

## Green innovation

### Rationale and objectives

Concerns about the environmental unsustainability of past economic growth patterns and increased awareness of the impact of climate change have propelled green growth issues to the forefront of economic and innovation policies (see the policy profile on “National strategies for STI”). Awareness has moved to policy action as illustrated by the adoption of Paris Agreement on Climate Change and discussions on implementation to ensure the world can achieve the Paris Agreement’s long-term aims to limit the extent of climate change to “well below 2°C”. Green innovation must of course be part of the solution.

There are several rationales for policy action in the area of green innovation. One is the negative externalities associated with climate change and other environmental challenges. These have implications for both the creation and diffusion of technologies. Because greenhouse gas (GHG) emissions are not priced by the market, incentives to reduce them through technology development are limited. Similarly, if market signals regarding the environmental benefits of such technologies are weak, demand for green innovation will also be below the social optimum and there will be less diffusion and adoption of green technologies. In turn, there will be little incentive for companies to invest in innovation, because there will be little demand for any resulting products or processes (OECD, 2011).

These negative environmental externalities are the target of environmental and resource policies such as pricing policies, carbon taxes, tradable permits or other market instruments to internalise the price of externalities. Apart from the externalities associated with the environment, there are also important market failures specific to innovation, and particularly to green innovation. These include technological path dependencies, dominant designs in certain markets, such as energy and transport that favour incumbents, uncertainty about the prospects for success, the long timescales for infrastructure replacement and development, a lack of options for product differentiation, liquidity constraints of smaller challenger firms or barriers related to behaviour (e.g. consumer resistance to change). Other barriers to innovation are more generic such as lack of capabilities (OECD, 2012).

From the perspective of system-wide change – here defined as a drastic change in governance practice – other types of policy failure that are relevant for green technologies in the context of transition policy can be identified. These include the lack of a shared vision regarding the direction of change (directionality failure), inability of consumers and the public sector to articulate demand for new solutions (demand articulation failure), misalignments or incoherence in policies (e.g. maintaining fossil fuel subsidies, indirect tax support to gasoline operated vehicles) and consequently incentives or the insufficient ability of the system to monitor, anticipate and involve actors in processes of self-governance (reflexivity failures) (see policy profile on “System innovation”).

### Major aspects and instruments

The scope of potential market and systemic failures suggests that policies for environmental and green innovation will only succeed if they enhance the performance of the economic system as a whole. “Getting prices right” is important but so is policy coherence. Policies that focus only on one element of the system, or are contradictory are unlikely to be effective in improving overall performance. Indeed, recent experience suggests that carbon pricing contributes primarily to incremental innovation, which tends to increase efficiency but may also result in growing consumption, as has sometimes been the case for personal transport. Other policies will therefore be needed to strengthen green innovation. As identified in the OECD Innovation and Green Growth Strategies, this will involve a broad approach, comprising incentives for firms to “green” their activities, strengthening public research capacity in environmental sciences, strengthening



networks, clusters and platforms for green technologies; addressing skills gaps for workers in green industries such as the bio and circular economy. Policy governance remains an important area for action as governments seek to improve vertical and horizontal coordination across the board (see the policy profile on “Innovation in bioeconomy”).

Ensuring sound framework conditions for business innovation and innovative entrepreneurship is essential for the greening of industries. This requires removing barriers to trade in clean technologies as well as to the entry of new firms, and improving access to finance and talent for young and small firms, especially as young firms are an important source of more radical innovations. Environmental regulations or price-based instruments such as carbon prices or emissions trading systems are important to change incentives and behaviour in the direction of lowering CO<sub>2</sub> emissions. Ideally pricing should be the primary policy tool used to drive abatement, for if regulatory or other policies lead, cost-effectiveness likely suffers (OECD, 2016).

Green public procurement can also boost demand for green technologies and innovation.

There is also the need for more effective and inclusive multilateral co-operation on science, technology and innovation (see also the policy profile on “Cross-border governance arrangements for STI”).

