ADDRESSING CLIMATE CHANGE THROUGH INNOVATION – THE CHALLENGES AHEAD

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Climate change mitigation policies have wide-ranging ramifications for economic activity and international cooperation. The transition to a low carbon economy will create business opportunities for those who anticipate the changes. Given the scale and systemic nature of the necessary shift towards low carbon technologies, there is a clear link between the challenges posed by climate change mitigation efforts and innovation policies.

Climate change mitigation policies are beneficial in the long-term when compared with the consequences of inaction and the disruptions created by global warming. Some measures, such as energy efficiency, have a double positive impact – reducing overall resource intensity and GHG emissions at the same time. However, in the short-term some interventions will bring costs, while the visibility of the future benefits remains unclear. Technological innovation contributes to reducing these costs and therefore to increasing the political and social acceptability of these efforts.

The object of this short essay is to briefly discuss the relations between climate change and innovation, stressing the insights that the literature on innovation offers when dealing with the complex realities of climate change mitigation.

The ultimate target of climate change mitigation policies is to reduce GHG emissions enough to contain the damage from rising temperatures. However, this needs to be compatible with continued economic expansion, so as to provide lasting improvements in prosperity that ensure the political feasibility of these policies. Reconciling these two targets means that the "carbon productivity" of the economy (the amount of GDP produced per unit of carbon equivalent) must increase dramatically. A recent study by the McKinsey Global Institute[11] estimates that in order to meet generally accepted carbon reduction paths, carbon productivity should rise tenfold by 2050.

Existing technologies can be deployed to achieve significant gains in the carbon efficiency of the economy. McKinsey calculates that around 70 per cent of the 2030 abatement potential is not dependent on new technology. The IPCC Fourth Assessment Report concluded that existing technologies or those than can be expected to be commercialized over the next decades, are sufficient to stabilize atmospheric GHG emissions. However, the widespread use of a known technology and the development of emerging options depend on the existing system of incentives and the general conditions for their adoption and diffusion. Thus, the IPCC emphasised that the assumption of technological feasibility of stabilization efforts hinges on the existence of "appropriate and effective incentives, for development, acquisition, deployment and diffusion of technologies", while addressing all related barriers.[12] These are the sort of questions that are central to the debates on innovation policies.

Innovation includes not only products and processes that are new to the world (pure innovation), but also those that are new to a particular firm or country (diffusion). In addition to pure innovation, diffusion of innovative technologies across countries will play an important role addressing climate change mitigation challenges. The deployment of existing technologies could be accelerated by means of active support policies which take advantage of normal capital replacement.

Emerging markets may be in a better position to avoid the constraining effects of lock-in technologies that hamper the deployment of innovative, superior alternatives. Installed infrastructure discourages the introduction of innovation, but dissemination of existing technologies in emerging markets would require harnessing appropriate sources of financing and overcoming other general barriers to technology adoption.

The transition to a low-carbon economy will require both the development of new technologies and implementation of existing solutions on a wider scale. New technologies, but also new ways of organizing economic activities, will be necessary. In essence, such dramatic change will require putting in place a policy, regulatory and institutional framework that supports innovation (including diffusion of existing technologies). First and foremost, this requires creating the right incentives and structures to promote large-scale, worldwide change.

[11] *McKinsey Global Institute (2008), The carbon productivity challenge: Curbing climate change and sustaining economic growth.*
[12] *IPCC (2007), Fourth Assessment Report.*

ECO-INNOVATION – A BROADER VIEW

Climate change mitigation efforts are concerned with the reduction of GHG emissions. Eco-innovation is a wider concept that includes any type of innovation (new products and processes) that reduces environmental impact or increases resource productivity. Eco-innovation policies take into account not only short-term implications on economic growth, but also the impact on sustainability over a longer time horizon.

In this approach, the environmental impact of a product or service is considered through the various phases of its life, from production to consumption. Empirical evidence suggests that most gains in efficiency can be obtained at the early stages of the life cycle of the product, i.e. when it is being designed or extracted.[13] This implies that environmental concerns should be incorporated early on.

