Assistance Providers) focusing on identifying and promoting collaborations among federal agencies to support small and medium-sized enterprises. Since late 2007, he has worked to build a collaborative inter-agency federal network to promote Green Jobs and sustainable economic development. David has been at EPA for 10 years. Before joining EPA, he held a number of international positions, serving as a research economist in The Philippines, China, and India. David earned undergraduate degrees from the University of California at Berkeley (political economy of natural resources; plant and soil biology), a master's in agricultural economics at Colorado State University, and his Ph.D. in applied and development economics from Stanford University.

Dr. Moon-Seob YOUN is currently the executive director for Environmental Technology Division of Korea Environmental Industry & Technology Institute (KEITI). Formerly, he was a director of KMAC (Korea Materials and Components Industry Agency). Moreover, he was a former head of the Center for Emerging-Technology at Science and Technology Policy Institute (STEPI). His current duties are technology planning, assessment of emerging technologies and knowledge discovery in Science and Technology database. He has a Ph. D. in management science from Korea Graduate School in Management, KAIST.

APPENDIX 3. A METHODOLOGY TO DEVELOP CASE STUDIES ON ECO-INNOVATION, BY GILLES LE BLANC[8]

This note aims at defining a common framework for the case studies on eco-innovation which will be developed jointly by the OECD and the European Commission. The case studies are focused on the role of associated public policies. The methodology developed here builds on three key elements: 1) the specific economic patterns of eco-innovation with respect to standard innovation, 2) a review of the major determinants considered in the literature, 3) a refined framework setting the technological competitive environment based on the submarkets approach. The final section derives the implications for empirical research and interviews in the context of the case studies.

Specifying the economic nature of eco-innovation

Eco-innovation exhibits a number of distinctive economic features, which a comprehensive and insightful case study must consider. Fieldwork research and academic literature have identified the following key elements:

- Contrary to innovative products based on the creation of a new utility or quality improvement, there is no clear, undisputed, instantly valued by the customer, and widely shared evaluation of superior utility for green products or services. Most of them exhibit higher prices with no superior performances, quality improvement, nor satisfaction of a previously uncovered need. They usually actually offer a replacement alternative for existing solutions, with improved environmental impact, but at a higher price.

- Economic evaluation of eco-innovative products requires a life-cycle analysis to take into account savings over a long period of time. Even direct customer benefits such as energy saving must be aggregated on a life-cycle basis to compensate the purchase premium price.

- Some (not all) green technologies involve network externalities (either knowledge spillovers or facilitating infrastructure networks).

- They combine traditional product innovation valid in a specific market or sector with transversal enabling innovation, potentially valid for any sector.

- Very often, they involve several independent technological trajectories (i.e. limited demand substitution or R&D scope economies), raising irreversibility issues for public support or firm's R&D effort.

[8] Ecole des Mines de Paris / CERNA

Determinants of eco-innovation and role of policy instruments

Academic research on environmental innovation usually considers three types of explanatory variables: regulation, market and firm-internal conditions (ZEW, 2001; Bernauer et al., 2007). The vast empirical literature then builds an ad hoc framework to test relations between environmental innovation and a set of factors aimed at capturing the various forces at work in each field. To illustrate that strain of research, consider for example three recent papers. Cleff et al. (2008) examine five factors that can potentially act as driving forces stimulating innovation, or as barriers hampering innovation activities: 1) Financing of innovation, 2) Taxation, 3) Competition in product markets, 4) Demand, 5) Regulation. Horbach (2005, 2008) suggests determinants of eco-innovation should be grouped in three distinct fields: supply side, demand side, institutional and political influences. Technopolis (2008) lists the following elements: 1) Cost and demand, 2) Regulation and standards, 3) Taxation, 4) Competition, 5) Socio-cultural factors.

