Patents and clean energy: bridging the gap between evidence and policy

Final report

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FOREWORD

Climate change is the most pressing challenge of our time. Addressing it requires an unprecedented mobilisation of human and financial resources to alter our patterns of production, consumption and energy use. The large-scale development and diffusion of technologies is the key to making such a transition possible.

Enhancing technology transfer has been a key pillar of the global climate change regime since the inception of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The current climate change negotiations recognise the need to strengthen this pillar by, among other things, the establishment of a technology mechanism to accelerate technology development and transfer.

In this context, the role of intellectual property rights in the development of climate change mitigation and adaptation technologies, and especially their transfer to developing countries, has emerged as a particularly contentious issue. Despite repeated calls for reliable and continuously updated information about climate change technologies and patents, this vigorous debate has been marked by a general lack of impartial data and evidence that would enable policy-makers to make informed choices.

Recognising the need for more empirical evidence, data and transparency, the United Nations Environment Programme (UNEP), the European Patent Office (EPO) and the International Centre for Trade and Sustainable Development (ICTSD) announced in spring 2009 that they would undertake a joint project on the role of patents in the transfer of climate change mitigation technologies.

Interim results of this project were presented at the Copenhagen UN Climate Change Conference in December 2009 and at the June 2010 Bonn UN Climate Change Talks, the latter co-hosted with the UNFCCC secretariat and the World Intellectual Property Organization (WIPO).

This final report represents the culmination of the joint work undertaken. It includes the findings from a comprehensive mapping of clean energy technologies, an in-depth analysis of the patent landscape for these technologies and a survey of licensing activities in this field. A groundbreaking outcome of the project has also been the creation by the EPO of a new patent classification scheme and a searchable database.

The report concludes by pointing to the continuing need to further develop empirical analysis in order to better understand the impact of the patent system on the development and transfer of climate change technologies.

Ultimately, we hope that this partnership and its focus on generating knowledge and data will contribute to a more informed policy debate, and thereby to global efforts to address climate change.

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EXECUTIVE SUMMARY

Technology development and its rapid diffusion are considered crucial for tackling the climate change challenge. In particular, enhancing technology transfer towards developing countries has been an integral part of the global climate change regime since the inception of the United Nations Framework Convention on Climate Change (UNFCCC). The Bali Action Plan reaffirmed its centrality, and the Copenhagen Accord calls among other things for the establishment of a mechanism to accelerate technology development and transfer.

The role of intellectual property rights (IPRs) in the transfer of climate change technologies has emerged as a particularly contentious issue in the past two years. Against this background, the United Nations Environment Programme (UNEP), the European Patent Office (EPO) and the International Centre for Trade and Sustainable Development (ICTSD) joined forces to undertake an empirical study on the role of patents in the transfer of clean energy technologies (CETs).

The project consisted of three main parts: a technology-mapping study of key CETs, a patent landscape based on the identified CETs and a survey of licensing practices. For the purposes of this study, CETs are defined as energy generation technologies which have the potential for reducing greenhouse gas emissions.

The patent landscape

Based on the technology mapping study, a new taxonomy for CETs was established in order to derive the patent data. A statistical analysis was then carried out with this data. According to this analysis, patenting rates (patent applications and granted patents) in the selected CETs have increased at roughly 20 per cent per annum since 1997. In that period, patenting in CETs has outpaced the traditional energy sources of fossil fuels and nuclear energy. The surge of patenting activity in CETs coincided with the adoption of the Kyoto Protocol in 1997, which provides a strong signal that political decisions setting adequate frameworks are important for stimulating the development of CETs. The fields experiencing the most intensive growth include solar PV, wind, carbon capture, hydro/marine and biofuels.

Patenting in the selected CET fields is currently dominated by OECD countries. However, a number of emerging economies are showing specialisation in individual sectors, providing further competition in the field and potentially changing the future of the CET patent landscape.

The leading six countries with actors innovating and patenting CETs are Japan, the United States, Germany, the Republic of Korea, the United Kingdom and France. Concentration of patenting activity in these countries reflects patenting trends in other technology sectors. Aside from geothermal, concentration in all CETs is relatively high. Notably, the top six countries account for almost 80 per cent of all patent applications in the CETs reviewed, each showing leadership in different sectors.

However, a number of other countries emerge as significant actors in selected fields when CET patent data is benchmarked against total patenting activity (all technology sectors) in a given country. For instance, such an analysis reveals that India features within the top five countries for solar PV, while Brazil and Mexico share the top two positions in hydro/marine.

In terms of patent filing trends between countries (structure of patent families), unsurprisingly, most activity is currently taking place in the patent offices of the top six patenting countries. However, China is the next most important filing destination for actors in the top six countries.

Finally, the patent landscape also identified which technologies, including their sub-groups, have peaked in maturity and where future activity might be concentrated.

The licensing survey

Structured in three parts, the licensing survey first addressed different elements of the respondents' licensing practices and activities. Second, it addressed participation in collaborative intellectual property (IP) mechanisms and R&D activities. Third, it looked at licensing practices in CETs in relation to developing countries (non-OECD countries). The survey was carried out with the assistance of industry and business associations representing technology owners. The response rate amounted to 30 per cent of the organisations which were approached (160 key organisations responded).

Whereas overall there is little CET out-licensing activity towards developing countries among the survey participants, the general level of such activity is no lower than in other industries. Moreover, findings from other industries indicate that there are a number of hurdles to overcome in out-licensing due to factors such as the transaction costs involved, identifying a suitable partner and the right licensing conditions (i.e. pricing and the geographical or exclusive scope of the agreement). Indeed, the willingness to out-license is often much higher than the actual level of licensing. As the results of the present survey show, this trend seems to be even greater for CETs.

This overall difficulty with markets for licensing may create particular challenges in the case of CETs, where rapid diffusion is needed. Thus there is a need for improving market conditions and encouraging licensing in the context of efforts to enhance technology transfer to developing countries. For the time being, where licensing agreements have been entered into, the main beneficiaries are actors in China, India, Brazil and Russia.

The survey results also provide some useful insights as to the perceptions of technology holders in undertaking out-licensing activity. Generally, IP protection in the country of the licensee was an important consideration when determining whether to enter into a licensing agreement. However, IP protection in the recipient country was not found to be the only significant factor for licensing agreements in developing countries. Overall, respondents attached slightly more weight to factors such as scientific infrastructure, human capital, favourable market conditions and investment climates. However, licensing-intensive respondents attached somewhat greater importance to IP protection than to these other factors.