Eco-innovation policies combine the traditional objectives of environmental and innovation policies to promote simultaneously environmentally friendly outcomes and economic competitiveness. This approach is in line with the view of innovation policy as a horizontal policy that represents a dimension of intervention in other areas such as research, education, energy, transport or environment. Such an understanding of innovation policy goes beyond a focus on science and technology to encompass more comprehensive, systemic interventions with a multisectoral character. This has obvious implications for the governance and design of innovation policies, which require coordination between various policy layers and agencies, including those dealing with environmental issues.

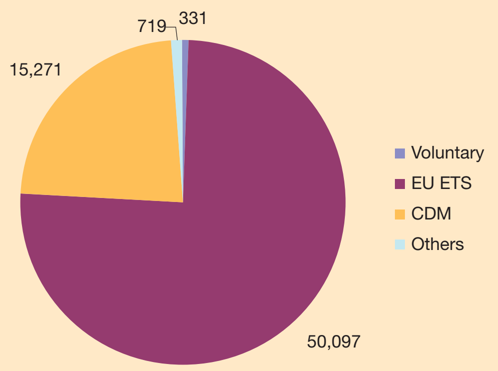
GETTING INCENTIVES RIGHT

A fundamental condition to facilitate the transition to a low carbon economy is the existence of a framework that reassures investors, firms and consumers that their decisions (involving definite costs) would generate an adequate return that can be estimated within an acceptable range. A long-term perspective is required to reduce the financial risk of investments and encourage R&D efforts. Given the long life of infrastructure used in energy production, long-term price signals are critical in the deployment of appropriate technologies.

The most basic incentive for shifting towards a low carbon economy and promoting innovation in this area is the existence of a price for carbon emissions, which is sufficiently high and predictable to encourage change. A price for carbon would serve to internalize the environmental impact of economic activities. Research shows that increased implicit prices of emissions encourage innovation activity, as demonstrated by the number of patents in related areas.[14]

A high price of carbon would result in structural changes throughout the economy. Although the current situation does not yet comply with these requirements, developments are moving in that direction. There is as yet no global emissions trading

Figure 1 Carbon markets, $ million, 2007



Source: Ecosystem Marketplace, New Carbon Finance, World Bank.

Note: EU ETS European Union Greenhouse Gas Emission Trading Scheme
CDM Clean Development Mechanism

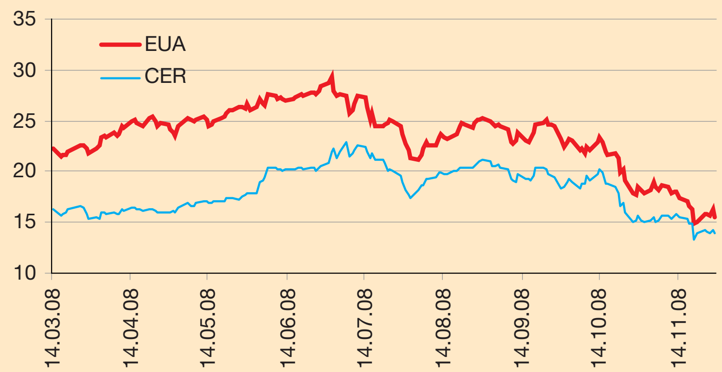
[13] *Alasdair Reid and Michal Miedzinski (2008), Eco-Innovation. Final report for Sectoral Innovation Watch, Europe Innova.*
[14] *R. C. Vollebergh (2007), Differential impact of environmental policy instruments on technological change: a review of the empirical literature. Tinbergen Institute Disc*

regime but, in addition to the cap-and-trade EU Emission Trading System, some other regional schemes are emerging, although linkages between them have yet to be defined. Carbon markets remain disconnected globally.

Moreover, the sector coverage of existing arrangements is limited, which reduces the incentives for change via price mechanisms in sectors that remain outside the schemes. A more widespread coverage would help to reduce the cost of abatement, with the resources allocated where emission reductions are cheaper to achieve. Uncertainty regarding the future price of carbon and whether that price will come into effect is a major disincentive for the adoption of more carbon efficient technologies. Further progress in developing a global framework would create better incentives for companies, consumers and governments to adapt.

