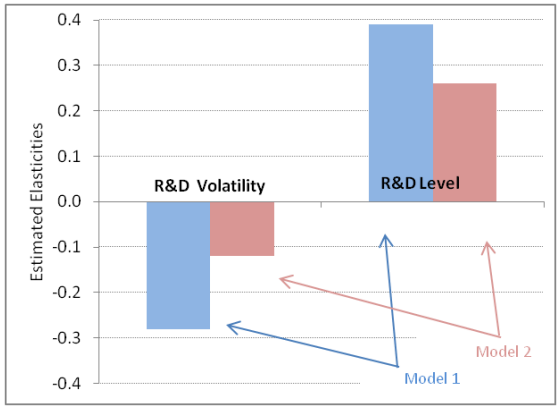
Providing Predictable Signals

Besides commercial and technological uncertainty, investors in environmentally-sensitive sectors face an additional source of uncertainty – that which is associated with a country's environmental policy. There can be uncertainty about the future stringency, timing, nature or durability of the policy framework. Irrespective of the nature of the uncertainty, there is good reason to believe that an uncertain policy framework will result in less innovation in environmental technologies. For instance, recent empirical results provide support for the hypothesis that increased volatility of public R&D spending has a negative impact on innovation, undermining the benefits of given levels of support by one-half to two-thirds.

Effect on Innovation of the Level and Volatility of Public R&D Spending



Why is this the case? Policy signals that are difficult to predict encourage investors to postpone investments, including the risky investments which lead to innovation. In the face of unpredictability there is an advantage to waiting until the 'policy dust settles'. As such, adding to the risk which investors face in the market, an 'unpredictable' policy regime can serve as a brake on innovation, both in terms of technology invention and adoption.

However, it is important to note that changing the policy parameters does not necessarily provide more uncertainty to investors, as long as this is done in a predictable manner. For instance, periodic adjustments made in response to market developments are likely to be foreseeable to market participants. More generally, as new information becomes available, whether environmental or economic in nature, then adjustments in policies are likely to be necessary and desirable.

International Research Cooperation

International research collaboration is an important vehicle through which countries can share costs and increase knowledge spillovers. While international research collaboration has been common amongst OECD economies, it is interesting that for 'environmental' technologies inventors in many emerging economies are collaborating with partners in the OECD. The table below shows the most active co-invention pairs for four environmental technologies as well as for all technologies combined. While major OECD economies dominate the latter the situation is much more mixed in the environmental fields, with emerging economies and small OECD economies in greater evidence. Indeed, geographical patterns of research collaboration are increasingly diverse.

The Top Co-Inventing Country Pairs for Environmental Technologies, Compared to All Technologies

Sector	1	2	3	4	5	6	7	8	9	10
All Technologies	UK-US	Germany -US	Canada -US	Switz.-Germany	Japan -US	France -US	Netherl. -US	Germany -France	Switz.-France	Switz. -US
Wind	Denmark -UK	Germany -US	Canada -US	Germany -Netherl.	Netherl. -US	Germany -Denmark	**India -US**	**Belgium -S.Africa**	**Russia -US**	Denmark -Spain
Solar PV	Japan -US	Germany -US	UK-US	Switz.-Germany	Austria-Germany	Canada -US	**China -US**	Germany -France	Germany -Netherl.	UK-Italy
Energy Storage	UK-US	Canada -US	Germany -US	Japan -US	Japan-Korea	France -US	Switz.-Germany	Canada -France	**China -US**	Korea -US
CCS	Canada -US	Netherl. -US	UK-US	France -US	Germany -US	Australia -Netherl.	Germany -UK	UK-Netherl.	Norway -US	**China -US**

Note: Co-invention is measured as country of residence for patented inventions.

Recent work has investigated the relationship between the International Energy Agency's "Implementing Agreements" (IA) and co-inventive activities between participating countries. The evidence suggests that co-invention is significantly affected by membership of a country in the IA, although the magnitude of this effect varies across the different IAs (indicating that institutional arrangements and the substance of collaborative efforts play an important role). Given the urgency to develop effective international mechanisms to mitigate climate change, these results are encouraging.