However, empirical (sector, country) studies on the relative influence of each factor brings so far inconclusive results. This is well illustrated by Mickwitz et al. (2008) testing some "popular claims" (such as regulation providing no additional incentive to innovate, the superiority of taxes to other policy instruments, or the inefficiency of R&D subsidies) on two industries in Finland, and demonstrating that any generalization of the role of policy instruments for environmental innovation is unfounded and dangerous. Despite these limitations, several methodological insights from the literature are worth considering to organize the case studies. We suggest grouping them in three categories: the technological innovation system and its "failures", the dynamic view of markets and public intervention, the diversity of policy instruments and goals.

The first approach uses the concept of technological innovation system (TIS) to pin down some "system failures" hampering innovation. The systemic picture sees technological innovation as arising out of interplay between different actors and involving both knowledge flows and market interactions. In this richer picture of innovation process and diffusion, seven main functions of the TIS are identified and characterized (Bergek et al., 2008; Hekkert et al., 2007 among many references): knowledge creation and diffusion, entrepreneurial experimentation, definition of the directions of search, market formation, exchange of information, legitimation, and resource mobilization. This framework allows a more accurate analysis of barriers and incentives to innovate and the potential room for public policy, as the underlying view is that the overall system efficiency relies on the performance of each of those functions (see Hekkert et al., 2007 on the success case of cogeneration in the Netherlands, or Foxon, Pearson, 2008 on the identification of system failures in the UK associated with the lock-in of existing carbon-based technologies).

A second line of research insists on the dynamics of markets (product life-cycle) and public policy (timing, accumulation, and consistency of public instruments). Specific attention is here paid to the time process of innovation diffusion. Egmond et al. (2006) distinguishes between three stages of market development: the early market (innovators and early adopters), followed by the mainstream market (the early and late majority), and ending with the laggards. The interesting point is that the rationality to adopt innovation differs between these categories. While early adopters expect a radical discontinuity, bet on a change in the competition to build temporary monopolies through innovation and are prepared to bear with the associated risks and costs, mainstream players are careful decision-makers with routines and habits, consider innovation as an application to solve current problems, and seek gradual continuous change. This has important consequences on the relevance and efficiency of each potential policy instrument. Another similar time segmentation can be found in Foxon et al. (2005) based on five technological maturity stages: R&D, Demonstration, Pre-commercial, Supported commercial, Fully commercial. But public policy also has its own time frame and dynamics. Chappin et al. (2009) note that most studies on the effects of environmental policy on environmental innovation

neglect policy accumulation, or only focus on short time periods. They suggest to investigate the policy accumulation, i.e. the implementation of "a mixture of policy instruments with a variety of underlying mechanisms to enable the achievement of policy goals". Attention should then 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 the different time periods. The results reveal different effects: some instruments reinforcing each other, new instruments disturbing situations originating from earlier policy instruments, negative risk-adverse firm behavior triggered by several instruments implemented in a short time span.

Finally, several papers emphasize the variety of policy instruments used (fiscal incentives, direct subsidies, norms design, public procurement…) and argue that this diversity should be comprehensively reviewed to evaluate the impact of public policies on innovation creation and diffusion. Actually, instruments are not substitutes as they differ significantly across several dimensions. An efficient policy cannot solely rely on a single one and will mix a set of tools over time. As Egmond et al. (2006) claim, "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. To conduct such an analysis, an interesting comparative frame is developed by Aschhoff and Sofka (2009). To assess the role of public procurement on innovation policy, they compare it to other major policy instruments such as regulation, R&D subsidies, basic research at universities, along a set of key features: selection decision, selectivity, government objectives, input for the firm, incentives for the firm, effects on the firm, time horizon, and risk.