At the same time, 70 per cent of respondents said they were prepared to offer more flexible terms when licensing to developing countries with limited financial capacity. Notably, academic institutions and public bodies were slightly more willing than private enterprises to provide accommodating licensing terms to developing-country recipients. Small and medium-sized enterprises were slightly more likely than multinationals to offer more flexible terms. Another useful finding was that the majority of organisations favoured collaborative R&D activities, patent out-licensing and joint ventures over mechanisms such as patent pooling and cross-licensing.

Looking forward: a new patent classification for climate change mitigation technologies, and challenges ahead

In the context of establishing the patent landscape, the EPO developed and launched a new classification scheme for patents in climate change mitigation technologies, starting with CETs, which is now available on the EPO's public patent information service *esp@cenet*. The new scheme will provide continuous, accurate and user-friendly patent information and thus help to improve the transparency of the patent system in this critical technology sector.

While the report's findings are groundbreaking in many respects, there is a need to explore further areas of research in order to guide future action at the international level. One area where more information is needed is the demand side of the debate. Most studies, including this report, have focused on the supply-side perspective. A survey capturing the views of entities in the developing world seeking access to CETs is considered essential for a broader understanding of the issues at stake.

Future work and refinements should also be done on landscapes which identify patented inventions that have been commercialised in the marketplace. This would give a better idea of which technologies are working and inducing technological change. Further, a study of patenting by publicly funded institutions and universities would be important in helping to understand the source of new technologies and the role of government funding in their development.

Finally, this report concludes by identifying lessons learned which could help bridge the gap between evidence and policy-making, the raison d'être of this project. In this context, the report focuses on three main lessons: policy processes and signals do matter; accurate and publicly available information is urgently needed on existing and emerging CETs, including IP and licensing; and finally, options to facilitate licensing of CETs to developing countries should be considered.

Introduction

1 INTRODUCTION

The debate on technology transfer is not an issue that is new or exclusive to climate change. In the 1970s it acquired importance within international economic relations, with the negotiation of a draft International Code of Conduct on the Transfer of Technology (Patel et al., 2001). Already then, the role of intellectual property rights (IPRs) in technology transfer was a controversial issue (United Nations, 1975).

The interests and concerns surrounding technology transfer have since been a central theme of several multilateral discussions and agreements, most notably the Uruguay Round of trade negotiations which resulted in the establishment of the World Trade Organization (WTO) and the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). They have also been present in negotiations leading to a number of key multilateral environmental agreements, such as the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC).

The transfer of climate change mitigation and adaptation technologies to developing countries has been a permanent item on the agenda at all UNFCCC Conferences of the Parties (COP) meetings since the UNFCCC entered into force in 1994. As negotiations on means to enhance technology transfer in the UNFCCC context have increased in importance, so has the question of the role that IP can and should play. Polarised views have emerged on the issue, particularly since the UNFCCC meeting in Bali in 2007.

On the one hand, many developing countries and some non-governmental organisations (NGOs) have advocated the use and expansion of the flexibilities on IP available within the WTO TRIPS Agreement, such as compulsory licensing, arguing that this will help ensure greater access to climate change technologies. Arguments from the global debate on IP and public health are often referenced in their statements (Abbott, 2009). In contrast, many developed countries and business associations claim that only strengthened IP regimes will encourage the necessary innovation, transfer and diffusion of such technologies. This chasm in views is reflected in the heavily bracketed UNFCCC draft negotiation text on technology development and transfer, which emerged from the UNFCCC COP meeting in Copenhagen in 2009.[1]

Despite the importance attached to the role of IPRs in the transfer of climate change technologies to developing countries, it is only recently that empirical research has begun to appear on the issue. While this may be attributed to a variety of reasons, including difficulties in obtaining reliable data to track key technologies and their transfer, the absence of an evidence-based approach has fed into the rhetoric and stalemate in the climate change negotiations. In order to move away from the abstract to an evidence-based approach, there is an urgent need for greater empirical analysis.

[1] Paragraph 17, page 7, of UNFCCC FCCC/AWGLCA/2009/L. 7/Add. 3.

Cognisant of this challenge, this project included a patent landscape analysis[2] in order to obtain a better understanding of patenting activity and ownership for selected technologies and what these trends may mean for technology transfer in the area. However, it is already acknowledged that other IPRs, such as trade secrets, copyright, utility models, industrial designs and trade marks, also have an important role in technology transfer.

Therefore, to complement the analysis of patenting trends, a survey was conducted among private and public organisations to obtain further insights into how these organisations viewed the role of IP and other macroeconomic considerations in their decision-making process for licensing technologies. The survey was conducted with assistance from leading business associations.[3]

As with all studies of patenting trends, several methodological challenges had to be met.

With regard to terminology and definitions, a number of terms are commonly used to describe technologies that hold the potential for reducing waste and emissions, including greenhouse gas emissions, such as 'environmentally sound', 'environmentally friendly', 'green', 'clean', 'eco-friendly'. As the issue of climate change has gained prominence in political and public discourse, companies, and even whole industrial sectors, are adapting their business strategies. The use of these terms is now commonplace when characterising business practices and technologies associated with mitigating climate change.

There have been several collective efforts by international bodies, in particular by the IPCC and recently by the UNFCCC Secretariat, to identify technologies that may play a significant role in mitigating climate change. The UNFCCC and related documents generally use the term 'environmentally sound technologies' when referring to technologies that: protect the environment; are less polluting; use resources in a more sustainable manner; recycle more of their wastes and products; or handle residual wastes in a more acceptable manner than the technologies they replace.[4] They also often refer to the more specific case of technologies for mitigation and adaptation.

However, technologies, particularly in the energy generation field, do not always fall into simple categories. Although a technology may have a significant potential to reduce CO_2 emissions (compared with a given baseline), it may not be universally accepted as a genuine climate change mitigating technology. For example some 'clean coal' technologies reduce CO_2 emissions when compared with traditional coal combustion, but still contribute to greenhouse gas emissions.

[2] Comprising pending patent applications, as well as granted patents.
[3] Business associations that assisted with the licensing survey were the World Business Council on Sustainable Development, the Licensing Executives Society, the International Chamber of Commerce and the Fraunhofer Gesellschaft of Germany.
[4] Chapter 34 of Agenda 21 of the Rio Declaration on Environment and Development.

In view of the large number of technologies existing in the field, the study was limited to analysing patenting trends for selected technology domains. As part of the joint project, the EPO developed a specific taxonomy based on the technical attributes of technologies that have been loosely referred to as clean energy technologies (CETs). For the purposes of this study, CETs refer to those energy generation technologies that have the potential for reducing greenhouse gas emissions. Figure 01 provides a list of the categories of technologies covered in this study.

