CLIMATE INNOVATION INSIGHTS | Series 1.2
Accelerating the Evolution of Climate Innovation Clusters

Climate Innovation Insights offers a platform for reflections and lessons from renowned climate innovation experts to spark discussion about the process of tackling climate change through innovation. The independent opinion pieces discuss best practices, different methodological approaches towards climate innovation and implications for business, society and politics. The series is supported by Climate-KIC, Europe's largest public–private climate innovation partnership.

Sustaining Investment in Climate Innovation

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Key messages

- Limiting global warming to 1.5°C, the target under the Paris Agreement, will require massive investments in low-carbon innovation.
- After two decades of growth, patent filings for low-carbon technologies, and public research and development (R&D) expenditures on climate innovation, have both decreased in recent years.
- Higher and more stable carbon prices than exist today are necessary for sustained investment in low-carbon technologies.
- Public support for climate-related R&D is needed at all stages of innovation, but governments mostly support the diffusion of existing technologies.
- Public support for technologies further away from market must increase substantially to achieve climate targets.

Introduction

The Paris Agreement, adopted by 197 countries at the 21st Conference of the Parties (COP21) in December 2015, set the goal of limiting global warming to 1.5°C at the end of the 21st century compared to pre-industrial levels. According to the Intergovernmental Panel on Climate Change, reaching this objective requires halving global greenhouse gas emissions by 2050 and near zero emissions by 2100. Combined with sustained economic growth, this means that global carbon intensity needs to decline by 6 per cent each year – far more than the average 0.9 per cent annual decline observed since 2000.[1]

Decarbonising our economies will require the large-scale and rapid adoption of low-carbon technologies. This can only occur if the cost of these is reduced through massive investments in R&D, leading to greater innovation in low-carbon technologies. Innovation is critical because technological improvements will be a determining factor in keeping the cost of emission-reduction policies manageable. Further delays in deploying low-carbon technologies will also reinforce the process of economies being 'locked in' to a high-carbon energy supply infrastructure.

This *Insight* offers policy recommendations on how to further encourage low-carbon innovation.

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A dangerous decline in low-carbon innovation

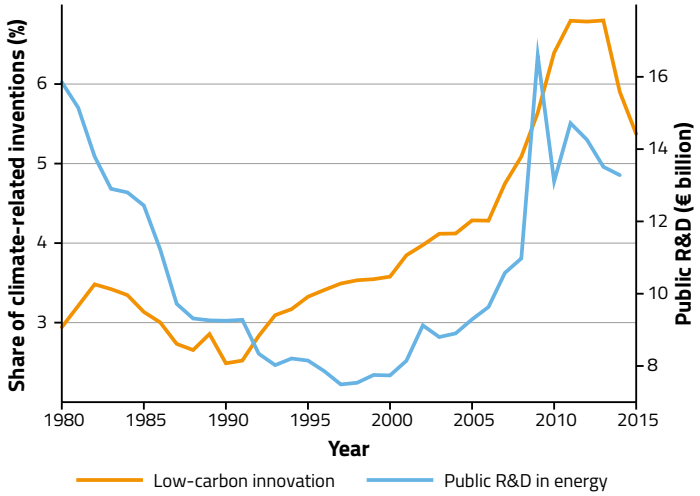
The pace and progress of low-carbon innovation can be measured by looking at global patenting activity in related technologies.[2] Figure 1 shows this activity between 1985 and 2015. The combined data cover most of the technologies available today to mitigate carbon emissions in five sectors:

- Buildings, for example energy-efficient lighting and heating, insulation
- Energy production, for example renewables, 'cleaner' coal, nuclear, biofuels, smart grids, energy storage, carbon capture and storage
- Manufacturing, for example energy-efficient industrial processes, material recycling
- Transportation, for example fuel efficiency, electric and hybrid vehicles, lighter materials
- Waste management, for example biogas capture and recycling

Because growth could reflect the general growth of patenting in all technologies, not just climate-related technologies, Figure 1 indicates low-carbon inventions as a share of climate-related inventions in all technology areas, as well as public R&D budgets for climate innovation.