There has been a lively debate on the relative merits of a carbon tax and a cap-and-trade system (resulting in a carbon price). This issue is considered in greater detail in the paper by Robert Shelburne in this Report. In any case, it seems that for all practical purposes, tradable permits will be the prevalent scheme. Tradable permits result in greater certainty over

Figure 2 Futures contracts, December 2008 settlement, EUR per ton CO_2



Source: European Climate Exchange

Note: European Union Allowances (EUA) and Certified Emission Reduction (CR) (units issued in the framework of the CDM).

environmental outcomes, since they define a priori the amount of acceptable emissions and let the prices adjust accordingly. However, tradable permits generate more price volatility in comparison with a carbon tax, which may deter innovation. In any case, this uncertainty about future prices seems unavoidable under both schemes, since any arrangement is likely to be revised in the future, as the understanding over the need for emission cuts changes and new technological developments take place. Moreover, financial instruments would emerge to offset the price volatility inherent in a cap-and-trade system.

Global cap-and-trade schemes can generate significant financial flows to developing countries. This is one of the advantages of these arrangements in relation to a carbon tax. The Clean Development Mechanism (CDM), as established by the Kyoto Protocol, finances emission mitigation projects in developing countries and serves to extend the reach of cap-and-trade programmes in developed countries. It accounts for a significant share of the global carbon market (figure 1). However, there are limitations in the CDM that constrain the scale and scope of climate mitigation measures in developing countries. In particular, there are sizeable transaction costs and some existing opportunities are too small to be exploited on a project basis. It has thus been proposed that the CDM could move from targeting specific projects to cover entire industries, or even include the implementation of policies.[15] These financial flows would be influenced not only by the existence of climate mitigation opportunities, but also by more general factors defining the investment climate and technological absorption capabilities of the recipient country.

Independent of the institutional setting regarding carbon pricing, it is obvious that high energy prices (provided they are predictable in the medium to long term) are a key driver for energy-saving activities and technological change aiming at higher energy efficiency. Moreover, high energy prices are associated with higher implicit emission prices.

Market-based mechanisms (such as pricing) are important for creating incentives for innovation. A distinct advantage in relation to command-and-control instruments is that market-based mechanisms require less information than regulatory targets. Standards do not create incentives for innovation beyond what it is necessary to ensure compliance.

However, price signals for investing in technological development remain weak (figure 2). In any case, price-based instruments are unlikely to provide a coverage that is comprehensive enough (in terms of countries and sectors) over the

[15] *Joseph Aldy and Robert Stavins (2008), The role of technology policies in an international climate agreement, The Harvard Project on International Climate Agreements.*

medium term. Given existing uncertainties and the institutional underdevelopment of carbon markets, additional instruments and interventions are required to complement market-based mechanisms.

The price mechanism (including both the elimination of energy subsidies and the existence of a carbon price) is a necessary but insufficient condition to bring about change. Moreover, the literature on innovation shows that there are market failures that need to be overcome, both in relation to pure innovation and the deployment of existing technologies. Firms invest less than what would be socially desirable because they cannot fully appropriate the returns on their investments. This is a feature that is shared with climate change mitigation efforts, whose benefits go beyond those who initiate them.

Market failures are also present in the diffusion of technologies, in connection with the presence of network and learning-by-doing effects. In the context of climate change mitigation, other market failures include the lock-in effects of existing carbon-based technologies and the high costs for early adopters of low carbon technologies. More generally, systemic failures slow or block interactive learning and innovation in a given national innovation system. These systemic failures are likely to be more acute in emerging markets, where the capabilities of companies to participate in interactive learning is limited, linkages between the various actors of the innovation system are weak and institutional capabilities are underdeveloped.

Market failures are especially relevant in regard to innovations related to climate change mitigation. The gap between social and expected private returns is particularly large because of the uncertainty regarding the future characteristics of climate policy, over a long horizon, in the absence of clear and well-defined commitments.

