Development and deployment of climate change mitigation technologies: evidence to support policy making

Policy Brief

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IRENA
International Renewable Energy Agency

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At COP21, the Parties agreed to make use of the "best available science" to decarbonise the global economy by the second half of this century. To achieve this goal, it is imperative to accelerate the development and global deployment of climate change mitigation technologies (CCMTs).

The purpose of this policy brief is to provide evidence on the latest trends in CCMT innovation and dissemination, with a focus on renewable energy technologies. These findings, some of which are published for the first time here, could provide a useful source of information for decision-makers as well as society at large. It is hoped that they will encourage informed debate in the field of climate mitigation technologies.

Inventive activity in CCMTs has been increasing globally in the past decade. This growth has been particularly strong in renewable energy technologies, where innovation has contributed over the same period to dramatic cost reductions and rapid technology deployment. Integrating renewable energies into reliable power systems is the next challenge at hand, as illustrated by the growing patent activity in the field of enabling technologies such as information and communication technologies (ICT) applied to renewables.

Climate policy has played a crucial role in contributing to such sustained inventive activity. Innovation may indeed involve high levels of uncertainty, which can be mitigated by stable and enforceable policy bringing clarity to the technology market.

Inventive activity in CCMTs is mainly concentrated in a few developed and emerging regions. Nevertheless, the number of inventor countries actively contributing to the development of such technologies worldwide is growing.

In addition to providing incentives for innovations, patents also support the international dissemination of newly developed CCMTs. They provide the legal protection necessary for an inventor to export to or produce in foreign markets. International CCMT transfers, as measured by the number of patents filed in the destination countries, are still mainly oriented towards developed and emerging regions. Common obstacles to technology transfers to developing countries include limited capacity to absorb new technologies but also lack of clear policy incentives.

The empirical findings contained in this policy brief rely on the most recent data sources available. In particular, most of the statistics are based on patent information which is public and freely accessible. Patent information represents a solid and powerful indicator of technological and economic developments in climate change mitigation technologies. Patent applications for CCMTs are identified using a dedicated tagging scheme developed by the EPO to facilitate search and dissemination of technical knowledge on sustainable technologies.

Dissemination of technical knowledge through the patent information system

To help companies, engineers, scientists and policy-makers involved in climate change issues to better access and use the wealth of knowledge available in patents, the EPO has created a dedicated tagging scheme for patent documents related to low-carbon technologies, making it possible for users to retrieve these technologies from its databases. In combination with patent statistics tools, the tagging makes it possible to map sustainable technologies, identify trends and produce facts and evidence for policy and business decisions. To date, the EPO's databases contain over 3 million documents related to CCMTs, covering energy, carbon capture and low-carbon inventions in buildings, transport, production, waste and smart grids. This is the biggest single repository of low-carbon technologies in the world, and the joint EPO-UNEP studies are only examples of what can be achieved with this information. See www.epo.org/y-classification

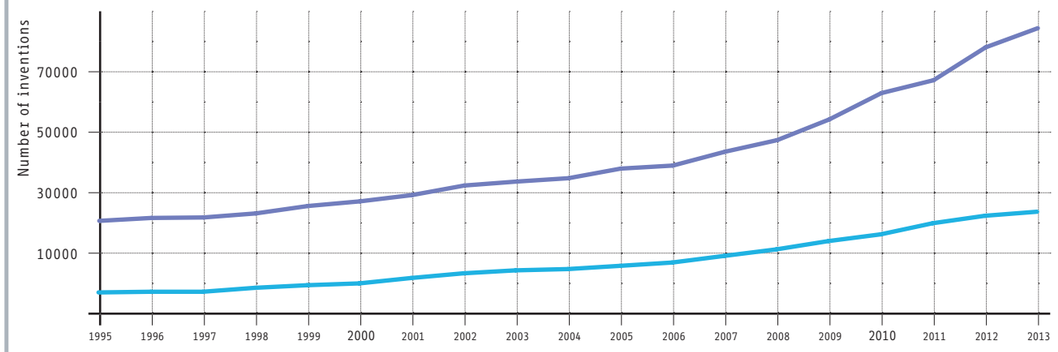
Searching for information about climate change mitigation technologies in patents