The rapid growth in the proportion of patent applications to protect climate mitigation technologies since the late 1980s can be seen clearly, with a particularly strong increase after 2005. Between 2000 and 2013, the number of new climate mitigation inventions that were patented globally grew at an annual rate of almost 10 per cent, more than double the rate of all technologies. However, low-carbon innovation efforts started to decline in 2013.

Figure 1. Worldwide patent filings and public R&D budgets for climate innovation



Source: Author's calculations from the PATSTAT database;[3] IEA energy technology R&D budgets

A similar picture emerges when looking at the public R&D budgets for the same technologies from countries in the Organisation for Economic Co-operation and Development (OECD), as reported by the International Energy Agency (IEA). Although public climate-related R&D expenditures[4] increased at an average annual rate of 8 per cent between 2000 and 2009, having stagnated for almost a decade, they have decreased recently; in 2014 expenditures were still 15 per cent below the level in the early 1980s, after the second oil shock. Today, climate-related public R&D expenditure represents a mere 0.03 per cent of gross domestic product in OECD countries.

What policies are needed to encourage low-carbon innovation?

So, why is low-carbon innovation declining just when it is needed the most? There is ample evidence that inventors develop energy-saving (and hence carbon-saving) technologies when energy prices are higher.[5] The recent decline in low-carbon innovation may be a direct consequence of the collapse in oil prices, which reduces the value of future energy savings.

More generally, market forces provide insufficient incentives for investment in the development or diffusion of low-carbon technologies at all stages of technological development. Economists point to two principal explanations for this underinvestment in climate-friendly R&D: the absence of prices on carbon emissions and wider constraints to innovation. Together, these justify the need for government intervention.

Carbon pricing to encourage carbon-saving R&D

When carbon can be emitted freely – despite the damage it causes by increasing climate change – businesses and consumers lack incentives to invest in emission-reducing technologies. Without policies to address this, the market for such technologies will always be limited; investment in R&D is largely motivated by profit, after all. But making carbon emissions have a cost, for example through carbon taxes or emissions allowances, encourages the development of new low-carbon technologies.

A recent paper demonstrates this clearly.[6] Since 2005, the European Union Emissions Trading System (EU ETS) has

required 12,000 industrial facilities across Europe to buy allowances to cover their carbon emissions.

Figure 2 shows the increased innovation in low-carbon technologies, measured through their low-carbon patenting activity, among companies operating facilities regulated by the EU ETS. It also compares these with a carefully selected control group of similar firms operating in the same countries and sectors (thus facing similar economic conditions, such as oil prices and R&D subsidies) but operating unregulated facilities. This group indicates what would have happened to EU ETS firms had they not become regulated.

Figure 2 shows that both groups had similar innovation activity before the introduction of the EU ETS. But from 2005, companies facing a price on their carbon emissions reacted by filing 30 per cent more patents in low-carbon technologies than the control group, particularly in renewable energy, energy storage, energy efficiency and carbon sequestration.

Interestingly, the main effect on innovation occurred around 2008, when the market price for carbon was about €30/tonne and companies expected prices to remain high for the foreseeable future. Since it is expectations about future prices that determine innovation, long-term regulatory predictability is crucial.

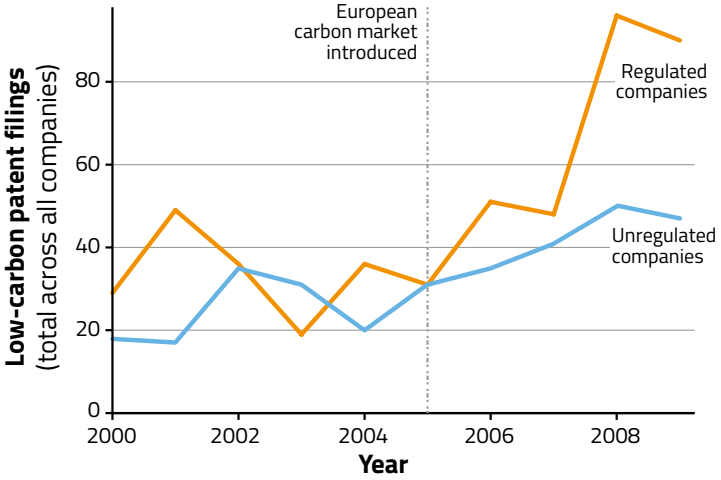
So, a sufficiently high and stable carbon price encourages the development of low-carbon technologies. However, recent analysis by the OECD[8] shows that the price of carbon emissions globally is still extremely low: 70 per cent of emissions are not priced at all and only 4 per cent of emissions are subject to a carbon price above €30.