Reconciling these three different approaches in a comprehensive (and potentially formal) model would be a huge and ambitious task, well beyond this study. While several attempts are worth noting in this direction (notably Foxon, Pearson, 2008 and Bergek et al., 2008), we suggest a rather pragmatic and empirical use of their results for the case studies. The various dimensions and descriptive variables introduced to specify the TIS functions, the market dynamics, the variety and time accumulation of policy instruments will be assessed for each eco innovation considered. This will indeed allow a richer and more accurate picture of the institutional and market features as well as the nature of public policy. However, the competitive environment and market structure also deserve more attention. The following section suggests a framework based on industrial organization research to capture their key features relevant for eco innovation.

Conceptual framework of eco-innovation diversity and competition

The technological landscape of eco-innovation is quite complex and often rests, as mentioned in section one, on a large variety of distinct technical solutions. Using the global R&D effort on a given market to evaluate the competitive impact can then be misleading and irrelevant. This calls for a finer and more accurate description of the technological environment. Recent works in the industrial organization literature may prove to be very useful in this respect.

The starting point is that most of competition models rest on the definition of a market as comprising a set of goods, all of which are substitutes. However in highly innovative and R&D intensive industries, we have to define a market broadly enough to incorporate all substitute goods, which may lead us to include various sets of products, each of them requiring some distinct technical knowledge, know-how or investment. For example, when electronic device aims at replacing mechanical equipment, both mother industries should be jointly considered to define the relevant and comprehensive competitive and technological landscape. In this case, the firm or the public institutions must choose not only the level of R&D spending, but also the way in which this R&D

effort must be divided among the various product groups. Those R&D programs may or may not contain common elements, raising small or large economies of scope in R&D across different submarkets. At the same time, on the demand side, the level of product substitution may significantly vary across submarkets, defining closely interlinked subgroups and more isolated ones. As public policy or firms's actions in one submarket will have effects on the competition, profits and strategic choices of firms in the other submarkets, one cannot dismiss this problem by working at a lower level of aggregation and simply moving the analysis of competition and market structure at the level of the submarket.

Actually, the pattern of linkages across submarkets on the demand (substitution) and technological (R&D scope economies) sides is often quite complex. Sutton (1998) suggested a response to these problems by introducing the notion of distinct technological trajectories, each of them associated with a distinct submarket. 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 on other trajectories and submarkets. On the other hand, when products in different submarkets are poor substitutes, the market becomes separable in a number of independent submarkets, where a superior R&D effort in one of them will have little impact on the others.

In this setting, two polar patterns may emerge in high tech and innovative industries. The first one is a pattern of R&D escalation along a single technical trajectory, leading to a high level of concentration. The second one 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 flowmeter industry (specific applications to particular types of buyers limit the scope of demand substitution and, despite a high-level of R&D intensity, allows for a large number of submarkets, of specialized firms, and fragmentation of the industry).

This framework could bring insightful results in the case of eco-innovation, allowing a distinction between markets where escalation mechanism prevails and those marked by a continuous proliferation of technological trajectories. This context will have significant implications for the analysis of the respective role of market forces (demand, supply) and public policies. This line of reasoning requires a definition of the overall utility in the market considered, a comprehensive identification of the various technical solutions available to answer this need, including the environmental ones, and a careful examination of the substitution and scope for R&D economies between them.

Implications for the empirical work

The discussion carried out in the three above sections suggests several methodological points for a rigorous empirical research along case studies of eco-innovation. All of them aim at defining a finer and more relevant framework taking into account the different economic dimensions of the eco-innovation considered. Four key elements can be successively underlined: overall utility definition, innovation patterns, demand characteristics, competition.

Definition of the overall benefit served and the associated market

The diversity of environmental issues must be clarified. Regulations usually do not target the overall environmental performance of products but consider specific issues such as toxic emissions, recyclability or energy consumption. Equally, innovation improves one, sometimes a few environmental attributes of products. Also firms do not face the same regulatory stringency for each

environmental issue. Product innovation, regulatory stringency and potential for customer benefit vary over the different environmental issues[9].

To define the market where the eco-innovation will compete, a comprehensive review of all existing or planned solutions fulfilling the same overall benefit must be carried out. This will help defining the different submarkets at stake.