The EPO's dedicated tagging scheme for climate change mitigation technologies ("Y02/Y04S") covers:

- Y02B CCMTs relating to buildings
- Y02C Greenhouse gas capture and storage
- Y02E Energy generation, storage and distribution
- Y02P CCMTs in production
- Y02T CCMTs relating to transport
- Y02W CCMTs in waste treatment
- Y04S Smart grids

The number of inventions in CCMTs and their commercial value are growing globally

1 Worldwide trends in CCMT inventions 1995-2013



A CCMT invention is defined as a patent family identified using EPO's Y02/Y04S tagging scheme.
High-value inventions are defined as inventions for which patent protection has been sought in at least two jurisdictions.
Latest year of fully available patent publication data using EPO's Y02/Y04S scheme was 2013.

Source: own calculations based on PATSTAT

Technological development in CCMTs as measured by the number of inventions for which patent protection was sought has accelerated over time, growing at a rate of 8.6% in the period 1995-2013 (Cumulated Average Growth Rate, CAGR). The rate is even higher, namely 10%, for high-value CCMT inventions, which are defined by the OECD as those for which patent protection has been sought in at least two jurisdictions.

The share of CCMTs in worldwide inventive activity increased from 3.3% in 1995 to 6.8% in 2011 and fell

slightly thereafter. Meanwhile, the share of high-value CCMT inventions out of worldwide high-value inventions increased from 4% in 1995 to more than 9% in 2012 and remained stable the following year.

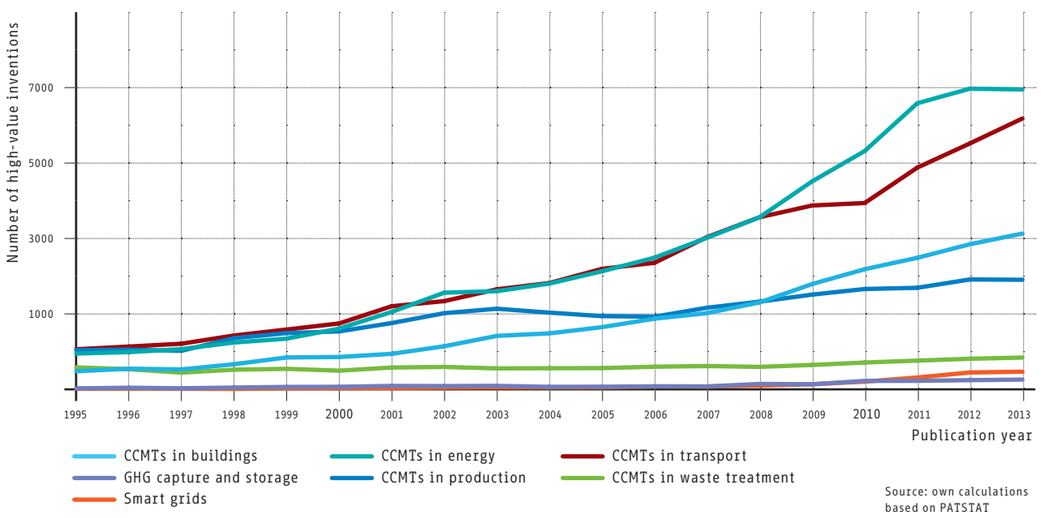
This indicates not only that CCMT inventions are likely to be more commercially valuable than the average invention but also that their commercial value has increased over time.

Most inventions relate to CCMTs in the energy sector, with renewables driving the growth

Most CCMT-related high-value inventions are developed in the areas of clean energy and clean transport, followed by technologies which are contributing to the reduction of GHG emissions in buildings and in production. CCMT inventions related to waste, carbon capture and smart grids still account for a relatively small share of worldwide CCMT inventions.

Between 1995 and 2013, the number of high-value inventions in CCMTs, except in waste (2.0%) and production (5.8%), grew at a double-digit CAGR. The CAGR was 12.5% in CCMT high-value inventions in buildings and 12.4% in clean energy, slightly higher than the rates in transport (11.1%) and carbon capture (11.1%). Smart grids, although starting with lower volumes, experienced the fastest growth, with a CAGR of 17.5%.