Climate change mitigation efforts have an obvious long-term dimension. This stresses the need to encourage a high level of innovation (and their diffusion) regarding technologies that can reduce GHG emissions, so as to lower future abatement costs.

INTELLECTUAL PROPERTY RIGHTS: A NEED FOR BALANCE

Intellectual property rights provide innovators with a degree of protection over the results of their efforts and are thus a basic component of the incentive system to encourage innovation. However, there is a need to reach a suitable balance between the creation of conditions for the rapid diffusion of climate change technologies and the incentives for innovation through the protection of intellectual property rights.

In particular, the needs of technology transfer to developing countries may require special arrangements, similar to those observed in the pharmaceutical industry, to make technologies available to developing countries at lower costs.

On the other hand, it has been argued that a major technological breakthrough in the area of climate change would have such significant implications that the commitment to protect intellectual property rights is not fully credible, thus deterring private investment.[16] This market failure reinforces the need for public involvement in R&D efforts.

Private initiatives have emerged to facilitate the diffusion of technologies contributing to climate change mitigation. Some companies have created "eco-patent commons", where some patents with a direct or indirect influence on protecting the environment are made available free of charge.

TECHNOLOGICAL SOLUTIONS FOR CLIMATE CHANGE MITIGATION: GENERATION AND DIFFUSION

The transition to a low-carbon economy requires a set of policies that encourage innovation, commercialization and diffusion of environmentally friendly technologies. There are a number of technologies available, with different stages of market maturity, all the way from R&D activities to proven commercial options. As mentioned earlier, many analyses agree that existing technology is sufficient to achieve significant abatement gains if deployed widely.

However, the scale of the necessary changes is very large. A fall of emissions to around 2 tons per capita by 2050 (implying a 50 per cent decline in global emissions relative to 1990 levels) requires that most of the electricity production worldwide is decarbonized by that date. In addition, emissions from transport, land use, building and industry would have to be cut sharply.[17]

[16] *Romain Duval (2008), A taxonomy of instruments to reduce greenhouse gas emissions and their interactions, OECD Economics Department Working Paper No. 636.*
[17] *Nicholas Stern (2008), Key elements of a global deal on climate change, London School of Economics and Political Science.*

Large increases in carbon efficiency can be obtained over the short term by wider diffusion of existing technologies. However, over the medium to long term pure technological innovation would be required to make this significant shift possible. To bring about this necessary technological breakthrough, increased R&D expenditure is required and these efforts need to be effective to deliver expected outcomes. This creates policy challenges that are central to the discussions on innovation but become even more acute, given the specificities associated with the development of climate change mitigation technologies.

The R&D effort is necessary not only to develop new technologies but also to make existing ones more affordable. Climate change mitigation policies and, more generally, the drive towards more environmentally friendly solutions, are prompting technological change in areas with traditionally low technological content, such as utilities. This increases the scope for technological innovation.

A variety of instruments and arrangements will have to be deployed to mobilize the necessary resources in an effective way. Public-private partnerships (PPPs) can be used to share risk efficiently in a situation where significant financial outlays under uncertain conditions are required. Moreover, PPPs can serve to overcome weak market incentives for the emergence of new technologies, accelerating their development. Public initiatives can work as a catalyst of links between established companies and academic institutes to develop research projects that can result in commercial technologies.

Public support can be necessary to carry out demonstration projects in promising technologies that require significant initial expenditures. An example is carbon capture and storage technologies, which are able to reconcile projected increases in energy consumption and coal use with the achievement of low emission targets. Public involvement may be a pre-condition for the development of commercial projects.

However, in the search for new technological solutions, it is important that policies in this area do not appear excessively prescriptive, imposing both solutions and the way to reach them. On the contrary, a certain degree of experimentation and technological portfolio diversification is useful to identify successful technologies. This is similar to the approach followed by venture capital companies when investing across a range of promising projects in the hope that a few of them will generate the exceptional returns that are commensurate with the risks undertaken.