01 Selected CETs in this report

Solar photovoltaic (PV)
Solar thermal
Wind
Geothermal
Hydro/marine
Biofuels
Carbon capture and storage (CCS)
Integrated gasification combined cycle (IGCC)

This report does not intend to unpack the entire debate on IPRs and technology transfer. Instead, its intention is to present some findings from empirical research, ask more questions about the data gathered and provide direction on what future research is needed to bring greater clarity and understanding to policy decisions.

Aside from this Introduction (Chapter 1), the report is structured into the following chapters:

Chapter 2 examines the role of IPRs in technology transfer in general and as applied to environmentally sound technologies in the light of recent discussions at the UNFCCC and of recent literature. Particular attention is paid to recent empirical studies which have used patent data to show trends in the patenting and transfer of such technologies.

Chapter 3 describes the steps towards compiling the patent data, starting with the mapping of energy generation technologies. It provides an analysis of the patent landscape, covering the countries which are leaders in CET patenting, but also the dynamics of emerging innovation hubs. It also deals with trends in patenting inventions across several countries and between applicants from different countries. Furthermore, data on the trends in market concentration for each sector of the selected technologies is also discussed.

Chapter 4 describes how the first licensing survey on the subject was constructed and analyses the retrieved data. It highlights the extent to which respondents have entered into licensing agreements with developing country entities and the key factors influencing their decision to do so. The analysis also provides insights into how organisations view different licensing and collaborative mechanisms.

Finally, Chapter 5 summarises and recapitulates key findings in the study. It considers the methodology used to develop the new classification scheme created by the EPO for CETs and its importance for future studies on climate change mitigation technologies. Future pathways for research and data collection in order to further bridge the gap between evidence and policy are also considered. It also includes some policy implications and points to the most important conclusions and perspectives.

2
TECHNOLOGY TRANSFER, INTELLECTUAL PROPERTY AND CLIMATE CHANGE

2.1
General considerations

The technology transfer debate with respect to climate change has raised a number of familiar issues and recurrent questions in multilateral forums, including the need for a clearer understanding of what technology transfer entails.

In this respect, the IPCC has stressed that technology transfer encompasses the diffusion of technologies and technology co-operation between developed countries, developing countries and countries with economies in transition. The process involves learning to understand, utilise and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies (IPCC, 2000).

More broadly, the issue continues to be one of whether technologies and know-how are flowing from developed to developing countries to enable the latter to build their technological capabilities and compete in the global economy. In this context, in the early years of the debate, technology transfer was generally assumed to be the passing on of technology, resembling a typical transaction between buyer and seller. However, as the understanding of the issue has grown, it is now more widely accepted that the process is complex, multi-faceted and not without cost, and that tacit elements of the transfer and learning of new skills are essential components (Roffe, 2005). Technology transfer can, therefore, be described as the capacity to assimilate, implement and develop a technology, which ultimately leads to its consolidation in the receiving country (Foray, 2009). Closely connected to technology transfer is how such technologies and related know-how are adopted and diffused in the receiving country; this depends on a number of factors, predominately the state of the recipient country's knowledge system (Oyerlaran and Gelh, 2009).

More specifically, technology transfer takes place through: (1) market-mediated mechanisms, where some form of formal transaction underlies the technology movement, and (2) non-market mechanisms (Maskus, 2004). The former mainly include transactions involving trade in goods and services; foreign direct investment (FDI); joint ventures; licensing; and cross-border movement of personnel. The non-market or informal channels may comprise legitimate forms of imitation; departure of employees; data in patent applications; and temporary migration.

A significant amount of economic and legal literature exists on the role of IPRs in the development and transfer of technology across sectors other than those targeted in this study, e.g. the chemical, pharmaceutical, machinery and electronic equipment industries. The negotiation and adoption of the WTO TRIPS Agreement was an important milestone in the discussion, as the argument put forward at the time was that strengthened IPRs in developing countries would enhance technology transfer flows.

However, while it is generally accepted that IPRs play an important role in incentivising innovation, the evidence on whether or the extent to which it promotes technology transfer to developing countries remains inconclusive (Correa, 2005). On reviewing empirical evidence from various studies, Braga and Fink (1998) concluded that there was no conclusive relationship between IPRs and FDI decisions.

In this regard, the role of IPRs appears to be country- and sector-specific. Maskus et al. (2005) noted that, in sectors with low innovation and research and development (R&D) rates, a strengthening of patents shifts incentives at the margin towards investment and away from licensing. In contrast, in sectors with high innovation and R&D rates, there is a greater tendency to enter into licensing contracts than to take the FDI route. These findings suggest that the impact of strengthened IPRs in increasing licensing as compared with FDI may also depend on the innovativeness of the industries involved and the relative impact of patents on imitation costs and fixed costs of technology transfer. Therefore IPRs may be a barrier to transfer in emerging economies that pose a competitive threat. This is particularly true for IP-sensitive goods. Poor countries without significant ability to imitate or compete are likely to be of limited concern to technology developers (Maskus, 2000, and Maskus and Okediji, 2010).

In summary, the evidence and existing literature suggest that in the examined sectors, IPRs are one of many factors influencing firms' decisions to transfer technology to, or to invest in, a particular country. Therefore, it becomes apparent that the effects of IPRs and their strengthening are often dependent on their interrelationship with other factors, such as the size of the domestic market, the structure of factor supply, productive infrastructure and the degree of stability of the macroeconomic environment.

2.2
The climate change context

Technology transfer is an essential pillar of the UNFCCC, which calls on developed nations to promote technology transfer to developing countries to enable them to implement the various provisions of the Convention. Article 4.5 UNFCCC states that:

'The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organisations in a position to do so may also assist in facilitating the transfer of such technologies.'

Despite the expectations raised by the 1992 Rio Earth Summit and the signing of several multilateral environmental agreements, including the UNFCCC, the period that followed saw limited tangible progress in this area. It was principally marked by developing countries' continuous demands for the fulfilment of commitments on the transfer of and access to environmentally sound technologies.[5] The issue was again raised in the Kyoto Protocol, which sets out specific greenhouse gas reduction obligations for developed countries.

While developed countries pointed to the lack of enabling environments as a barrier to technology transfer and the need to protect IP to foster a licensing-friendly environment, developing countries viewed market mechanisms, such as CDM and IPRs, as contributing inadequately to the fulfilment of the technology-related commitments.

UNFCCC reports and bodies have, at regular intervals, taken up the role of IPRs in the context of technology transfer, as in the IPCC Special Report on Methodological and Technological Issues in Technology Transfer (2000), which addressed a range of issues in connection with challenges raised by IPRs.