Carbon prices that are higher and more stable than today are a necessary condition to reinvigorate the low-carbon innovation sector. This is particularly important given that the other major driver of low-carbon technology development – the price of fossil fuels – is volatile and at a very low level. Agreeing on a single, internationally binding minimum carbon price,[9] or establishing a price band for carbon emission rights in existing carbon markets,[10] would offer the kind of stability that innovators currently lack.

Policies to support innovation in low-carbon R&D

Any efforts to limit carbon emissions require not only strong carbon-pricing policies, but complementary science and innovation policies as well; market forces alone provide too little incentive for innovation. Since inventions are essentially ideas, it is rarely possible for inventors to capture all the benefits of their innovations. For example, all smartphone makers were able to copy

Figure 2. The impact of the EU ETS on low-carbon innovation



Source: Calel and Dechezleprêtre (2016)[7]

Apple's iPhone idea, even if they couldn't copy the device itself. This 'public good' nature of knowledge reduces the returns from innovation, which in turn leads to underinvestment in R&D. This is particularly true for clean technologies.[11]

Further issues compound the private sector's underinvestment in innovation. These include barriers to financing R&D investments (since information about the potential of a new technology is only held by the innovator), long-lived infrastructure investments (e.g. in power plants, petrol stations), the dominant positions of incumbent businesses, and regulatory barriers in the energy market.

Overcoming these requires policies that support innovation. These include public funding for basic research, subsidies for private R&D, better access to finance, funding for demonstration projects, technology accelerators and incubators, and support for the commercial deployment of early-stage technologies, such as feed-in tariffs that subsidise electricity produced from renewable sources.[12]

Of course, there is a wide range of clean technologies, and different problems apply to different technologies. Newer technologies (e.g. solar photovoltaic cells) or those that have wide applications across the board (e.g. energy storage) require more support than mature technologies (e.g. hydropower).

An important question for policymakers is how much government R&D money to spend on climate-friendly innovation. Recent IEA estimates suggest that achieving global climate change ambitions requires a twofold to fivefold increase in public R&D spending.

Another important question is how to allocate funding across the various support policies. Recent evidence indicates that many governments put a strong emphasis on supporting policies for the deployment of new technologies, compared with support at earlier stages of the innovation process. For example, in 2010 the five largest European Union countries (France, Germany, Italy, Spain, United Kingdom) and the Czech Republic spent €315 million to support R&D for wind and solar power, but €48.3 billion – over 150 times more – to subsidise their deployment.[13]

Encouraging the development of low-carbon technology requires stronger public support at the early stages. There is evidence that this is starting to happen: through the Mission Innovation initiative,[14] 20 countries recently pledged to double public R&D funding for clean energy technologies. This is a welcome promise, but still faces major challenges to fully materialise.[15]

Conclusions

Meeting the commitments made in the Paris Agreement will require all countries to adopt new low-carbon technologies in all their economic sectors. Greater public funding for low-carbon R&D, along with higher and more stable carbon-pricing mechanisms, are essential for achieving this.

Governments across the world are taking up this challenge. For example, the Republic of Korea's government has developed a comprehensive and integrated policy framework, the 2010 Framework Act on Low Carbon, Green Growth. This combines climate policies that incentivise firms to choose close-to-market environmental technologies with support for the development of newer technologies through public R&D funding. Similar commitments to low-carbon innovation across the world are a central part of the way forward in tackling climate change.

Endnotes

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Climate-KIC is Europe's largest public–private innovation partnership focused on climate change.

Our partnership consists of dynamic companies, the best academic institutions and public authorities. We drive innovation in tackling climate change through creative partnerships large and small, local and global, and between the private, public and academic sectors. The UK and Ireland is a core geographic region within Climate-KIC and is home to some of the most energetic climate innovation clusters and businesses in Europe.

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