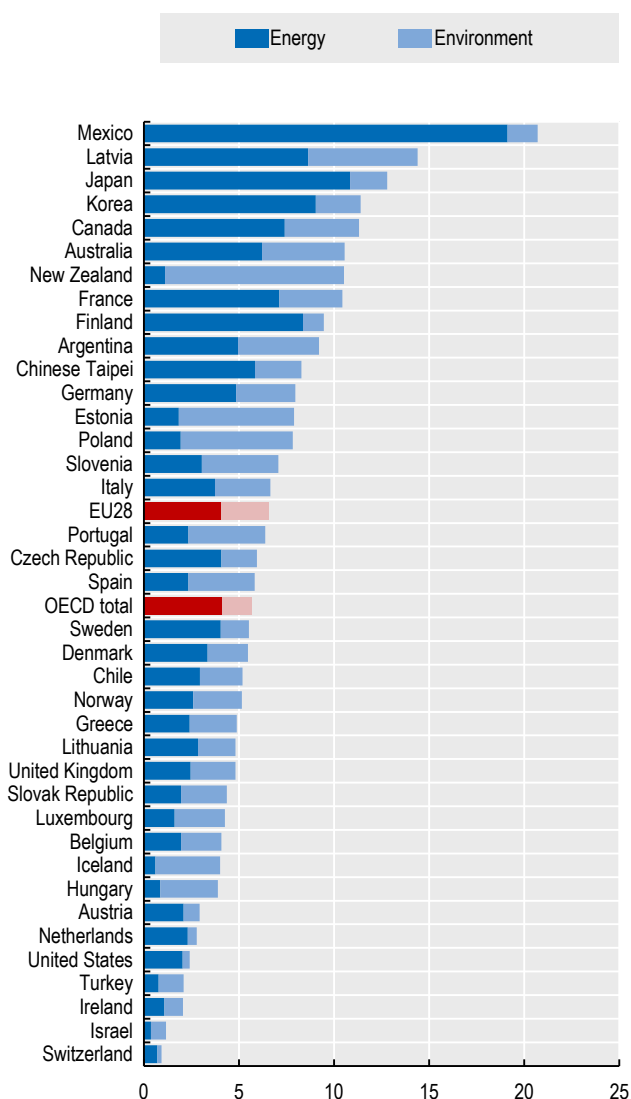
One important policy action is public investment in basic and long-term research. There has already been a general shift in research policy agendas towards environmental and societal challenges and the “greening” of national research policies has been prominent in many OECD countries since the late 2000s (OECD, 2010; OECD, 2012). However, public research will need to cover many areas, including mitigation and adaptation to climate change, and should rely on multidisciplinary and interdisciplinary approaches (see the policy profile on “Public research orientation and mission”). Recent data on government budget appropriations or outlays for R&D (GBAORD) show the public resources that economies invest in research on energy and the environment. In absolute terms, Japan, the United States and Germany are the largest funders, while Mexico, Canada and Japan are top investors in relative terms. With few exceptions, energy-related R&D accounts for the vast majority of GBAORD dedicated to the environment, although other investments in R&D - e.g. in chemistry and new materials, are also important in driving green innovation. Since 2002 most economies have increased the percentage of GBAORD going to energy and environment-related programmes (Figure 1).

A key challenge for moving to a lower carbon economy is the alignment of the goals of ministries, research funding agencies, higher education institutions and social and market-based institutions so that they focus on green growth in all of its dimensions. The effectiveness of policy design for specific areas will depend on the innovation and knowledge capacity of a given country and its ability to develop an appropriate policy mix for green innovation that includes energy, trade, transport, agriculture and the links between them. Strategic policy intelligence, including via the exploitation of open government data and sharing of that data across ministries, can help deliver more effective policy mixes for greener growth.



**Figure 1.** Government R&D budgets for energy and the environment, 2015 or latest available year

As a percentage of total government R&D budgets



Data for Belgium, Estonia, Hungary, Iceland, Israel, Italy, Korea, Luxembourg, Poland, Spain, Switzerland and the United Kingdom refer to 2014; data for Canada and Chile refer to 2013.