In 2001, UNFCCC COP 7 established a framework for meaningful and effective action to enhance the implementation of Article 4.5 of the Convention.[6] Five key themes and areas were identified: technology needs and needs assessments; technology information; enabling environments; capacity-building; and mechanisms for technology transfer.[7] To assist with the implementation of Article 4.5, an Expert Group on Technology Transfer (EGTT) was established[8] in order to analyse and identify ways to facilitate and advance technology transfer activities.

In 2007, the Bali Action Plan adopted by governments at the UNFCCC COP 13 negotiations emphasised enhanced action on technology-related matters as one of the main priority areas to be addressed in discussions 'to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012.' The Bali Action Plan made reference to:

'Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of:

(i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies.'[9]

In the post-Bali period, IP-related issues surfaced as particularly controversial and divisive.

Negotiations leading to UNFCCC COP 15 in Copenhagen (2009) witnessed familiar disagreements and stalemates regarding technology transfer and IPRs. Although the Copenhagen Accord mentions the establishment of a technology mechanism to accelerate technology development and transfer, the question of the role of IPRs in the process is absent from the text.[10]

5 South Centre and Center for International Environmental Law, Intellectual Property Quarterly Update, Fourth Quarter, 2008.
6 Decision 4/CP.7.

7 Page 24, Annex to UNFCCC FCCC/CP/2001/13/Add. 1.
8 Decision 4/CP.7, paragraph 2.
9 Paragraph 1(d), page 4 of UNFCCC FCCC/CP/2007/6/Add. 1.
10 Paragraph 11, page 3 of UNFCCC FCCC/CP/2009/L.7.

2.3 Previous studies

Given that existing studies show that the importance of IPRs in technology transfer is sector- and country-specific, as evidenced above, it is necessary to understand how this relates to environmentally sound technologies, and specifically to the CET sector. This section provides a brief review of the key relevant studies that have emerged in recent years.

A UNFCCC report in 2006 on the priority technology needs and economic barriers to technology transfer for non-Annex I respondents (under the Kyoto Protocol, 37 industrialised countries are called 'Annex I countries' and have committed themselves to specific emission reduction targets) found IPRs to be a factor of minimum significance (Figure 02). Other factors, such as lack of financial resources, high investment costs, subsidies and tariffs were considered greater barriers to accessing technology.

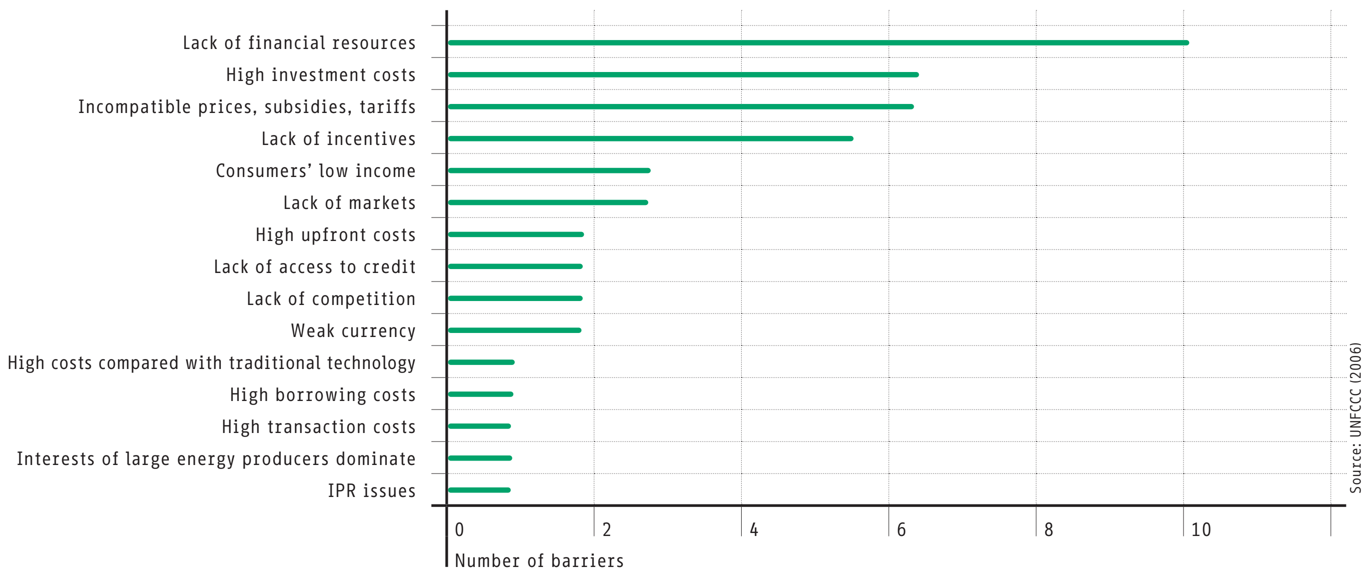
A study by John Barton for ICTSD in 2007 constituted one of the first efforts to address the role of IPRs in CET transfer using an evidence-based approach. The paper examined companies developing solar photovoltaic (solar PV), biofuel and wind technologies in Brazil, India and China, and concluded that IPRs are unlikely to be a significant barrier for these developing countries to access technologies in these sectors in the immediate future. Barton's reasoning was based on a number of factors. Unlike the pharmaceutical sector, the basic approaches to solving the specific technological problems in CETs have long been off-patent. Where IP issues may arise is with newer technologies being patented in solar PV and biofuels and a possible lack of competition in the wind sector due to the concentrated nature of the field. However, he concluded that even with possible competition issues, the availability of other competing technologies and traditional energy sources may only permit IPR holders to demand modest royalties.

Harvey (2008) identifies the importance of IPRs in attracting the necessary investment, innovation and diffusion to achieve a 'clean energy revolution'. He observes that most patents for CETs are not filed in least developed countries (LDCs), given their small market potential. Consequently, companies are free to use inventions in these countries.

While many commentators note that IPRs are unlikely to significantly affect access to the pertinent technologies, other studies suggest that the reality on the ground is more complex. In a study of wind power industry development strategies in India, China and Spain, Lewis (2006) found that developing country manufacturers often have to obtain technology from second- or third-tier wind power companies. This is because leading manufacturers are less inclined to license to would-be competitors. Lewis notes that the technologies obtained from the smaller companies may not necessarily be inferior to those provided by the larger manufacturers, but such smaller companies have substantially less operational experience.

The Energy and Resources Institute (2009) also revealed similar experiences amongst local companies in India, China, Indonesia, Malaysia and Thailand. The report cites examples in which local companies have terminated negotiations with licensors due to high royalty fees for licences or have incurred additional costs buying non-related equipment before accessing the desired technology. Watal (2007), citing the experience of Indian companies which sought technologies under the Montreal Protocol on Substances that Deplete the Ozone Layer in order to transition away from ozone-depleting substances (ODS), also found barriers, such as high costs or the reluctance of proprietors to license.