Publications

Invention and Transfer of Environmental Technologies (OECD 2011)
Bending the Trajectory: Energy and Climate Change Policy and Innovation (OECD, forthcoming 2012)
A Problem Shared is a Problem Halved: International Cooperation for Climate Change Innovation (OECD, forthcoming 2013)

See also: www.oecd.org/environment/innovation

OECD

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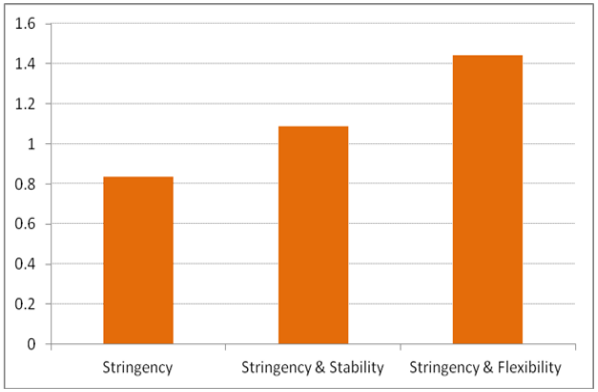
OECD Project on Environmental Policy and Technological Innovation

Technological change is undoubtedly one of the keys to ensuring that environmental improvements can be obtained without sacrificing economic growth. In order for this to be the case it is vitally important that environmental policies and policy instruments provide the right incentives for the development and diffusion of 'environmental' technologies.

As part of its work on decoupling environmental pressures from economic growth, the OECD's Environment Directorate has embarked on a large policy research project assessing the effects of public policy on technological innovation. The objective of the project is to provide guidance to governments on the improvement of the design, implementation and evaluation of environmental policies. Drawing upon data on research and development expenditures, patent filings, bibliometric records and other data sources, the links between public policy and technological change are being examined.

For instance, empirical work has been undertaken on the effects of different environmental policies (standards, taxes, public R&D, etc.) on innovation in areas such as renewable energy and alternative-fuel vehicles. More generally, the characteristics of the environmental policy framework (stringency, predictability, flexibility) are key in that they are likely to encourage innovation and technology transfer.

Effect of Environmental Policy Characteristics on Innovation



Note: The Figure shows the estimated coefficient of different combinations of characteristics of environmental policy framework in encouraging inventive activity in environmental technologies.

OECD

OECD Environment Directorate

www.oecd.org/environment/innovation

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Indicator of Innovation in Environmental Technologies

As a prerequisite for any such work, appropriate indicators need to be developed. This underlying **developmental work** includes: A) the elaboration of search strategies for various areas of 'environmental' technologies; and B) a methodology for the development of measures of innovation which are comparable across countries, time and technology fields.

The areas covered by the **ENV-Tech indicator** include, for example:

- *General environmental management*
  - *Air pollution control at stationary sources*
  - *Water and wastewater treatment*
  - *Oil spill clean-up*
  - *Material recycling*
  - *Soil remediation*
  - *Environmental monitoring*
- *Climate change mitigation technologies*
  - *Renewable energy (wind, solar, ocean, etc.)*
  - *Biofuels and waste-to-fuel*
  - *Combined cycle power plant (IGCC, etc.)*
  - *Combined heat and power (CHP)*
  - *Carbon capture and storage (CCS)*
  - *Energy storage, hydrogen, fuel cells*
  - *Motor vehicle fuel efficiency*
  - *Energy efficiency in buildings and lighting*
  - *Electric and hybrid motor vehicles*
- *Climate change adaptation technologies*
  - *Severe weather prediction & warning*
  - *Electricity grid resilience to extreme weather*
  - *Energy supply in remote locations*
  - *Efficient lighting in remote locations*
  - *Desalination*
  - *Rainwater collection*
  - *Solar/wind-powered water pumping*
  - *Solar water treatment & potabilization*
  - *Solar cooking*

For further details on these indicators see
www.oecd.org/environment/innovation/indicator