Source: OECD Research and Development Statistics (RDS) Database, April 2016, [www.oecd.org/sti/rds](http://www.oecd.org/sti/rds); Data retrieved from IPP.Stat on 02 August 2016, [http://stats.oecd.org/Index.aspx?DataSetCode=GBAORD\\_NABS2007](http://stats.oecd.org/Index.aspx?DataSetCode=GBAORD_NABS2007).

StatLink <http://dx.doi.org/10.1787/888933434265>

## Recent policy trends

Many OECD and non-OECD countries have established green growth strategies or prioritised activities within their national S&T strategies to create critical mass and accelerate the transition to green growth. Indeed, most countries continue to place environmental issues, climate change and energy high on the list of priorities for innovation policy in general. However, specific policy priorities for green innovation and technology differ markedly, depending on countries' scientific and economic specialisation, competitiveness goals and social objectives.



- In 2015, the Finnish government defined strategic priorities for the country's bioeconomy and clean technologies, including renewables, the sustainability of wood production and water resources. The government is implementing this strategy through essential reforms in the areas of employment, competitiveness, education, health, bioeconomy and clean technologies, among others.
- In the same year the Portuguese government signed its Green Growth Commitment, a national strategy aiming to foster growth based on the sustainable creation of value across the whole economy by stimulating green sectors of economic activity and promoting the efficient use of resources.
- Colombia introduced its Green Growth Strategy 2014-2018 setting out the country's priorities to face climate change and other environmental challenges, including strengthening capacities to assess and manage environmental resources and improving the framework conditions for the sustainable development of businesses based on biodiversity. The strategy will be implemented through public calls, direct contracting and public-private partnerships.
- Croatia drafted the Low-Carbon Development Strategy that sets several goals for sustainable growth up to 2030 including the development of the green economy, rural and regional development, securing sources for sustainable energy and the reduction of air pollution and other health hazards.

Countries have also launched strategies focusing on particular aspects of the green economy, for example:

- Italy introduced a Marine Strategy in 2014 aiming to align its legislation on marine protection with that of the EU. Korea launched its Third Energy Technology Plan 2014-2023, planning to make the country reach the most advanced standard in energy technologies and setting out the creation of a new energy industry and innovation ecosystem. The plan allocates around 20 billion USD for 10 years and covers the energy generation-transport-utilisation-storage cycle.
- Austria continues to implement its Electromobility Strategy, fostering R&D in the automotive industry and relevant sectors and improving the framework conditions for the market introduction of e-mobility products and services (e.g. standardisation, regulation and the recharging infrastructure).

Several strategies have emphasised adaptation to and mitigation of climate change. Italy unveiled in 2013 a National Strategy for Adaptation to Climate Change that highlights potential impacts on society and ecosystems and underlines the necessary set of actions to be carried out to counteract trends in climate change. Korea also developed a strategy for adaptation to climate change for the 2015-2017 period that aims to mobilise the country's strengths in the ICT sector to build capacity of the energy industry. Mexico introduced a Special Programme for Climate Change seeking to reduce the vulnerabilities of the population and the productive sector to climate change and to increase the resilience of the country's key infrastructures. The programme also contemplates the conservation, restoration and management of ecosystems to guarantee the sustainability of the country's environmental resources, the reduction of GHG emissions and diminishing emissions of short-lived climate pollutants to promote health and well-being. In 2015, Spain's Plan PIMA ADAPTA sets out 46 specific interventions on coastal, rivers and natural parks to mitigate risks associated to climate change in areas subject to environmental vulnerability. Lithuania implemented a national research programme focused on the sustainability of agro-, forest and water ecosystems for 2015-2021, aiming to understand and manage the general effects of climate change and the intensive use of natural resources.