2 High-value CCMT inventions by main technology 1995-2013

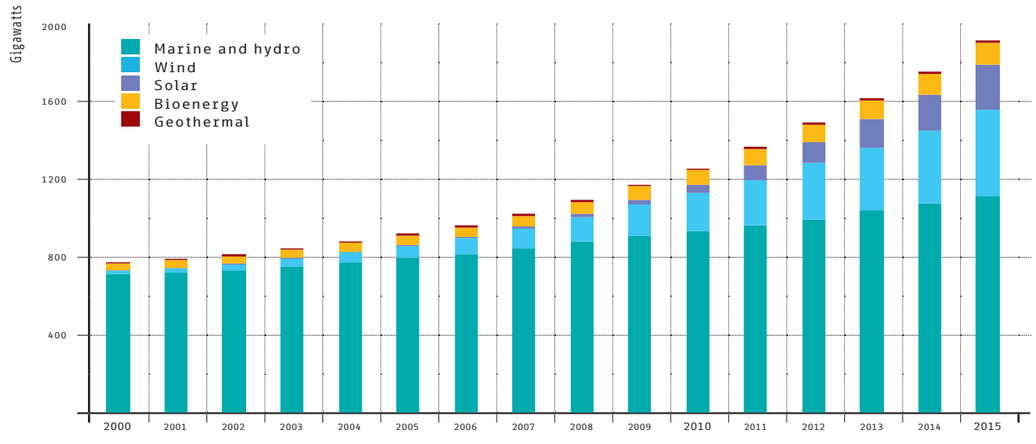


Source: own calculations based on PATSTAT

Within clean energy technologies, the growth of new inventions in renewables was by far the strongest. During that period the deployment of renewables followed the same growth pattern. Total installed capacities of renewable energy sources more than doubled between 2000 and 2015.

In 2015, renewables already accounted for around 25% of total global electricity generation. 47 GW of PV additional capacity and 63 GW of wind power additional capacity were installed in 2015, representing more than a 20% growth compared to 2014 (IRENA, 2016d). Since 2013 more than half of all new power generation worldwide is renewable despite low fossil fuel prices.

3 Renewable power – total installed capacity 2000-2015

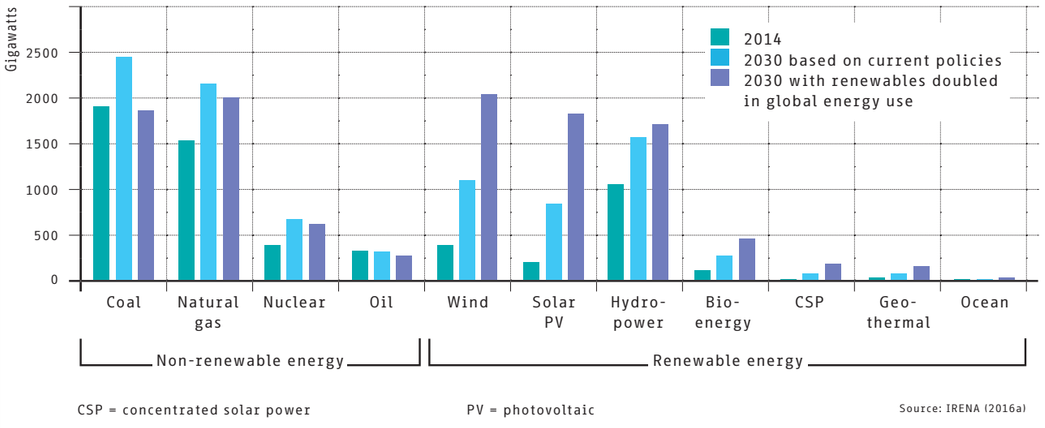


Source: IRENA (2016d)

Innovation has indeed brought renewable power from a promising suite of technologies just a decade ago into being mainstream power supply technologies. Nonetheless, these efforts must be reinforced to get the world on track to achieve the Paris Agreement.