Specification of the eco-innovation

The eco-innovation can be detailed with the classical distinction between product, process and organization innovation. Actually, organizational innovation in the field of eco-innovation is rarely examined and taken into consideration, while this factor could play a crucial role in the adoption and diffusion rate.

It is also worth examining, depending on the technology and the market considered, the scope and composition of the double externality in eco-innovation (Renning, 2000): environmental quality improvement in addition to traditional R&D spillover.

Finally, the definition of an environmental product innovation could be enriched by characterizing its extent (i.e. the proportion of products for which green innovations have been implemented) as well as its degree of novelty (for the firm or for the market respectively).

Demand

The potential direct benefits for the customer (green marketing literature) should be carefully examined and specified. Products which besides public benefits also bring direct private environmental gains for the customer will generate stronger demand. The potential sources are multiple: cost and energy savings, improved durability, better repair, upgrade and disposal possibilities, reduced health impacts…

A distinction between individual and firms' demand will be introduced, as this defines quite distinct market and competitive environment.

Competition

Following the approach presented in section 3, the extent and nature of demand substitution and R&D scope economies between the different technologies and submarkets will be carried out. On this basis, a definition of the technological context in terms of escalation or proliferation can be suggested.

A specific attention will be given to the dynamic effects. While most of the studies have a static view focusing on the innovation R&D, conception, the final outcome is clearly determined by the adoption, diffusion and deployment process. This is particularly true in markets with technological proliferation (multiple distinct trajectories).

In conclusion, let's note that the set of cases (electric car, CSS, CHP, fuel cell, biopackaging) considered in this study covers the differentiating variables suggested. For instance, it includes product innovation (electric car) as well as transversal enabling technologies (CSS, CHP). The electric car environment is marked by technology proliferation while CSS and CHP are based on a limited number

[9] For an empirical illustration, see Kammerer, 2009 on the case of the German appliances industry.

of technological options. Markets for electric cars and CHP systems already exist though rather small, while CSS is still at a development and experimental stage.

Scope and of content planned interviews for the case studies

The methodological approach developed below also has important implications for the interviews to be carried out for the case studies. First, it suggests an enlarged scope of relevant targets for fieldwork research. To assess the competition between distinct technological trajectories as well as the potential for product substitution and R&D scope economies, one should not limit the analysis to the eco-innovation per se, but also consider the other alternatives and the associated industries. This will allow a practical evaluation of network externalities, market structures, diversity of technological trajectories, crucial for the successful adoption of an eco-innovation in its specific technological and competitive environment. Secondly, the customer side should be carefully examined, to evaluate the potential direct benefits brought by an eco-innovation, according to existing substitutes and the nature of market competition (price, product differentiation, quality, brand…). Finally, the analysis of public policies in terms of instruments' scope and coordination will be enriched by the specification of market structure, technological environment, customer potential direct benefits, as well as the timing and variety of public tools.

References

Aschhoff B., Sofka W. (2009) "Innovation on demand – Can public procurement drive market success of innovations", *Research Policy*, n° 38, pp. 1235-1247.

Bergek A., Jacobsson S., Carlsson B., Lindmark S., Rickne A. (2008) "Analyzing the functional dynamics of technological innovation systems: A scheme of analysis", *Research Policy*, vol. 37, n° 3, pp. 407-429.

Brown M., Canzler W., Fisher F., Knie A. (1995) "Technology innovation through environmental policy. California's Zer-emission vehicle regulation", *Public Productivity & Management Review*, vol. 19, n° 1, pp. 77-93.

Brunnermeier S., Cohen M. (2003) "Determinants of environmental innovation in US manufacturing industries", *Journal of environmental economics and management*, n° 45, pp. 278-293.

Callon M. (1979) "L'État face à l'innovation technique : le cas du véhicule électrique", *Revue française de science politique*, vol.29, n° 3, pp. 426-447.