Some countries are also tackling the sustainability challenges such as clean water through national actions plans to implement the UN Sustainable Development Goals. On 12 October 2016 for example, China released its national plan for implementing the 2030 Agenda for Sustainable Development; a plan that translates each target of the Sustainable Development Goals (SDGs) into "action plans" for China. Korea, Sweden and Finland have or are planning to develop national plans for the SDGs which will reinforce many of the strategies already in place to promote greener growth.



### *Towards clean energy and cutting low carbon emissions*

Carbon taxes continue to be reinforced in a number of countries as a part of a wider strategy to lower emissions. The Irish government increased in 2013 its carbon tax to EUR 25 per ton. In 2015, the Norwegian Green Tax Commission recommended a combination of environmental taxes and financial grants to stimulate the development of green technology. Spain started a gradual introduction of CO<sub>2</sub> taxes, at EUR 6 per ton in 2014, which was later raised to EUR 13 for 2015-16.

Clean energy is another area of continued public action and investment. The energy sector emits more CO<sub>2</sub> than any other sector. Electricity-related emissions account for more than 40% of emissions from the energy sector. Increasing the share of renewable energy technologies and expanding the sources beyond current technologies (e.g. biomass and hydro) are key policy goals. Demand-side policies that lead to increases in energy efficiency and demand for renewables (and lower demand for conventional sources) such as smart grids are also an important part of energy transition policies. Germany launched the Smart Energy Showcases funding programme 2016-2020, which aims to develop and demonstrate regional solutions for solar- and wind-based energy supply that are climate-friendly, secure and efficient. Energix is a Norwegian energy research programme that provides funding for research on renewable energy, efficient use of energy, energy systems and energy policy. The programme also aims to improve efficiency and flexibility in energy generation and distribution and to further integrate Norway's energy system with Europe. Chile's Solar and Renewable Energy Programme 2014-18 aims to support companies developing technological innovations (e.g. products, processes and services) based on solar energy. In 2015 the Russian government emitted a decree promoting the use of renewable energy sources through favourable electricity tariffs. Croatia's 2016 Work Programme of the Environmental Protection and Energy Efficiency Fund aims to increase the energy efficiency of residential houses, public, apartment and commercial buildings.

### *Promoting finance for eco-innovation and research for green growth*

Greening industry through eco-innovation – innovations that reduce the use of natural resources and decrease the release of harmful substances across the entire life cycle – is another trend. Eco-innovation initiatives involve both technological and non-technological change. Eco-innovation policy instruments include regulations, economic incentives, negotiated agreements, public procurement and eco-labels. Since 2012 the United Kingdom's Green Investment Bank provides financial solutions to accelerate private sector investment in the green economy. The bank currently prioritises the following sectors: offshore and onshore wind, energy from waste and biomass, waste processing and recycling and energy efficiency. The Czech Republic's EPSILON Programme 2015-2025, which provides financial support for R&D and innovation activities, prioritises the sustainability of energy and material resources and protecting the environment as a means of ensuring well-being. As part of its Smart Specialisation Strategy, Croatia funds companies' R&D and innovation investments in Food and Bioeconomy (e.g. agriculture, aquaculture and wood production).

Several initiatives specifically target entrepreneurship and SMEs. Through the Empreverde programme, Spain continues to provide support to entrepreneurial activities SMEs aiming to promote green growth, foster eco-innovation and facilitate the adoption of environmental regulation. Latvia's Programme on Green Industry Innovation funds SMEs activities in green entrepreneurship and environmental innovation, supporting entrepreneurs for equipment purchases and promoting friendly solutions in manufacturing processes. Similarly, Lithuania started to allocate funds in 2016 to support SMEs activities in eco-innovation not only by financing product development but also by sponsoring consultancies geared towards the efficient use and preservation of natural resources. Russia introduced the industry-specific programme for Commercial Aquaculture Development 2015-2020 that provides entrepreneurs with financial support.

On the supply side, R&D remains important, particularly in specific research areas or technologies relevant to green growth. Ireland funds research centres established around marine issues (Marine Renewable Energy Ireland), sustainable energy (the International Energy Research Centre) and energy systems (the Electricity Research Centre).