According to an analysis produced by the International Renewable Energy Agency (IRENA), the share of renewables should be doubled up to 36% to avoid up to 12 gigatonnes (Gt) of additional CO2 emissions per year in 2030 compared to business as usual (while energy efficiency measures should be implemented to save a further 8 Gt). This doubling in renewables represents nearly 2 000 GW of wind power and 1 700 GW of PV installed capacity by 2030, from the current 416 GW and 220 GW installed capacity respectively (IRENA, 2016a and 2016d).

4 Power generation capacity (installed by 2030)



CSP = concentrated solar power

PV = photovoltaic

Source: IRENA (2016a)

The integration of ICT into renewable energy technologies remains a key challenge

As renewable power technologies have reached maturity, a key challenge is now to better integrate these intermittent sources of energy in dynamic power systems (IRENA, 2016b). Such integration will require deploying flexibility options across the whole power system, from generation, transmission and distribution to consumption (IRENA, 2015). Enabling technologies such as ICT are going to play a key role in facilitating the deployment of all flexibility options, including new business models, market approaches and operational practices.

5 Yearly growth rates in high-value inventions in selected CCMT fields

Source: own calculations based on PATSTAT

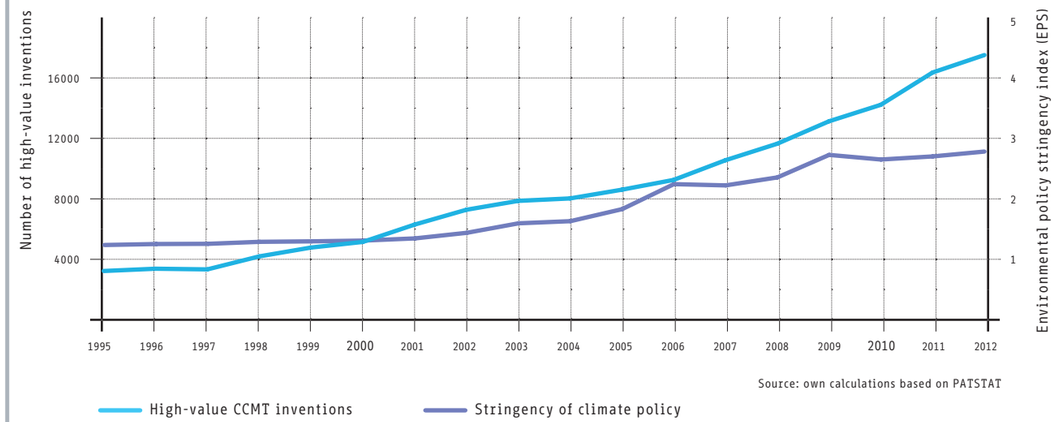
The increasing relevance of innovation in the ICT sector for renewable energy is reflected in patent information. In recent years, a deceleration has been observed in the growth rate of inventions in PV and wind power for which patent protection is sought each year. However, in the same period, annual growth rates of patents filed for ICT aiming at renewable energy systems have remained highly positive. This indicates an increasing effort to address system integration issues for renewables through ICT. The benefits of having the renewable power and digitalisation eras meeting each other are already resulting in new approaches to designing, building, managing and operating power systems. Virtual power plants, smart meters, advanced weather forecasting and artificial intelligence in demand-side management are typical examples of advancements where renewable power technologies and ICT go hand in hand.

Information on international standards and patents in renewable energy

IRENA's information platform on International Standards and Patents in Renewable Energy (INSPIRE) enables users to search patent information delivering reports on historical patent trends for different renewable energy technologies by country or patent applicant. INSPIRE uses the EPO's PATSTAT data and its Y02 classification, as it is the most detailed RE categorisation available. INSPIRE is being used by policy-makers and other RE stakeholders who are not experts in IPR to get a hold on the technology trends for RE based on patent information.
Link: www.irena.org/inspire