Chen C. (2001) "Design for the Environment: A Quality-Based Model for Green Product Development", *Management Science*, vol. 47, n° 2, pp. 250-263.

Cleff T. et al. (2008) *Regulatory and policy issues influencing innovation in the eco-innovation sector*, Final Report, ZEW, April.

Egmond C., Jonkers R., Kok G. (2006) "One size fits all? Policy instruments should fit the segment of target groups", *Energy Policy*, n° 34, pp. 3464-3474.

Eiadat Y., Kelly A., Roche F., Eyadat H. (2008) "Green and competitive? An empirical test of the mediating role of environmental innovation strategy", *Journal of World Business*, n° 43, pp. 131-145.

Foxon T., Gross R., Chase A., Howes J., Arnall A., Anderson D. (2005) "UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures", *Energy Policy*, vol. 33, n° 16, pp. 2123-2137.

Foxon T., Pearson P. (2008) "Overcoming barriers to innovation and diffusion of cleaner technologies: some features of a sustainable innovation policy regime", *Journal of Cleaner Production*, n° 16, pp. 148-161.

Gibbins J., Chalmers H. (2008) "Carbon capture and storage", *Energy Policy*, n° 38, 4317-4322.

Hekkert M., Harmsen R., de Jong A. (2007) "Explaining the rapid diffusion of Dutch cogeneration by innovation system functioning", *Energy Policy*, vol. 35, n° 9, pp. 4677-4687.

Horbach J. (2008) "Determinants of environmental innovation – New evidence from German panel data sources", *Research Policy*, n° 37, pp. 163-173.

Kammerer D. (2009) "The effects of customer benefit and regulation on environmental product innovation. Empirical evidence from appliance manufacturers in Germany", *Ecological Economics*, n° 68, pp. 2285-2295.

Klepper S., Thompson P. (2006) "Submarkets and the evolution of market structure", *The Rand Journal of Economics*, vol. 37, n° 4, pp. 861-886.

Mickwitz P., Hyvättinen H., Kivimaa P. (2008) "The role of policy instruments in the innovation diffusion of environmentally friendlier technologies: popular claims versus case study experiences", *Journal of Cleaner Production*, n° 16, pp. 162-170.

Nill J., Kemp R. (2009) "Evolutionary approaches for sustainable innovation policies: From niche to paradigm?", *Research Policy*, n° 38, pp. 668-680.

OECD (2008) *Environmental innovation and global markets*, Working party on global and structural policies, Environment Directorate, Environment Policy Committee, Paris, February.

Otto V., Reilly J. (2008) "Directed technical change and the adoption of CO_2 abatement technology: the case of CO_2 capture and storage", *Energy Economics*, n° 30, pp. 2879-2898.

Pujari D. (2006) "Eco-innovation and new product development: understanding the influences on market performances", *Technovation*, n° 26, pp. 76-85.

Rae J. (1955) "The Electric Vehicle Company: A Monopoly That Missed", *The Business History Review*, vol. 29, n° 4, pp. 298-311.

Reid A., Miedzinski M. (2008) *Sectoral innovation watch in Europe / Eco-innovation*, Final Report, Europe Innova, May.

Rennings K., Ziegler A., Ankele K., Hoffmann E. (2006) "The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance", *Ecological Economics*, vol. 57, n° 1, pp. 45-59.

Sutton (1996) *Sunk Costs and Market Structure*, Cambridge, The MIT Press.

Sutton J. (1998) *Technology and Market Structure*, Cambridge, The MIT Press.

Vega-Redondo F. (1996) "Technological change and market structure: an evolutionary approach", *International Journal of Industrial Organization*, n° 16, pp. 203-226.

ZEW (2007) *Analysis of regulatory and policy issues influencing sectoral innovation patterns, Sector report eco-innovation*, draft, Sectoral innovation watch, Work Package 6