Policy Brief

INNOPATHS

Innovation for Decarbonisation

Harnessing low-carbon innovation and its co-benefits to support the rapid decarbonization of European economies

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Key Messages

- The European transition towards net-zero emissions by 2050 requires both competitive technology costs and the removal of a wide array of non-cost-related diffusion barriers.
- Innovation successfully takes place when a diversity of actors and institutions share a common value system, which can be promoted by EU institutions providing a unifying framework across member states to reduce the impact of countervailing national and cross-national pressures.
- Increased public support for net-zero R&D is still crucial. Support for R&D in small firms and startups is a particularly useful tool to advance the twin goals of innovation in hard-to-decarbonize areas and economic competitiveness and opportunities, provided it is designed adequately.
- Many of the policy instruments that have been deployed to reduce GHG emissions have also been shown to promote technology innovation alongside emissions reductions.
- Demand-pull policies play an important role in promoting diffusion and reducing different barriers, but they need to be designed to be flexible and adjustable to minimize negative competitiveness and distributional impacts, particularly for small firms and low income households.

Background and Context

Europe has a long history of commitment to climate mitigation. Yet, in order to meet the climate neutrality challenge, efforts will have to be strengthened on all fronts.

Innovation plays a key role in economic development. Furthermore, it is also a major driver of climate mitigation and adaptation: emission reductions in model-based scenarios are driven by the diffusion of climate mitigation technologies. However, emission reductions projected in many models rely on some technologies that are not fully market-ready today. Increased efforts in low-carbon technology innovation and deployment are a core component of a sound climate-neutral strategy.

For this reason, policies supporting innovation in technologies relevant for the transition towards climate neutrality and their diffusion of will have to be put into place.

The European transition towards net-zero emissions by 2050 requires both competitive technology costs and the removal of a wide array of non-cost-related diffusion barriers.

The fast and large-scale deployment of mitigation technologies to meet stringent climate targets will be possible only if the costs of several technologies relevant for the transition towards climate neutrality decrease, promoting market take-up. Overcoming cost-related barriers will have to be achieved through learning-by-searching (i.e. the development of novel technological solutions) as well as learning-by-doing (i.e. the reduction of costs associated with increase in the scale of production/technology development). At the same time, appropriate regulatory interventions will have to address the comparative advantage resulting from sizeable fossil fuel subsidies and the fact that environmental externalities are not currently adequately priced in all sectors and all countries.

Yet many cost-competitive technologies still face significant diffusion barriers. These non-cost related aspects relate to network or infrastructure externalities, the co-evolution of technology clusters over time (referred to as "path dependence"), the lack of adequate institutional frameworks, but also behavioral aspects such as risk-aversion of users, personal preferences, expectations and perceptions, and uncertainty around technology outcomes and/or the presence, stability and the level of environmental and innovation policies.

As illustrated by the case of solar technologies in the last decade, and more recently by and lithium ion batteries in the last decade, technology deployment leads to learning-by-doing and other innovation processes that can significantly lower the cost of novel low-carbon technologies and, consequently, the cost of compliance with stringent targets. But assuming that cost is the sole driver of low-carbon technology diffusion will provide too optimistic expectations regarding the timing of action, or the availability of a given technology and its speed of diffusion. The role played by both cost-related and non-cost related barriers varies significantly by technology, sector and country, and needs to be considered by appropriate research and included in policy making.

Innovation successfully takes place when a diversity of actors and institutions share a common value system, which can be promoted by EU institutions providing a unifying framework across member states to reduce the impact of countervailing national and cross-national pressures.

A large number of actors and institutions within the innovation system contributes to the "success" or "failure" of actions promoting a specific low-carbon technology or the decarbonization of a specific technology. If a given innovation system is characterized by a strong "champion" supporting low-carbon technology development, or if all the components of the innovation system are present, share common values and work together towards a specific goal, low-carbon innovation deploys successfully. Conversely, entrenched opposing interests and lobbies significantly slow the progress of low-carbon innovation systems. There is significant heterogeneity in Europe with respect to the strength of value systems, not only across different countries, but also with respect to different sectors or specific technologies within a given country. In several countries and sectors, governing parties and coalitions hostile to the decarbonization process have significantly limited the effectiveness of climate-related and decarbonization efforts.