Climate policy is a main driver of innovation in CCMTs

6 CCMT inventions and stringency of climate policy in OECD countries 1995-2012



Source: own calculations based on PATSTAT

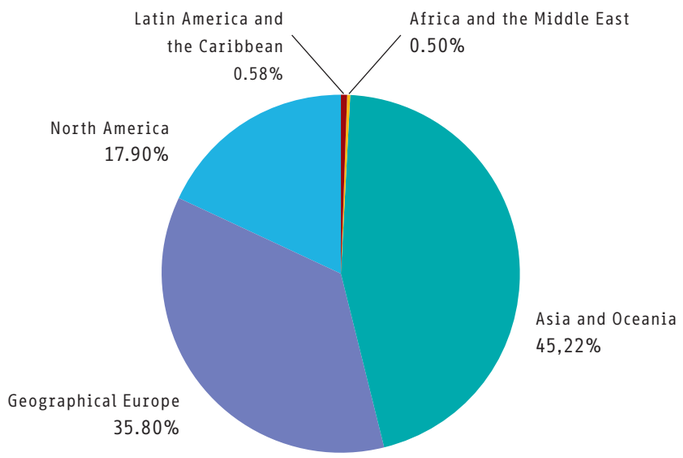
The stringency index was developed by the OECD (Botta, E. and T. Kocuk (2014): Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach) and is available for all OECD countries for the period 1990-2012.

Investing in research and development (R&D) may bring high levels of uncertainty, and this also applies to innovation in newly emerging CCMTs. Policy clarity, stability and enforcement are key factors supporting investments in innovation with a positive impact on technology development and deployment. The same applies to climate policies.

Mapping the stringency of environmental policies against the number of CCMT inventions shows a positive relationship between the two developments for OECD countries. During the period 1995-2012, as more restrictive climate policies were introduced, including the Kyoto Protocol in 1997, inventive output in CCMTs greatly accelerated. It is also likely that these policies have triggered additional investments in technologies intended to curb greenhouse gas emissions (GHG).

Inventive activity in CCMTs is mainly concentrated in a few regions of the world but diversity of inventor countries is growing

7 Share in high-value CCMT inventions by region 2005-2013



Source: own calculations based on PATSTAT

Most of the technological development in CCMTs still originates from Asia and Oceania, Europe and North America, with the three regions combined accounting for almost 99% of worldwide inventive activity.

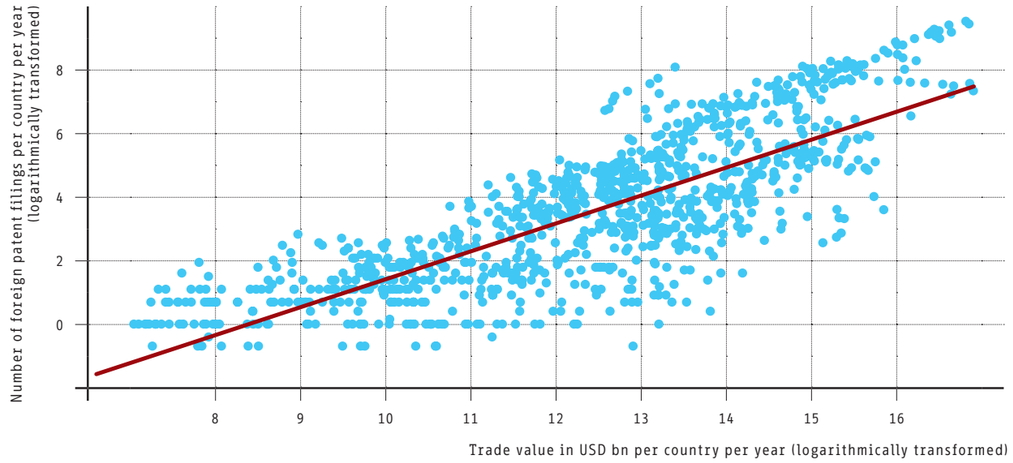
Despite the strong concentration in the EU, Japan and the USA, trends show an increasing participation of other countries in the development of CCMTs. In the most recent period, 2005-2013, the share of the top three decreased in favour of a more diverse range of inventor countries, notably from Asia, with an increasing role played by Korea and China, but also from other regions.

