

## *Executive summary*

Green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. Increasing concern about the future sustainability of economic growth patterns underpin the demand for a greener model of growth. Existing production technology and consumer behaviour can only be expected to produce positive outcomes up to a point; a frontier, beyond which depleting natural capital has negative consequences for overall growth. By pushing the frontier outward, innovation can help to decouple growth from natural capital depletion. Innovation and the related process of creative destruction will also lead to new ideas, new entrepreneurs and new business models, thus contributing to the establishment of new markets and eventually to the creation of new jobs. Innovation is therefore the key in enabling green and growth to go hand in hand.

Business is the driver of innovation, including green innovation. However, government action is essential to shape the environment for green innovation. Several well-known market failures provide the rationale for policy actions to foster green innovation. The first are the negative externalities associated with environmental challenges. If firms and households do not have to pay for the environmental damage they inflict, there will be little incentive to invest in green innovation. Second, there are important market failures specific to the market for innovation, notably the difficulty for firms to fully appropriate the returns from their investments, which typically results in under-investment in innovation. Third, the market for green innovation is affected by specific barriers, notably the prevalence of dominant designs, technologies and systems in energy and transport markets. This can create entry barriers for new technologies and competitors due to, for example, the high fixed costs of developing new infrastructures.

Unleashing green innovation will therefore require government policy action, based on a sound overall framework for policies for innovation, as set out in OECD's 2010 Innovation Strategy. A number of policy areas are particularly important as part of a broad strategy for green growth.

First, boosting green innovation requires clear and stable market signals, *e.g.* carbon pricing or other market instruments addressing the externalities associated with environmental challenges. Such signals will enhance the incentives for firms and households to adopt and develop green innovations. They will enhance efficiency in allocating resources by establishing markets for green innovation, and will lower the costs of addressing environmental challenges. Pricing mechanisms tend to minimise the costs of achieving a given objective as they provide incentives for further efficiency gains and innovation. Such signals are also important as they indicate the commitment of governments to move towards greener growth.

However, better pricing will not be enough to deliver the necessary green innovation. Recent experience suggests that carbon pricing contributes primarily to incremental innovation, which tends to increase efficiency but may result in growing consumption, as has been the case in personal transport. Additional policies will therefore be needed to strengthen green innovation.

One important policy action is public investment in basic and long-term research. Such research has a public good character and is therefore unlikely to be undertaken by the private sector. It helps address fundamental scientific challenges and fosters technologies that are considered too risky, uncertain or long-gestating for the private sector. Public research will need to cover many areas, including both mitigation and adaptation to climate change, and should increasingly be based on multi-disciplinary and interdisciplinary approaches. It should also be neutral with respect to specific technologies, as innovations may emerge from a wide range of fields. Public investments in research will need to be well designed to complement private investments in research and should aim for scientific excellence and areas in which social returns and spill-over effects are potentially the greatest. Exploratory research focused on potentially radical innovations – characterised by high risk and uncertainty – should be included in the funding mix. Given the significant potential for research to reduce the costs of meeting environmental goals, greater public investment in research at the global level is needed. However, governments can also provide greater direction to the existing research effort, *e.g.* in prioritising thematic and mission-oriented research programmes aimed at addressing these challenges, though without necessarily specifying the nature of the research required. Moreover, governments can take action to improve the process of translating research into innovation, *e.g.* in strengthening the

links between science and business. To enable research efforts to materialise the policy commitment to such research should be stable over a long period.

A greater research effort focused on fostering green innovation will also benefit from enhanced international co-operation. This will help share the costs of public investment and can also help improve access to knowledge and foster the transfer of technology across countries. One important element is enhancing the research effort aimed at the local needs of developing countries, as these often do not yet have the capabilities to adopt green technologies and adjust these to their own national needs. Moreover, these countries are likely to face the largest environmental challenges. Enhancing research aimed at these countries could, for example, involve a closer alignment of activities and financial flows emanating from Official Development Assistance (ODA) with those related to scientific and technological co-operation. Strengthening the absorptive capacities of developing countries should also be an important policy goal in a broad-ranging green growth strategy.

A third set of important policy actions to drive green innovation are interventions to overcome specific market failures associated with green innovation, notably those linked to the dominance of existing technologies, systems and incumbent firms. Key policies in this area include:

- *Support for private investment in innovation*, notably R&D, and for the commercialisation of green innovations. Such support may be required as green innovation faces additional barriers in some markets, *e.g.* barriers to entry in the electricity sector. Provision of targeted support can be risky because of the lack of information on the maturity of specific technologies, and their likely future commercial potential. The design of schemes to provide direct support is therefore of great importance. Good policy designs need to ensure competitive selection processes, focus on performance rather than specific technologies, avoid favouring incumbents or providing opportunities for lobbying, ensure a rigorous evaluation of policy impact, and contain costs. Proven ways to guard against these problems include multi-year appropriations, independence of the agencies making funding decisions, use of peer review and other competitive procedures with clear criteria for project selection, and payments based on progress and outcomes rather than cost recovery or choice of technologies. Support for commercialisation should also be temporary and accompanied by clear sunset clauses and transparent

phase-out schedules. It also requires a good understanding of the state of development of alternative technologies and the market structure in which they are being developed; support should not be provided before technologies reach a sufficiently mature state of development. Government support policies also need to be aligned with existing international commitments, notably under the WTO, and with competition policy.