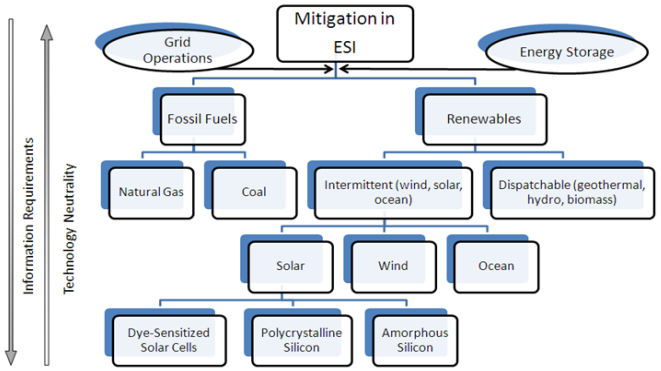
Public Support for Directed Innovation

With the recognition that 'technology-neutral' policies such as emissions taxes need to be complemented with other policies which target specific technologies, the role of government policy necessarily becomes more complicated and riskier. How to target technological 'winners' against a background of imperfect information on future technological trajectories?

In recent years many governments have intervened directly in energy markets in order to promote increased investment in low emission technologies, such as renewable energy power plants. However, increasing the penetration of intermittent renewable energy sources (wind, solar, ocean) presents significant challenges to electricity grid management. Improved energy storage and grid management can overcome this constraint by increasing system flexibility.

The benefits of targeting public R&D expenditures at system flexibility (energy storage and grid management technologies) may be greater than directly at intermittent generating technologies. Preliminary empirical evidence suggests that focussing policy incentives on innovation in system flexibility may obviate some of the problems associated with trying to "pick winners" amongst a portfolio of generating technologies of unknown potential. The reasoning is simple: improved grid management and energy storage will yield benefits, irrespective of which intermittent renewable energy technologies ultimately prove to be 'winners'.

Policy Incidence and Technology Neutrality



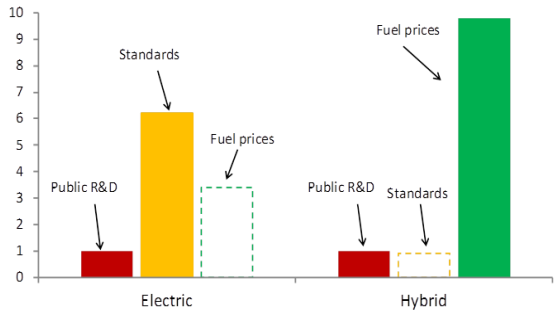
Note: The figure illustrates trade-offs in targeting public R&D expenditures, using the electricity supply industry (ESI) as an example.

Policy Mixes and Breakthrough Technologies

The ideal instrument is one which targets the environmental 'bad' directly and gives innovators flexibility to identify the best means of meeting given environmental objectives. For these reasons, price signals arising out of emission taxes and tradable permit systems are a necessary condition for innovation. However, price signals may not always be sufficient, particularly if breakthrough technologies are to be induced. For instance, recent work undertaken in the area of alternative-fuel vehicles assessed the relative importance of fleet-level fuel-efficiency standards, after-tax fuel prices, and public support for R&D on innovation in electric and hybrid vehicles.

It was found that relatively minor changes in a performance standard or automotive fuel prices would yield an increase in patented inventions that is equivalent to a much greater proportional increase in government R&D budgets for some technologies. The results also suggest that there are significant differences between the effects of different policy measures depending on the type of technology, whether electric or hybrid vehicles. This indicates the importance of the appropriate mix of policy measures. Relative prices may have a lesser role to play than ambitious performance standards, or significant public support for research, the further a technology is from being directly competitive with the incumbent technology (petrol- and diesel-driven technologies). While in theory a price sufficient to induce an equal level of innovation for such technologies could be introduced, such a measure would likely be politically infeasible in practice. Moreover, even if introduced, potential innovators may not perceive it as credible over the longer-term.

Relative Effect of Technology Standards, Fuel Prices and Public R&D on Innovation in Electric and Hybrid Vehicles



Note: For ease of interpretation. Elasticities have been normalised such that effect of R&D=1. Unfilled bars indicate no statistical significance.