EU policies provide a strong framework within which to foster low-carbon innovation system. This role is particularly crucial when (a) not all the elements of the innovation system are present or support the transition or (b) national policy is too weak. In particular, the innovation system around a given technology shows substantial inertia when there is no EU policy to provide a common framework. This is the case, for instance, in the Land Use, Land Use Change and Forestry (LULUCF) sector (see the Policy Brief on biochar), which currently lacks a strong framework of EU climate mitigation policy, compounded by the fact that the EU Common Agricultural Policy gives Member States much discretion in implementation.

Many of the decarbonization policy instruments that have been deployed to reduce GHG emissions also promoted technology innovation in the energy sector.

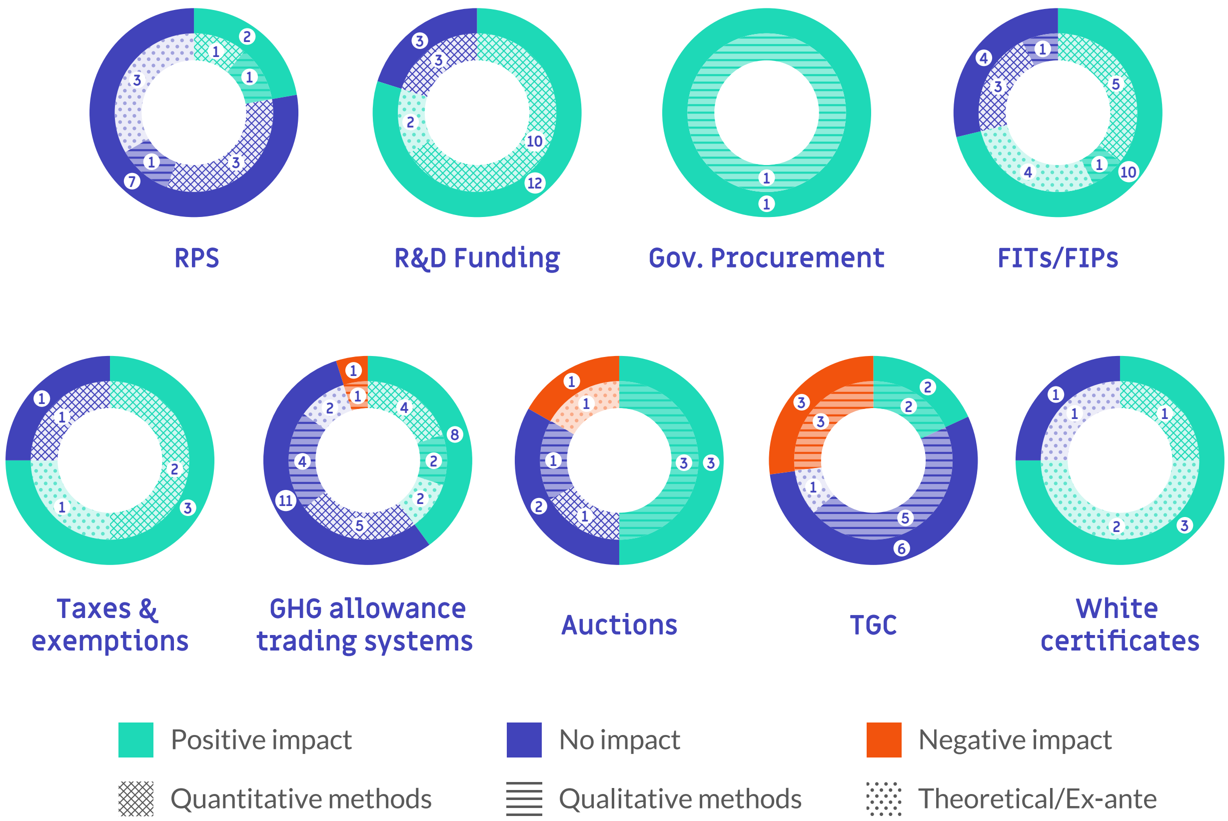
Environmental, energy and climate policies play a key role as drivers of low-carbon innovation - even if promoting innovation is not their primary goal. The need to meet the given environmental, energy or climate target generates incentives for private actors to invest in the development and deployment of novel technological solution. A wide range of environmental, energy and climate policy instruments have been implemented in several countries and sectors in the last decades. These include regulatory instruments – such as standards and quotas – and economic and financial instruments – including RD&D funding and Government Procurement, Feed-in tariffs (FITs), Auctions, Tax exemptions, GHG emissions allowance trading schemes, and Green and white certificates.

