Sparking Technological Innovation for a Low Carbon Society

Key Findings

- Technological innovation is crucial to creating a low carbon society. Power generation is responsible for between one-third and one-half of all global CO₂ emissions. However, the structure of the industry and the risks faced by investors hinder the innovations and technological shifts needed to reduce these emissions.

- Government policy is essential to create early markets for clean technologies and drive down cost through research and development (R&D) that takes a long-term perspective.

- Solar photovoltaic (PV) technology is growing rapidly and has shown great potential for cost reductions. Public subsidies and market creation policies have been central for this development. Historically, the feed in tariffs implemented in Europe have been most effective in achieving deployment, though recent trends in the United States indicate that a combination of tax incentives and tailored renewable portfolio standards (RPS) can also work well.

- Interest in and support for carbon capture and storage (CCS) has grown in recent years. Progress on CCS depends on large-scale demonstration. Several projects have been planned but few have yet been initiated, due to insufficient funding and political commitment.

- The innovation systems for solar PV and CCS have become increasingly international. For both solar PV and CCS, market formation is the least internationalised part of the innovation system. European markets, and European policies, play a dominant role globally for both CCS and solar PV. For the technologies to develop rapidly and sustainably, it is crucial that European efforts are balanced by market formation elsewhere.

Technological change crucial for a low carbon society

Technological change is crucial for reducing emissions of greenhouse gases. Some of the technologies necessary to reach a low carbon society are ready to implement now, while others need further development and cost reductions to become scalable alternatives that can reduce emissions. Investing in new ‘clean’ technology has received significant political and media attention, as new technologies are often associated with growth and progress, where other measures (such as efficiency or conservation) may be associated with restrictions. Nevertheless, the technological shifts and the innovations needed are not happening fast enough. Change and innovation is necessary in several sectors. However, the electricity sector is particularly important as it is responsible for about 40 per cent of global CO₂ emissions, and as electricity is used throughout the economy. However, the electricity sector also presents challenges for achieving and implementing innovations. Old, long-lived fossil-fuel technologies dominate; private sector R&D is relatively low; and markets are not easily formed. Where policy has attempted to stimulate technical change, progress has been limited by risks, as capital intensity and long investment cycles leave investors exposed to political change.
New markets and demonstration projects needed

In partnership with the business leaders’ initiative Combat Climate Change (3C), Stockholm Environment Institute has researched the development and deployment of two technologies of key importance in a low carbon society – solar photovoltaics (PV) and carbon capture and storage (CCS) – with a particular focus on the US and Europe.

For solar PV, a primary risk relates to the formation of markets. Due to the high costs of solar PV compared to other energy technologies, the deployment of solar PV has so far been almost entirely dependent on support schemes. To date, European countries (especially Germany) have constituted the main markets for solar PV, and these markets have spurred the development of an international industry, with PV production now occurring in several countries worldwide. This has meant that the PV industry is driven by policy and political support in just a few countries. Inadequate policy design and political changes in these countries can therefore create major problems for the industry and the progress of the technology. For PV technologies to develop rapidly and play a leading role in GHG abatement, further development and expansion of markets in other parts of the world is crucial.

Likewise, for CCS, development is currently highly dependent on European policy. CCS risks entering the so-called “valley of death” between R&D and commercialization: demonstration projects are needed to ensure the viability of the CCS technology on a larger scale, and to move from technological development to deployment. While several such projects have been planned, most of these have not been carried out, due to a combination of insufficient funding and underdeveloped policy frameworks for storage. Whereas the European Emissions Trading System should provide a market for CCS from 2025 or 2030, uncertainties about timing remain, and similar policies in the US and other parts of the world are lacking.

Targeted policies required for less mature technologies

While it is commonly suggested that policies should support research in the early stages of technology development, followed by support to market creation in later stages, the findings from the project point to the need for both ‘push’ and ‘pull’ mechanisms throughout the development. Exclusive focus on R&D ignores the role of market formation in stimulating learning and new ideas, while excessive focus on market deployment may lead to short-termism in research and development. While market formation policies have stimulated in-
novation in PV, generous guaranteed incentives may simultaneously undermine development over time, as the greatest overall benefit accrues to those actors who can deploy market-ready technologies at volume. In addition, overly generous incentives may harm development by easing pressure to be cost-competitive. The US has traditionally favoured support to research whereas European policies more often focus on market creation. Governance of Solar PV and CCS has followed this pattern, with European markets driving demand while the US plays an important role in R&D.

Globalisation of economies influences innovations

Innovative activity for both PV and CCS increasingly takes place in many countries. Such activity has been clustered in certain regions of the world, a tendency that has increased over time. Industrial activity for PV occurs in several parts of the world, and China plays an increasingly important role. Markets, however, are still concentrated to a few areas in the world.

This internationalisation of the innovation systems – where the innovation systems that earlier had a more national character are now to an increasing extent international – can be seen as positive for the growth of the industry and cost reductions. However, at the same time, it imposes challenges on policy makers that seek to stimulate emissions reductions while at the same time stimulating innovation and industry growth domestically. Increasing international competition in solar PV has led some to question such single-country ‘green jobs’ strategies, and political voices in for example Italy and India have called for trade measures to protect domestic PV industries. Yet, despite increasing production of solar panels in China, a large portion of the economic value of solar PV installations has tended to stay in the country where the installation is made.

Economic growth and industrial policy as a driver

Policies that support renewable energy technologies are often discussed in terms of their job-creating benefits. It is clear that both the US government and the European Union see such targets as one argument for their support to low-carbon technologies. While the technologies in question create higher costs of energy, industrial policy has in some countries supported the development of technological capacity and export industries, for example in Germany and China. While European markets have constituted the main driver for the development of the Chinese PV industry, measures have also been taken to stimulate a Chinese PV market in order to support the Chinese PV industry.

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Important trends and developments

- The exact effect of the feed in tariffs on solar PV innovation is difficult to assess. When deciding on the exact level and design of feed in tariffs and similar support instruments, there is often a trade off between achieving fast deployment, inducing technological advancements and ensuring high quality installations.

- Political support has struggled to meet the necessary scale of the CCS demonstration challenge. Even with unprecedented public funding, the capital intensity and perceived risks associated with large-scale CCS investments are proving difficult to overcome.

- Political goals with respect to job creation and industrial growth have in many cases functioned as a driver and legitimization for the development of markets for PV.

- Lack of public support has been identified as a barrier for both CCS and PV – for different reasons in different cases and regions.