Technological breakthroughs in the area of climate change are most likely to have an international impact. It is therefore important to coordinate actions globally to create a consistent framework for investment and to avoid duplication of efforts in R&D. Collaboration would allow covering gaps and disseminating good practices, while addressing barriers that at the international level prevent the development and transfer of technologies. However, it is important that coordination initiatives avoid the risk of excessive delays in crafting the necessary responses.

Technology transfer is an important dimension of climate change mitigation efforts, which underlines further the need for international cooperation in this area. Low-carbon, energy-saving technologies should flow to the developing world, where energy efficiency is lower and carbon intensity is higher. However, the adoption of a technology (and its diffusion through the economy), including in areas relevant for climate change mitigation and other environmental purposes, requires a number of supportive conditions. Financing and technological availability are not a guarantee of successful and efficient outcomes. The absorptive capacity is determined by issues such as the existence of complementary infrastructure, the quality of human capital, and the linkages between the various actors of the national innovation system or the type of governance. Barriers to technology transfer may be related to intellectual property rights or trade systems and have to be addressed as part of the overall country development policies. Initiatives to increase the absorptive capacity of an economy take time to deliver results and therefore should be undertaken early as part of climate change mitigation efforts.

In both developed and emerging markets, supply-side, technological-push solutions are insufficient to bring about the desired outcomes – technologically superior solutions that are widely used. Policies need also to encourage the demand for these technologies through a variety of means, including the use of standards. Environmental needs are set out through a defined policy and regulatory process. These can provide a critical input for innovative activities, thus clarifying the desired results of this process. There is not the need for product discovery that is required, for example, in consumer industries, where businesses sometimes have to both identify the potential demand (which has not been expressed by consumers) and the way to satisfy it. Thus, the articulation of credible demand is an essential requirement for the success of innovative activities. Public procurement could pay a critical role in encouraging innovation, if it goes beyond conventional specifications to allow innovative solutions to reach commercial size.

Given the nature of the challenges involved and their enduring character, technological innovation in this area requires a long-term vision that involves different stakeholders and provides an institutional space for public-private cooperation. This is similar to the technology foresight exercises underpinning the formulation of innovation policies in many countries, thus providing a broad roadmap for technological change that reconciles both demand and supply considerations. Climate change policies should therefore be included in these broader technology foresight exercises.

Technological innovation avoids the need to make hard choices and negotiate difficult trade-offs between environmental protection and economic growth. However, technology support policies provide no certain outcomes and risk is an inherent element of these activities. R&D endeavours need to be complemented with mutually supporting actions in other areas. The intensity of the R&D efforts required depends on the incentives created by the price system and other policy actions. If carbon intensive or environmentally dirty technologies remain attractive on the basis of existing market prices and taxes, the hurdle that needs to be overcome is much greater. Temporary subsidies can offset the initial disadvantages of new technologies competing with traditional ones until the non-conventional proposals are mature enough. For example, solar energy has developed rapidly on the back of public subsidies, in the form of feed-in tariffs, which remain critical for this sector.

Climate change policies (including both regulation and direct and indirect pricing influences) will have a dramatic effect on many industries over the coming years, although over different time horizons. For example, the impact of biofuel requirements on crop prices is already affecting input costs in some sectors, while rising carbon prices will shape energy-intensive activities, such as aluminium production, over the medium-term. These pressures will lead companies to look for new sources of competitive advantage, thus encouraging innovation also beyond environmentally related areas.[18]

FINANCING INNOVATION

As is the case with other innovative technologies, there is a financing gap that needs to be covered in order for promising ideas to become fully-fledged commercial proposals. This gap is a particularly strong constraint in carbon-saving technologies that require large upfront capital investments. In any case, conventional financial intermediaries, such as banks, tend to avoid early-stage activities, where risks are high, cash flows uncertain and there is little collateral available to back up requests for financing. This is also observed in relation to environmental technologies. However, even at a later stage, when bank lending may come into play, environmental technologies are at disadvantage because of the lack of specialized expertise in financial institutions to assess associated risks.[19]