The innovation outcomes of some of these policy instruments, i.e. their ability to generate a continuous incentive for technical improvements, has been studied using R&D (input) or patent (output) data or the implicit learning(-by-doing) that can be measured by changes in installed capacity (learning curves). Some policy instruments promote innovation, while others are less successful (Fig. 1). R&D and Feed-in-tariffs emerge as sconsistently supporting innovation, whether measured in terms of technology cost reductions or patent applications. With respect to R&D investments, an important aspect that deserves more consideration is the role of public R&D investments as a catalyst for private funds, a topic to which we return below. GHG allowance trading systems, Tradeable Green Certificates (TGCs) and Renewable Portfolio Standards, on the other hand, show no consistent impacts on innovation.

Evidence is lacking regarding innovation outcomes associated with policy instruments more often implemented in the building and transport sectors, which will play in future decarbonisation pathways. This is a key area where further research is needed.

> “Differences in policy instrument design explain why in some instances a given instrument displays stronger trade-offs between climate mitigation and other societal goals”

Fig. 1 Aggregated assessment of the impact of a set of policy instruments on innovation outcomes.



The circles summarize the aggregated assessment from the systematic literature review. The outer circles represent the number of positive impact (blue), no impact (grey) and negative impact (orange) evaluations by type of policy instrument. The inner circles represent the type of methodology that was used in the evaluations determining the different impacts. The checkered pattern denotes quantitative methodologies, the striped pattern represents qualitative methodologies, and the dotted pattern represents theoretical literature and models and/or ex-ante evaluations.

Source: Peñasco et al. (2021)

Demand-pull policies need to be designed in such a way as to be flexible and adjustable to minimize negative competitiveness and distributional impacts, particularly for small firms and low-income households.

The implementation of policies supporting the deployment of low-carbon technologies, even if successful, may entail significant short- to medium-term transitional costs or trade-offs. The most frequently observed trade-offs between environmental outcomes and competitiveness and distributional outcomes are for demand-pull policies such as taxes, TGCs, GHG emission allowance trading schemes and FITs. Mitigating such tradeoffs is a key concern for policy makers. To this end, it is necessary to implement tailored, predictable and adjustable policy instruments. Indeed, differences in policy instrument design explain why in some instances a given instrument displays stronger trade-offs between climate mitigation targets and other societal goals. Renewable energy auctions are generally associated with positive competitiveness impacts for large firms, but can be negative for small firms due to the tighter cost margins of auction schemes when compared to FITs. To overcome this, governments can design specific auctions for small producers or design additional ways to support their participation. The combination of different policy instruments, e.g., FITs plus auctions, can support different producers and technologies at different stages of development.

To avoid the emergence of competitiveness trade-offs for small companies, energy tax reforms can modify the object of taxation rather than increase tax benefits. Several examples of tax designs reducing burdens for small companies are already in place in some OECD and European countries. When energy tax revenues are used to reduce payroll taxes, and if wage-price inflation is prevented, significant short- to medium-term reductions in GHG emissions, small gains in employment, and marginal variations in production are likely.

For carbon-pricing schemes, recycling mechanisms and compensatory non-environmental exemptions in carbon pricing can be used to mitigate negative outcomes for small firms because tax revenues can be used to reduce corporate taxes or social security contributions. Carbon taxes without exemptions and revenue recycling tend to have negative distributional impacts, above all for SMEs.