- *Support for general-purpose technologies.* Because targeted support tends to be focused on specific innovations, the problematic prospect arises of governments attempting to pick winners. One possible approach to providing support that is technology neutral is supporting general infrastructure or basic conditions for a wide range of alternative technologies, e.g. storage technologies that are needed for a wide range of technologies, or general-purpose technologies such as ICT that have a wide range of applications. Information and communication are pivotal for a system-wide mitigation of environmental impacts and adaptation to inevitable changes in the environment. ICTs offer great scope for efficiency improvements throughout the economy, including in the context of smart grids, and also provide scope for further green innovation. Biotechnology, in particular industrial biotechnology, also plays an important role in delivering eco-efficiency. Nanotechnologies likewise offer a wide range of environmental benefits, under the proviso that potential safety issues are addressed.
- *Fostering the growth of new entrepreneurial firms.* New entrepreneurial firms play an important role in delivering more radical green innovations that challenge existing firms and business models. Policy needs to create the room for such new firms by enabling their entry, exit and growth, ensuring fair competition and improving access to finance, which remains a major constraint for the entry and growth of young firms.
- *Facilitating the transition to green growth in small and medium-sized enterprises (SMEs).* SMEs face additional problems in adopting green innovations, as they often have weak innovation capabilities. Policy can help to improve access to finance, enable small and medium-sized enterprises to participate in knowledge networks, strengthen the skills that can lead to innovation, and reduce the regulatory burden on firms. Opening (green) public procurement to SMEs may also help in strengthening green innovation in such firms.

Policies to foster green innovation should not only focus on the creation and supply of new technologies and innovations, but also on the diffusion and take-up of green innovations in the market place. Such policies make up the fourth area of action, and include policies to:

- *Foster diffusion.* To foster the wide diffusion of green innovation within and across countries, new approaches to the diffusion of knowledge and technologies need to be explored. Such approaches need to be based on well-functioning systems of intellectual property rights (IPR) protection and enforcement that provide incentives for investment in innovation and establish the framework for IPR protection and diffusion. To accelerate the diffusion of innovation, new mechanisms that enhance technology transfer to developing countries are currently being developed e.g. voluntary patent pools and other collaborative mechanisms for leveraging IP. Some good practice already exists but significant scale-up is required.
- *Strengthen markets for green innovation.* In addition to the need for carbon pricing or other ways of dealing with environmental externalities, demand-side innovation policies are an important part of the policy mix to foster green innovation as these can help strengthen green innovation in specific markets. Standards, well-designed regulations and innovative procurement, for example, can encourage green innovation in areas where market signals are not fully effective, e.g. housing markets. Such policies need to be well designed to ensure that they support and do not distort market formation, and should be well aligned with competition policies and international commitments, notably under the WTO.
- *Change consumer behaviour.* Consumers also have an important role to play in fostering and taking up green innovation. Pricing the use of environmental resources has proven to be a powerful tool for influencing consumer and household decisions. But consumers often focus on short-term costs, without fully considering longer-term factors. This suggests that efforts to highlight cost implications of consumer choices over the product life cycle may be needed to influence choices for consumer durables. “Softer” instruments also need to be given close attention in influencing consumer and household behaviour. This includes consumer policy and consumer education, as well as green labelling and certification.

Policy also needs to consider the innovation timeframe and the respective benefits and risks of specific policies. Some innovations are already available commercially and can be deployed rapidly, and some win-win options may exist too; these may need no or only limited policy action to become effective in improving environmental performance. Other technologies are still under development, and may be in a demonstration or pre-demonstration phase. Yet others will only emerge over a much longer term horizon and will require further research and development. The policy efforts will differ over this time frame, ranging from basic research to pre-competitive research and demonstration efforts, to policies aimed at developing or shaping the market.

The timing of innovations may precipitate an advantage of one technology or innovation over another, however. For example, a technology having greater short-term advantages over another technology may become too dominant and “lock out” other technologies. Even if the long-term benefits of the “locked in” technology would result in lower overall social benefits, it may succeed at the exclusion of other technologies. Another aspect of this situation of lock-in is the impact on incentives for further innovation. For example, if policy focuses exclusively on the deployment of currently available technologies, this will reduce the market for future innovations, which will reduce incentives to invest in R&D and efforts to develop such innovations.

There are no simple answers to this problem. One approach that can help inform long-term investment decisions associated with the introduction of new technologies and innovations involves the use of scenario studies, technology foresight and roadmapping. This can provide insights into the scope for technological progress and innovation in different areas and may therefore help in guiding decisions. Fostering a diverse range of potential options for action, and delaying some of the most lumpy and irreversible investments, may also help in preserving options for the deployment of new technologies and innovations as they emerge.