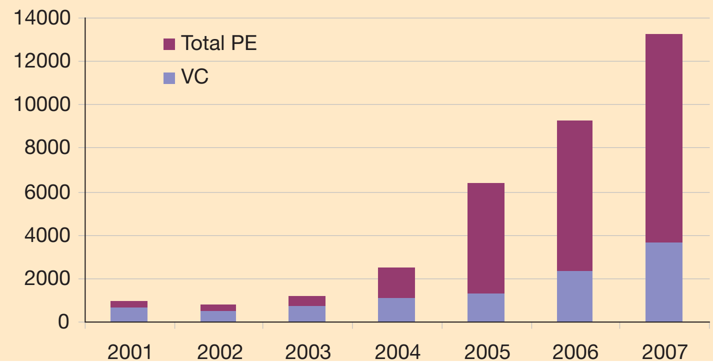
As in other industries, venture capital financing (both formal and informal) provides access to capital and managerial guidance in the early stages of development of innovative enterprises, when other sources of financing are not yet available. An increasing share of global venture capital is targeting the development of "cleantech", as investors seek to take advantage of a growing (existing and anticipated) demand for green technologies. This concerns a wide range of areas, including energy, waste treatment and water but also industrial processes and product design.

Despite the existing enthusiasm, cleantech venture capital investment faces several barriers. Many of these investment areas have not been traditionally backed by the venture capital industry. This creates difficulties in finding the necessary technical expertise to support investment decisions.[20] Environmental technologies, especially those associated with climate change mitigation, are perceived as particularly risky, since they are more prone to regulatory risk and suffer from competitive disadvantages under current prices. Prevalent fuel prices do not fully reflect the environmental impact of high-carbon content energy forms, thus discouraging innovation in low-carbon alternatives. The environmental impact of these choices is not fully internalized. This is why the pricing of carbon, as discussed earlier, has a dramatic impact on the real possibilities for developing alternative technologies and their transformation from niche solutions into mainstream proposals.

The time horizon for returns on investment on environmental technologies is often very long in comparison with other opportunities. Long-term investment horizons, which are typical of climate mitigation activities, imply that a small degree of uncertainty can have a large impact on expected returns. On the other hand, the pace of innovation (the time it takes to bring to the market a product or process) is likely to shorten as climate change-related technologies mature, as has been observed in other industries such as biotechnology.

[18] *Carbon Trust (2008), Climate change – a business revolution? How tackling climate change could create or destroy company value.*
[19] *FUNDETEC (2008), Comparison and assessment of funding schemes for the development of new activities and investments in environmental technologies.*
[20] *Ernst & Young (2007), Partnerships. Clean technology global trends and insights report 2007.*

Figure 3 Venture capital and private equity investment in sustainable energy, $ million



Source: UNEP, New Energy Finance.

Scale issues also complicate efforts to raise financing. Some projects, especially in renewable energy, are small, which implies that transaction costs are high. At the same time, in comparison with other early-stage high-growth areas typically targeted by venture capital (for example information and communication technology), the scale of many cleantech projects is far larger and more capital intensive. Scaling up projects from the demonstration phase to commercial operations requires significant resources.

Venture capital backed companies can play an important role in generating disruptive technologies, which are unlikely to originate in established companies. Their development should be a target of innovation policies in this area. Public support can serve to bridge the gap between early-stage innovation and commercialization, increasing the amount of private financing available for climate change mitigation projects and other environmental concerns. On the supply side, public-private funds can improve the risk-return profile of investment, making opportunities more attractive to would-be private investors. Grants and technology incubators (for example, the specialized United Kingdom Carbon Trust Incubator) help to develop new ideas, so as to generate a deal flow that can be considered later by formal and informal venture capitalists. Tax credits and other forms of public support often have important implications for the profitability of the projects undertaken and the available choices regarding the financing structure.

On the demand side, there is a need to increase awareness and expertise among technology developers on the forms of support available and to enhance skills that help them to become "investment ready".