- Similarly, Norway provides time-limited support to research centres conducting concentrated, focused and long-term research aiming to solve specific challenges in the energy sector. Currently eleven Centres for Environment-Friendly Energy Research are in operation. Eight new centres will start in 2017 and replace the centres whose grants expire.
- Since 2013, Turkey has several programmes funding large scale R&D projects on flue gas purification (MILKAS), hydroelectric energy (MILHES) wind power (MILRES) and thermal power (MILTES). The United Kingdom's Department of Energy and Climate Change introduced an Innovation Programme 2016-21, to stimulate and leverage private sector investment on low carbon energy technologies.



- Finland introduced in 2015 a Research Programme on New Energy aiming to develop new infrastructures and service models along with new energy solutions that will improve the Finns' well-being. Germany launched the 2015-19 R&D Framework Programme on Sustainable Development to fund interdisciplinary and effective research on sustainability.
- Peru, despite having a small national research system, will implement its National Programme on Environmental Science between 2016-21 to support research on biotechnology (materials science, environment, valuation of biodiversity, ICTs and basic sciences).

Governments have also introduced platforms acting as hubs for the demonstration and deployment of green technologies.

- The United Kingdom has “Catapult Centres” on offshore renewable energy, energy systems and transport systems that support business activity focused on the development and commercialisation of new technologies that originate in the country’s research base.
- Since 2013 Germany’s *Energiewende* Research Forum facilitates dialogue for the different actors (high-ranking public officials, researchers and representatives from industries and societal groups) involved in the transformation of the country’s energy system.
- *NordBio* is a three year international programme (2014-16) chaired by Iceland that aims to improve the efficient use of natural resources and reduce waste generation in Nordic countries. The programme will coordinate co-operation in different issues of the bioeconomy and map opportunities for international funding of R&D. Experts from participating nations will pool their efforts in collaborative projects in the areas of food production, biomass, forestry, marine transport and ecosystem resilience against natural hazards.

## References and further reading

OECD (2011), *Fostering Innovation for Green Growth*, OECD Green Growth Studies, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264119925-en>.

OECD (2012), “Transitioning to green innovation and technology”, in *OECD Science, Technology and Industry Outlook 2012*, OECD Publishing, Paris. [http://dx.doi.org/10.1787/sti\\_outlook-2012-5-en](http://dx.doi.org/10.1787/sti_outlook-2012-5-en).

OECD (2014), Science, Technology and Industry Outlook Policy Database, edition 2014, Environmental Challenges, available at <http://qdd.oecd.org/Table.aspx?Query=404491A2-2462-4C9B-9C21-9879F30264A7>.

OECD (2016) OECD (2016), *Effective Carbon Rates: Pricing CO<sub>2</sub> through Taxes and Emissions Trading Systems*, OECD Publishing, Paris. DOI: <http://dx.doi.org/10.1787/9789264260115-en>.

© OECD, 2016. This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

<http://oe.cd/STIOutlook> – [STIPolicy.data@oecd.org](mailto:STIPolicy.data@oecd.org) –  @OECDInnovation – <http://oe.cd/stinews>



**From:**  
**OECD Science, Technology and Innovation  
Outlook 2016**

**Access the complete publication at:**  
[https://doi.org/10.1787/sti\\_in\\_outlook-2016-en](https://doi.org/10.1787/sti_in_outlook-2016-en)

**Please cite this chapter as:**

OECD (2016), "Green innovation", in *OECD Science, Technology and Innovation Outlook 2016*, OECD Publishing, Paris.

DOI: [https://doi.org/10.1787/sti\\_in\\_outlook-2016-19-en](https://doi.org/10.1787/sti_in_outlook-2016-19-en)

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of OECD member countries.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to [rights@oecd.org](mailto:rights@oecd.org). Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at [info@copyright.com](mailto:info@copyright.com) or the Centre français d'exploitation du droit de copie (CFC) at [contact@cfcopies.com](mailto:contact@cfcopies.com).