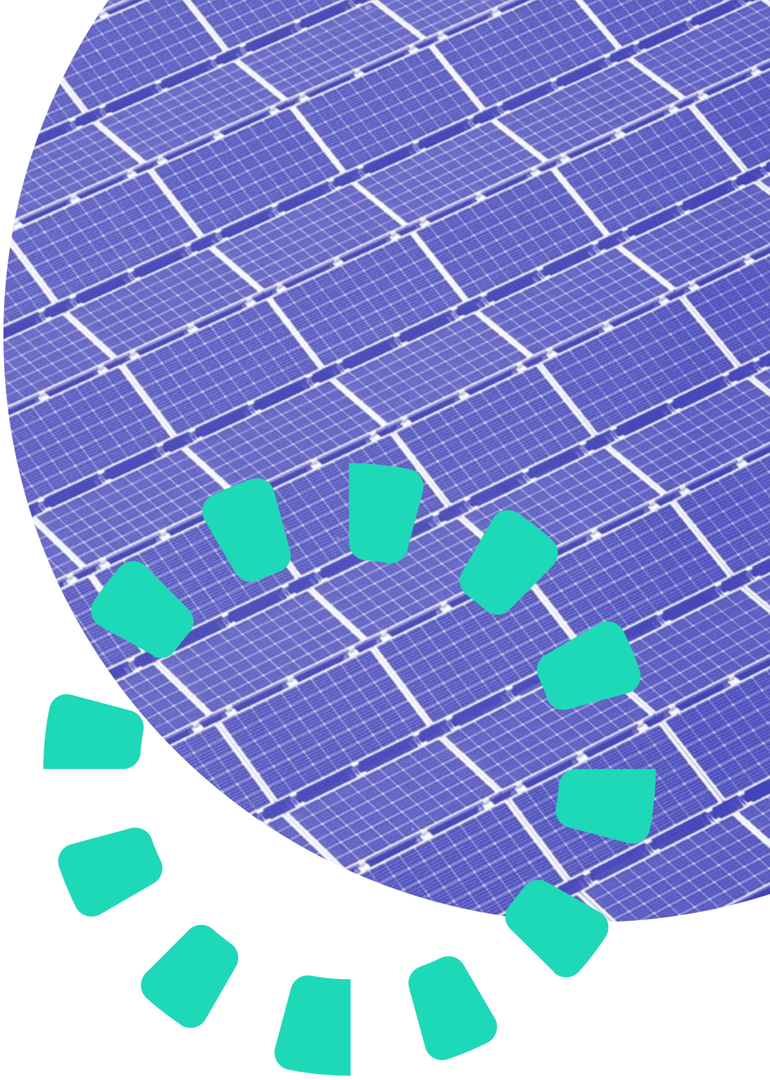
Importantly, these policies need to be sustained, predictable and adaptable, and part of a broader framework to advance innovation and competitiveness effectively.

Support for R&D and government procurement in small firms and startups can be particularly useful tools to advance both net-zero innovation and competitiveness goals.

Increased public R&D investment is an important component of an effective strategy to promote low-carbon technological innovation. The role of technology-push policy instruments specifically targeted at reducing the cost of low-carbon technologies – which includes R&D investments but also innovation subsidies – varies across the different phases of the innovation process, as technologies become mature and cost-competitive. Public R&D funding is associated with a positive innovation impact on competitiveness metrics, including the export dynamics of environmental goods and the ability to attract venture capital funding in the cleantech sector. An important research topic is the role of public R&D investments as a catalyst for R&D investment in the private sector.

For small companies, a combination of direct R&D funding and R&D tax credits may stimulate higher R&D private expenditures than the application of each policy instrument independently. Novel public energy R&D allocation models based on the US DARPA model have been shown to advance innovation in cleantech startups and could play a role complementary to that of other R&D funding mechanisms.

Government procurement can also promote innovation and competitiveness in small firms because it creates market opportunities, particularly in economically stressed areas. Provisions that facilitate the involvement of small firms and overcome potential trade-offs include targeted procurement programs or the possibility to adjust individual contracts and bids to remove barriers specific to small firms.



Further Information

For further information, please consult the following publications:

- INNOPATHS Deliverable D2.4 – Report on the sectoral and national (plus EU) innovation system case studies
- Anadon, LD, Baker, ED, Bosetti, V. *'Integrating uncertainty into public energy research and development decisions.'* *Nature Energy* (2017) 2:17071. DOI:10.1038/nenergy.2017.71
- Goldstein, AP., Doblinger, C., Baker, E., Anadon, LD. *'Patenting and business outcomes for cleantech startups funded by ARPA-E.'* *Nature Energy* (2020) DOI: 10.1038/s41560-020-00683-8.
- Peñasco, C., Anadón, L.D., Verdolini, E. 2021 Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments. *Nature Climate Change*, 11 (3):257-265 (DOI: https://doi.org/10.1038/s41558-020-00971-x)
- Verdolini E., Diaz Anadon L., Baker E., Bosetti V. and Aleluia Reis L. 2018 Future prospects for energy technologies: Insights from expert elicitations, *Review of Environmental Economics and Policy* 12 , no. 1, 133--153.

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