Despite all the challenges, private capital is being increasingly attracted to developing new environmental technologies. According to the figures collated by the United Nations Environment Programme (UNEP) and New Energy Finance[21], global private equity/venture capital investments in sustainable energy companies increased from $0.8 billion in 2002 to $13.2 billion in 2007 (figure 3). Venture capital investments alone rose by 54 per cent in 2007, reaching $3.7 billion. A noticeable shift is the growing emphasis on early-stage venture capital investment, which more than doubled in 2007 to $2 billion. Venture capital investment accounted for around 28 per cent of total private equity investment, with early-stage venture capital representing around 15 per cent. These ratios are rather high in comparison with those observed in mainstream private equity, suggesting that clean technologies attract a comparatively large share of investment in less mature proposals. Available figures for 2008, with a 33 per cent annual increase in the second quarter, indicate continued interest.

CONCLUDING REMARKS: THE ROLE OF THE PUBLIC SECTOR

Climate change mitigation requires an unprecedented effort to coordinate initiatives across many different areas, involving multiple actors over a sustained period of time. The public sector is bound to play a crucial role not only in defining the regulatory and policy framework that drives change, but also in designing and funding arrangements to overcome the market failures that hamper progress. An important element of this agenda of change is the introduction of new technologies and processes and their diffusion within and across countries on a massive scale. This demands specific interventions in a number of typical innovation-related areas, such as early-stage financing, R&D commercialization or intellectual property rights. More specifically, the funding of large-scale demonstration projects where risk cannot be absorbed by the private sector may also be necessary.

Effective policies also require the development of supportive framework conditions that enhance the impact of individual measures and projects. In particular, obstacles to technology absorption and diffusion have a more general significance but

[21] *UNEP and New Energy Finance (2008), Global trends in sustainable energy investment 2008. Analysis of trends and issues in the financing of renewable energy and e*

also need to be addressed in the context of climate change mitigation policies. The right mix between horizontal and vertical measures needs to be achieved.

Climate change mitigation efforts and the development of environmentally friendly products do not have a single "silver-bullet" solution. They require a large number of innovations across a wide range of economic activities. The systemic, wide-ranging character of the necessary changes and the need to pay attention to life-cycle product considerations reinforce the leading role of the public sector in promoting change. It is worth noting that many sectors linked to the development of new environmental technologies are associated with regional or local authorities, such as water distribution, construction or transport, which defines a new layer of intervention.

There are limits to what can be achieved through the price system. For example, some consumer decisions are difficult to influence through levies on prices, since the impact on individual purchases may be negligible as the overall monetary amounts involved are not large enough to generate a change in behaviour. However, on aggregate, the overall significance may be appreciable. This situation therefore needs to be addressed through awareness campaigns that educate consumers, who then create the demand for new, more environmentally friendly products and processes.

Regulations that generate demand for environmentally friendly technologies play a particularly relevant role as drivers for innovation. Investors' surveys often emphasise the importance of regulatory and legal frameworks stimulating final demand for sustainable products and services. However, uncertainty regarding future regulations is a distinct source of risk that discourages private investment. While regulation is a source of innovation, the lack of visibility regarding future policies hampers private initiatives.

The public sector faces the challenge of reacting flexibly to the availability of new information while at the same time putting in place a relatively predictable environment that creates a suitable system of incentives for R&D and innovation.

The potential use of an invention often depends on the emergence of other innovations, which only make sense under a certain set of policies. This regulatory insecurity may thus have a restraining effect on innovation activity. A perception that incumbents in key industries can extract concessions often delays the needed change. On the other hand, even in the absence of clear positive indications, some companies may opt for a defensive attitude by avoiding behaviours that could be eventually affected by regulation.

Globally, further developments in the emergence of an institutional framework for carbon pricing (including a new global deal at the United Nations Climate Change Conference (Fifteenth Conference of the Parties) in Copenhagen in December 2009) would support climate change mitigation efforts. Participatory foresight exercises can help to map out the future and to mobilize the financing necessary to make it happen.