8 Top five inventor countries in high-value CCMT inventions

	Country/region	Share % 1995-2004	Country/region	Share % 2005-2013
1.	EU	36.44	EU	34.20
2.	Japan	30.66	Japan	26.89
3.	USA	22.47	USA	16.75
4.	Korea	3.26	Korea	8.70
5.	Canada	2.06	China	5.31
Sum Top 5		94.88		91.67

Patents support the deployment of CCMTs

9 Relationship between patent filings and imports of CCMT goods

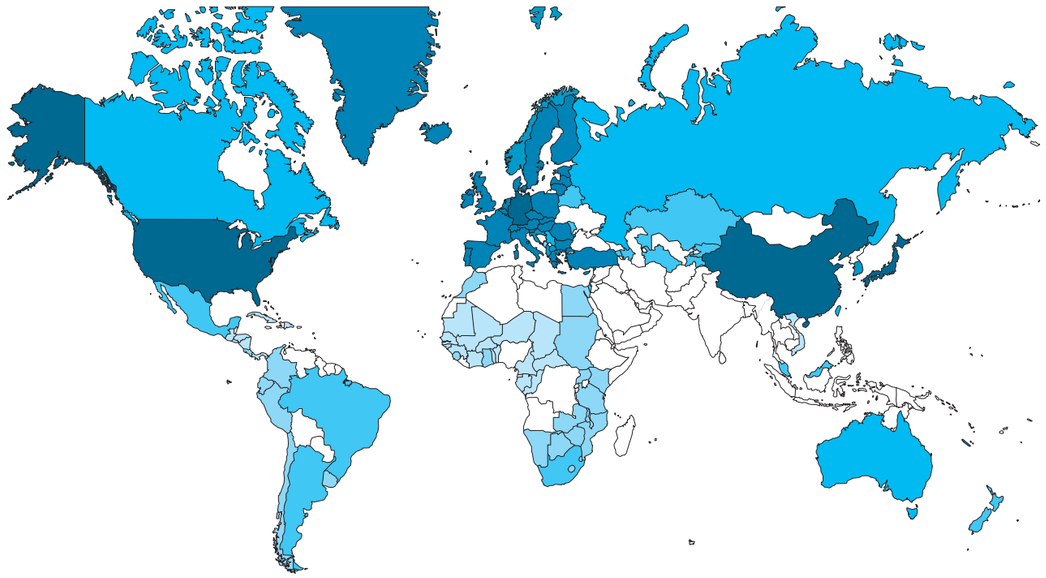


Source: EPO, UNEP 2015

Patent systems worldwide incentivise innovation by securing returns on R&D investments. In addition, patents also facilitate the international dissemination of inventions by providing legal protection across multiple markets and the necessary framework for companies to transfer their inventions. It fosters exports, foreign direct investment (FDI) and licensing contracts, which are all major channels for international technology diffusion.

Patent protection is also relied upon to protect CCMT goods that are either exported or produced locally from imitation in the destination country. For example, comparing incoming trade in CCMT goods with foreign patent filings in CCMTs shows a strong positive correlation. Trade in CCMT goods is likely to require patent protection in the recipient country. Higher incoming trade volumes are, on average, associated with higher numbers of patent filings from the originating countries. A similar relationship is observed for patent filings and FDI in CCMTs (EPO, UNEP 2015).

10 Destination of CCMT patent filings worldwide 2005-2013



Source: own calculations based on PATSTAT

As shown in the map above, the large majority of patent applications for inventions relating to CCMTs are filed in developed countries and in a limited number of emerging countries, such as China. This suggests that international transfers of CCMTs are still mainly oriented towards the same regions where most inventive activities are located.

Conversely, low volumes of patent filings in developing countries are an indication of the still limited dissemination of CCMTs to these countries through the export, FDI and licensing channels.

Typical obstacles to technology transfers to these countries include limited capacities to absorb new technologies (such as lack of scientific capability, infrastructure and human capital), but also lack of clear policy incentives to make use of those technologies.

Imprint

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Y02 and Y04S
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EPO's previous reports:
CCMTs in Europe: evidence from patent and economic data (EPO, UNEP 2015) www.epo.org/climate-europe
Patents and CCMTs in Latin America and the Caribbean (EPO, UNEP 2014) www.epo.org/LAC
Patents and CETs in Africa (EPO, UNEP 2012) www.epo.org/clean-energy-africa
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IRENA (2016d), Renewable Energy Statistics 2016, The International Renewable Energy Agency, Abu Dhabi.
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