02 Economic and market barriers to technology transfer *



* By UNFCCC Non-Annex I parties

According to Hutchinson (2006), the overall effect of strong patent protection on the transfer of technology is not clear, and in some cases it is probable that the WTO TRIPS Agreement is an impediment to technology transfer. Hutchinson postulates that as the climate change regime evolves to increase the demand for new technologies, competitive impulses from the private sector may frustrate technology transfer through the refusal to license and the use of other kinds of restrictive business practices.

Ockwell et al. (2007), through a collaboration between the UK and Indian governments, conducted extensive literature reviews and case studies to assess the barriers to transfer of low-carbon energy technology between developed and developing countries. Case studies of companies, including in India, involved in developing technologies for coal gasification (including IGCC), LED lighting and biomass (including fuel supply chain issues, hybrid vehicles and combustion efficiency) were carried out. Based on the case studies, Ockwell et al. found that gaining ownership of or access to IP may be a necessary but not sufficient requirement for successful low-carbon technology transfer. Citing the example of the LED industry, case studies showed that without improved technological capacity, ownership of relevant IPRs would make little difference to India's ability to manufacture white LEDs. In relation to IGCC, the case study showed that the key barrier to transfer was not ownership of IPRs but rather a lack of knowledge of whether IGCC would work with low-quality Indian coal.

An area where the authors felt IPRs would not be a barrier was in hybrid drive-trains, as used in hybrid vehicles. Although subject to IPRs, where hybrid drive-trains have been supplied to countries (e.g. China) the IPR owners have trained engineers and mechanics in the recipient country. This passing on of knowledge and skills implies the potential for companies in recipient countries to develop their own technological capabilities. Ultimately, the authors noted that internationally collaborative approaches to low-carbon technology research and development may have an important role to play in overcoming obstacles to transfer of technology.

In the second phase of their study, Mallet, Ockwell et al. (2009) found that while consumers in developing countries may not experience specific IPR-related barriers to accessing low-carbon technologies, they may face a cost barrier because of IPRs. They also noted that IPRs seemed to be slowing down the rate at which Indian firms are able to develop commercial hybrid vehicle technologies without infringing existing international patents owned by industry leaders such as Toyota and General Motors. Indeed, the study found this to be the case where there were complex numbers of IPRs relating to single low-carbon technologies. Finally, the study recognised that trade secrets and tacit knowledge in general are equally as relevant as patents when it comes to understanding and acquiring knowledge-related technologies.

Cahoy and Glenna (2009) reviewed patenting trends in the US for ethanol in relation to biofuels. The authors assessed whether the biofuels sector would follow the trends that emerged in the analogous agricultural biotechnology field, where there was evidence of patent clustering followed by a few organisations privately ordering the landscape through consolidation. Based on their US patent landscape for ethanol-based biofuel technologies, the authors found that current patent ownership was diverse and ran the risk of patent excesses such as patent trolls and thickets[11] hindering technological development. However, the authors predict that, as with the agricultural biotechnology industry, there will be a consolidation of ownership between firms that will allow efficient commercialisation of technologies to exist.

Brown et al. (2008) conducted a literature search and interviews with experts from government, national laboratories, industry, universities and consulting companies to assess barriers impeding the commercialisation and deployment of pertinent technologies in the US. Their investigation looked at the role of IPRs, including anti-competitive patent practices and the impact on innovation in the field. The research found that many of the IPR barriers facing greenhouse gas reducing technologies do not hold equal weight, with some areas inherently contradicting each other. Notably, the study revealed that while small firms often cited the strength of current patent laws as a deterrent to innovation, multinational firms believed that domestic and international protection for IP needed to be strengthened. Ultimately, the authors found that the relationship between IPRs and technological development and diffusion was far from absolute.

11 The term patent troll is usually reserved for individuals or companies that enforce patents in an opportunistic manner where they do not have the intention of manufacturing or marketing the patented invention. Patent thickets (or clusters) are when a single company may file several patents around the same technology so as to make it difficult for competitors to design around a single patent.

While the above studies provide some evidence of the relative role of IPRs in the transfer of technologies pertinent to the UNFCCC debates, much of it is based on anecdotal, limited or partial practical information and patent data. However, more recently, a number of empirical studies have emerged incorporating more detailed patenting data on select technologies and their potential impact on technology transfer.

On the basis of the International Patent Classification (IPC) system, Copenhagen Economics (2009), as commissioned by the European Commission (Directorate-General for Trade), collected and analysed patent data relating to waste and biomass, solar, fuel cell, ocean, geothermal and wind power technologies. The data showed that only 0.1 per cent of the 215 000 patents filed in the 1998-2008 period were in LDCs.[12] However, a significant increase in patenting in emerging economies was found, the vast majority being sought in Latin America, eastern Europe, India and China. A third of all registered patents in emerging markets were owned by residents of those countries, with two-thirds owned by foreigners. China was the largest owner of patents in emerging economies for wind and solar technology, with Brazil having the largest percentage of patents in ocean technology. On the basis of this patent data, Copenhagen Economics concluded that IPRs were not the main barrier to the diffusion of technology and that healthy competition exists between technology holders. Instead, the report found that the presence of strong IPR systems, especially in emerging markets, is a prerequisite for western firms to be willing to transfer technology.

Also using the IPC system, Dechezlepretre et al. (2009) studied global patent data, from 1978 to 2003, for wind, solar, geothermal, ocean, biomass, waste-to-energy, hydropower, methane destruction, climate-friendly cement, energy conservation in buildings, motor vehicle fuel injection, energy-efficient lighting and carbon capture and storage (CCS). The data showed Japan to be the leading innovator country across all the selected technologies except biomass, where the US ranked first. The US had the second highest percentage of patented inventions for CCS, ocean and waste technologies. Germany ranked second for patented inventions relating to energy conservation in buildings, fuel injection, hydro, methane, solar and wind technologies. Notably, China featured as the second-ranked country for patented inventions relating to cement and geothermal. The Republic of Korea came in second for patents on lighting technology, with Russia third for CCS, cement and geothermal.

[12] It is not clear from the study's interchangeable use of the terms 'filed' and 'registered' whether the authors counted filed applications or granted patents. It is assumed that the patent counts in the study relate to filed applications.

According to the data presented, as of 2003, emerging economies accounted for 16.3 per cent of the patented technologies studied. Dechezlepretre et al. also attempted to show trends in technology transfer, using as a proxy indicator the share of inventions patented in at least two countries. Under this methodology and the widespread conceptualising of transfer, the authors found north-south transfers accounted for less than 20 per cent of all patents. For instance, patents filed in Japan were filed in other countries less than 20 per cent of the time.

Lee et al. (2009) presented data on global patent ownership of wind, solar PV, concentrated solar power (CSP), biomass-to-electricity, CCS and 'cleaner coal' combustion. Rather than relying solely on the IPC system, the methodology for the study also included Boolean search algorithms and assignee-focused searches. Behind the US and Japan, China was found to be the most popular destination for patent filings. With the exception of wind technology, multinational entities were shown to have the greatest share of the patents. However, the concentration of patent ownership suggested there was no lack of competition in the six technology areas reviewed. Further analysis of the origins of the top patentees by ranking in each energy sector showed for:

The wind sector	US, Germany, Denmark, Japan followed by the UK. Among the emerging developing economies, China was the top patentee;
Solar PV	US, Japan, Germany, the Republic of Korea and the UK. Again, among the emerging developing economies, China was the top patent holder;
Biomass	US, China, Germany, Japan and the Netherlands;
CSP	US, China, Germany, Japan and the Republic of Korea;
'Cleaner coal'	US followed by China, Japan, Germany and the Republic of Korea;
CCS	US, Canada, Japan, Germany and the Netherlands.

Lee et al. also studied the co-assignment of patent holders as a proxy for understanding technology diffusion. Their dataset showed that most collaboration took place between entities from countries within the Organisation for Economic Co-operation and Development (OECD). Collaboration between entities from OECD and non-OECD countries represented only two per cent of the dataset. Notably, collaboration was most common between multinational entities.

Cullen (2009) analysed patenting trends in wind, solar and marine energy technology using the Derwent World Patent Index. The study looked at the contributions of large and small commercial entities, as well as government-funded bodies. The findings indicated that smaller commercial entities had the largest share of patents in the US, Germany, China, the UK and the Republic of Korea. In the three technology areas studied, a large number of entities were

filing patents, indicating healthy competition. Patenting by public and academic institutions was shown to be strong in China, the UK and the Republic of Korea. The data showed that the highest number of filings for patents on wind, solar and marine were in Japan, US, China and Germany. India featured in tenth place. Overall, the study demonstrated that there was considerable patenting activity in the three technology areas, suggesting incremental innovation and overlap between inventors.

Johnstone et al. (2010) investigated patenting trends in the light of environmental policies using patent counts generated through the OECD Patent Database and the IPC. Only patent applications filed at the EPO between 1978 and 2003 were used for the study. The results showed patenting trends in the fields of solar, wind, ocean, geothermal and biomass waste, with wind and solar having the highest counts. Based on filings at the EPO as of 2003, patents filed by German applicants showed the highest counts, followed by the US, Japan, France and the UK. Based on the patent counts over the period studied, Johnstone et al. reviewed the effects of public policies in various countries on patenting rates. The data showed that wind power activity demonstrated rapid growth in the mid-1990s. Patenting in ocean energy was also shown to be a high-growth area, but there was little growth in the areas of geothermal and biomass/waste-to-energy. Notably, it was shown that the signing of the Kyoto Protocol in 1997 had a positive impact on patent activity with respect to all the technologies studied, in particular in wind and solar power.

As the above literature review shows, most of the studies and empirical research on the role of IPRs in the transfer of technologies which are relevant to the UNFCCC process have been conducted in the past five years. The evidence to date comprises a mixture of theoretical assessments, case studies and patent data on specific technology areas.

Unsurprisingly, and in line with the most general trends, most of the evidence to date on whether IPRs, in particular patents, will impact technology transfer to developing countries remains inconclusive.

However, what is apparent from the studies that include analysis of patent data, e.g. Lee et al. and Dechezlepretre et al., is that in the areas of wind, solar, ocean, biomass and CCS the origins of applicants with the most patents are in OECD countries. Depending on the methodology used by the studies and the particular technology sector, the ranking order of countries as leading patentees tends to alternate between the US, Japan and Germany. Interestingly, whereas Lee et al. show the US as being ranked in the top place for patent filings in wind, solar, biomass and CCS, Dechezleprete et al. have Japan as the leading place of origin for patenting in those technologies (with the exception of biomass, where the US is the leading inventor country). Notably, whereas Lee et al. show China as the country with the second most patentees in biomass, this is not shown to be the case in the study by Dechezlepretre et al. However, both studies show that China is an emerging country in terms of patent ownership in selected technologies.

Of the studies conducted using patent data, Copenhagen Economics is the only one that specifically looks at patenting trends mainly in LDCs. According to Copenhagen Economics, because there are so few patents filed in these countries, IPRs should not be a barrier to technology transfer.

The Lee et al. and Dechezlepretre et al. studies attempt to use patent data to measure technology transfer and diffusion. While Dechezlepretre et al. use patents filed in more than one country as an indicator of technology transfer, Lee et al. take patent applications where more than one organisation is listed as an owner as an indicator of diffusion.

While these methods may provide some indicators of technology transfer, they are subject to numerous limitations. For example, patents filed in more than one country may not necessarily result in the technology actually being licensed or assigned to a local partner or becoming available in that country until after the patent expires.

Notably, all the studies to date have used the IPC system to classify technologies, supported by additional keyword searching. However, as will be explained below, use of the IPC alone also has its limitations. Moreover, the patent counting methods used in the various studies discussed can be problematic. For example, one study on the top patent-filing locations includes applications filed through the WIPO-PCT system. However, as many PCT applications will often designate the EPO or other member states, it is open to question whether the same applications are featuring in more than one place.

Aside from the studies relying on patent data and using the information to measure technology transfer, most evidence to date comes from limited case studies. Studies by Ockwell et al., the Energy Resources Institute and Lewis all suggest that companies from developing countries are facing some difficulties in obtaining technologies, whether it is the high cost of licensing or having to obtain technologies from second-tier technology holders. However, all of these studies note that there is a degree of technology transfer taking place in the market, though in a very limited number of developing countries, especially China and India.

Although the above studies have contributed useful and much needed insights into trends in patenting and evidence of technology transfer, numerous gaps in the evidence landscape remain. It is the objective of this study to take an important step forward by filling at least some of these gaps in the specific technology areas that the report considers.

3
TECHNOLOGY MAPPING AND THE PATENT LANDSCAPE

3.1 Mapping clean energy technologies

To conduct the patent landscaping exercise, it was first necessary to carry out an in-depth study of the various CETs in the marketplace or under development. This is relevant to a major challenge faced by patent landscaping studies to date, viz. the limited ability of patent classification systems to correlate accurately and comprehensively with CETs.

To avoid this potential pitfall, ICTSD, with UNEP's support, commissioned a study undertaken by the Energy Research Centre of the Netherlands (ECN) to map both mature and emerging CETs (Lako, 2009). The study drew upon the technology categories within the energy supply sector identified by the IPCC (2007), providing an assessment of existing and potential technologies for mitigating climate change. This mapping study was sent for further peer review to the lead authors of the IPCC Working Group III Report (2007b) and to a number of other experts from relevant international organisations, academia and the private sector.

The study identified several renewable energy technologies which are commercially available or have strong prospects of commercialisation in the near-to-medium term. Technologies are assumed to be commercially available if they are mature or if they are in the pre-commercial stage after having been demonstrated. This definition is meant to provide a demarcation from technologies that are currently not mature, or are expected to become commercially available about five to ten years from now. However, this demarcation is not always straightforward. Some technologies may be at the demonstration stage, but are hampered by economic feasibility and may therefore not be commercially available in the short term. Other technologies may not yet be considered commercial or sufficiently demonstrated and still turn out to enter the commercial stage within a couple of years.

The six main categories of renewable energy technologies examined in the study were:

- Solar energy, which is broken down into solar thermal power, solar heating and cooling, and solar PV
- Wind energy, which is broken down into onshore and offshore wind energy
- Ocean energy
- Geothermal energy
- Hydropower
- Biomass

The mapping study provides an overview of each technology category, identifies its sub-categories and indicates their degree of maturity. Its findings can be summarised as follows:

CSP or 'solar thermal power' has been around for about 25 years (with a combined capacity of approximately 400 MWe) and is just now gathering momentum as a 'new' renewable energy technology. There are two technologies that are relatively mature: solar trough and solar tower systems. The most mature is solar troughs, with a maximum (peak) efficiency of 21 per cent (conversion of direct solar radiation into electricity). Two other technologies are less mature: solar dish (based on the Stirling engine) and Fresnel lens-based CSP.

Solar heating and cooling in the built environment, particularly for hot water in dwellings and offices, is becoming a mainstream renewable energy technology. It can reduce the amount of fossil energy needed for water heating by 40 to 50 per cent. The maturity of this technology is demonstrated by steady growth in collector area in both industrialised countries (e.g. the European Union (EU), which mainly uses flat-plate collectors) and developing countries (e.g. China, which mainly uses evacuated-tube collectors).

Solar PV is used for grid-connected systems and off-grid systems. PV is based on photovoltaic modules (based on PV cells), the rest of the system being made up of an inverter, a battery, electronics and other components. PV is experiencing high growth rates in Europe, Japan and the US. As a consequence, costs are in general coming down correspondingly. The technology is also becoming more diverse, with various options using silicon, thin-film and other forms of PV cells. Developing countries, including emerging economies like China and India, are becoming significant producers of PV cells and modules. Expansion is running at around 30 per cent per year in developing countries, mainly in rural areas where electricity from the grid is either unavailable or unreliable.

Wind energy is now a mainstream technology. Wind turbines consist of various components such as blades, gearbox, generator, etc. There are several 'multinational' wind turbine manufacturers, but also a number of manufacturers with a more regional (e.g. European) scope. The production of wind turbines and wind turbine components is becoming more international, with two Chinese and one Indian manufacturer in the global 'top 10' based on commercial production capacity. Know-how with regard to (onshore) wind turbine manufacturing is spreading fast. With regard to offshore wind, much experience exists in a number of European countries. In addition, the US and a number of countries in south-east Asia are developing offshore wind farms.

The potential for energy generation from ocean energy technologies is huge, although the economic potential is still modest. Wave power and tidal stream power technologies are entering the commercial stage. At least four wave power technologies are being developed and demonstrated in EU countries with medium-term prospects of commercial application. Beside tidal range power (based on a barrier) which is already relatively mature, there are at least three tidal stream power technologies in stages of R&D and demonstration. These technologies are likely to become commercial in the same timeframe as wave power.

For geothermal energy, there are three main applications: power generation, direct heat and ground-source heat pumps. Commercial geothermal power plants range from those based on dry steam to the organic Rankine cycle. Concepts relating to deep geothermal heat and small-scale applications are under development, with prospects for rapid commercialisation. Direct use of heat for buildings and industry is a commercially viable technology. Ground-source heat pumps (using shallow geothermal heat) are experiencing fast growth and cost reductions.

With regard to hydropower, a distinction is made between large (>10 MWe), small (1-10 MWe), and micro (<1 MWe) hydropower. Hydropower is commercial (approximately 19 per cent of global electricity generation comes from it), although there is still significant development potential for micro hydro. Large hydropower turbines and other components are manufactured mainly in Europe, the US, Canada, China and India. The manufacturing base for small hydropower turbines is broader, encompassing the OECD, the former Soviet Union, China, India, Brazil and others. In developing countries, however, hydro is expected to be the fastest-growing renewable energy source.

Biomass is currently the most important renewable energy source in terms of primary energy supply on a global scale. There is much experience with commercial medium- and large-scale biomass-based combustion systems to produce power or heat and combined heat and power. Also, gasification systems for power and combined heat and power are developing into the commercial stage, at least on a medium scale, and are being used in industrialised and developing countries alike. As these applications increase, the technologies become more competitive, with biogas being used for small-scale power generation. In addition to more or less established biomass applications, the production of so-called first-generation biofuels mainly for transport (vehicles) is gaining momentum in numerous countries around the globe. Some technologies offer prospects of becoming main second-generation technologies for biofuels, making use of ligno-cellulosic biomass, though these remain mainly at the R&D stage with some pilot-plant and pre-commercial scale demonstrations in place or under development.

As shown by these findings, a large number of commercially available renewable energy technologies are showing high growth rates and corresponding cost reductions.

However, there are several renewable technologies that are largely at the R&D stage and have not yet been demonstrated on a commercial scale. But for many of the following technologies commercialisation in 5-10 years from now may be expected:

- Solar heating with seasonal storage (in shallow underground) and solar cooling
- PV systems based on modules with nanotechnology-based PV cells
- Floating offshore wind
- Ocean thermal energy conversion
- Salinity-gradient-based power
- Small-scale geothermal power
- Hot dry rock geothermal power
- Biomass integrated gasification combined cycle
- Biomass pyrolysis
- Biomass torrefaction
- Cellulosic ethanol
- Second-generation biodiesel and algae
- Dimethyl ether from biomass
- Biorefinery

Concerted action by governments and private companies at the research, development and demonstration stages may shorten the time until commercialisation of the technology.

Technologies related to electricity storage, which may become important for renewable electricity generation, are at different stages of development, demonstration and market introduction.

Annexes 1-3 provide an overview of the CET mapping study.

3.2
Data mining and quality

Based on the findings of the technology mapping study, the EPO developed a list of approximately 50 technical fields related to CETs, which includes technology and application sectors as well as appropriate apparatuses and components (such as turbine blades, rotors, etc.). Further, to ensure consistency, feedback on the definition of these fields was sought and received from outside experts, as well as from the OECD Environment Directorate, which has conducted similar analyses. The full list of technology fields identified is presented in Annex 4.

Using this new taxonomy, the EPO reviewed 60 million patent documents and reclassified patents according to 50 technical categories related to CETs, such as solar photovoltaics and geothermal. Some 400 000 patent documents matching these criteria were retrieved worldwide. For the final data extraction and grouping according to the defined indicators, the EPO/OECD Worldwide Patent Statistics Database (PATSTAT) was used.[13] The international coverage of the patent data is presented in the following box.

The EPODOC (EPO DOCumentation) database contains references to patent documents which make up the systematically classified search documentation of the EPO. The documents consist of published applications, granted patents and classified non-patent literature. The EPODOC database essentially corresponds to the DOCDB database, which is the internal EPO master file used for management of the search documentation. The bibliographic data (i.e. the publication, application and priority numbers and dates, the IPC classes, the inventor and applicant data and the title) is available for patent documents of most countries or other patent authorities.

Detailed information can be found under:
www.epo.org/data

[13] PATSTAT is a snapshot of the EPO master documentation database (DOCDB) with worldwide coverage, containing 20 tables including bibliographic data, citations and family links. This database is designed to be used for statistical research and requires the data to be loaded into the customer's own database.

Once the data mining had been completed, the data set was shared with the OECD Environment Directorate in order to check the quality of the information retrieved. To check the inclusiveness of data, a further quality check was carried out for CCS technologies, as patent data related to these technologies had been gathered by US experts independently of this project.

More details about how the EPO undertook the data mining and developed a new classification scheme in this field are given in Chapter 5.

The OECD Environment Directorate applied the concept of 'claimed priorities' for counting patent numbers. Claimed priorities in this context refers to patent applications that have been filed in other countries based on the first filed patent for a particular invention. Using data on patent families (priority and equivalent patents),[14] the OECD identified the relevant patent applications from the data pool provided by the EPO. It also constructed frequency counts of claimed priorities deposited at patent offices worldwide, taking into account priority date (based on the first application filing date worldwide), application authority and inventor country.

3.3
Major technology trends[15]

The past two decades have witnessed the internationalisation of the patent system and an increase in the rate of patenting in most technology areas.[16] International agreements such as the WTO TRIPS Agreement and the WIPO PCT have contributed to this development.

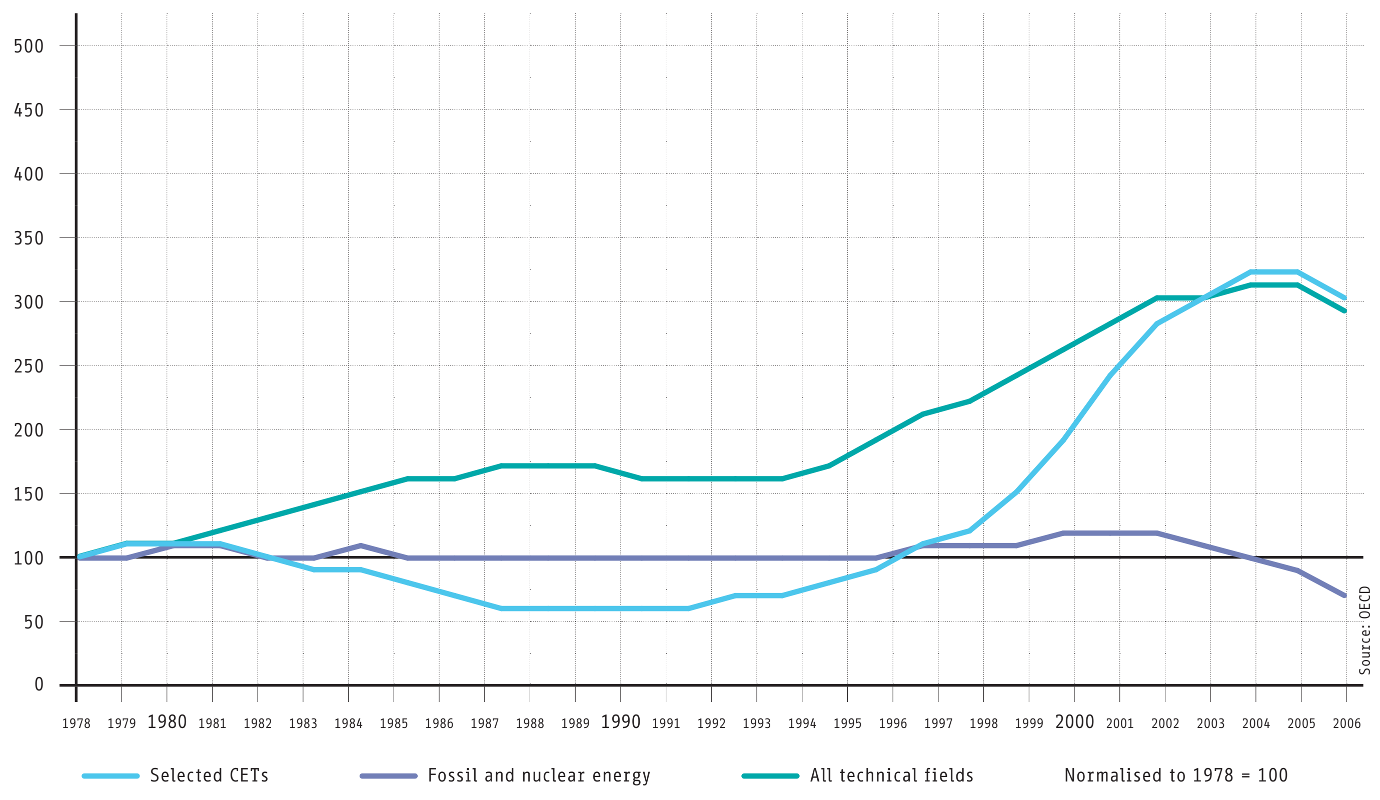
Figures 03 and 04 show the patenting trends for selected CETs. The ordinate in these figures represents the number of claimed priorities normalised to 1978 (value = 1). The 'TOTAL' for all technical fields refers to the entire stock of corresponding claimed priorities contained in PATSTAT.

Figure 03 reveals that the general patenting trends mentioned above prevailed also for the case of the selected CETs, which - following a period of stagnation, even of relative decline, until the mid-1990s - have seen a rate of increase sometimes in excess of 20 per cent per annum.

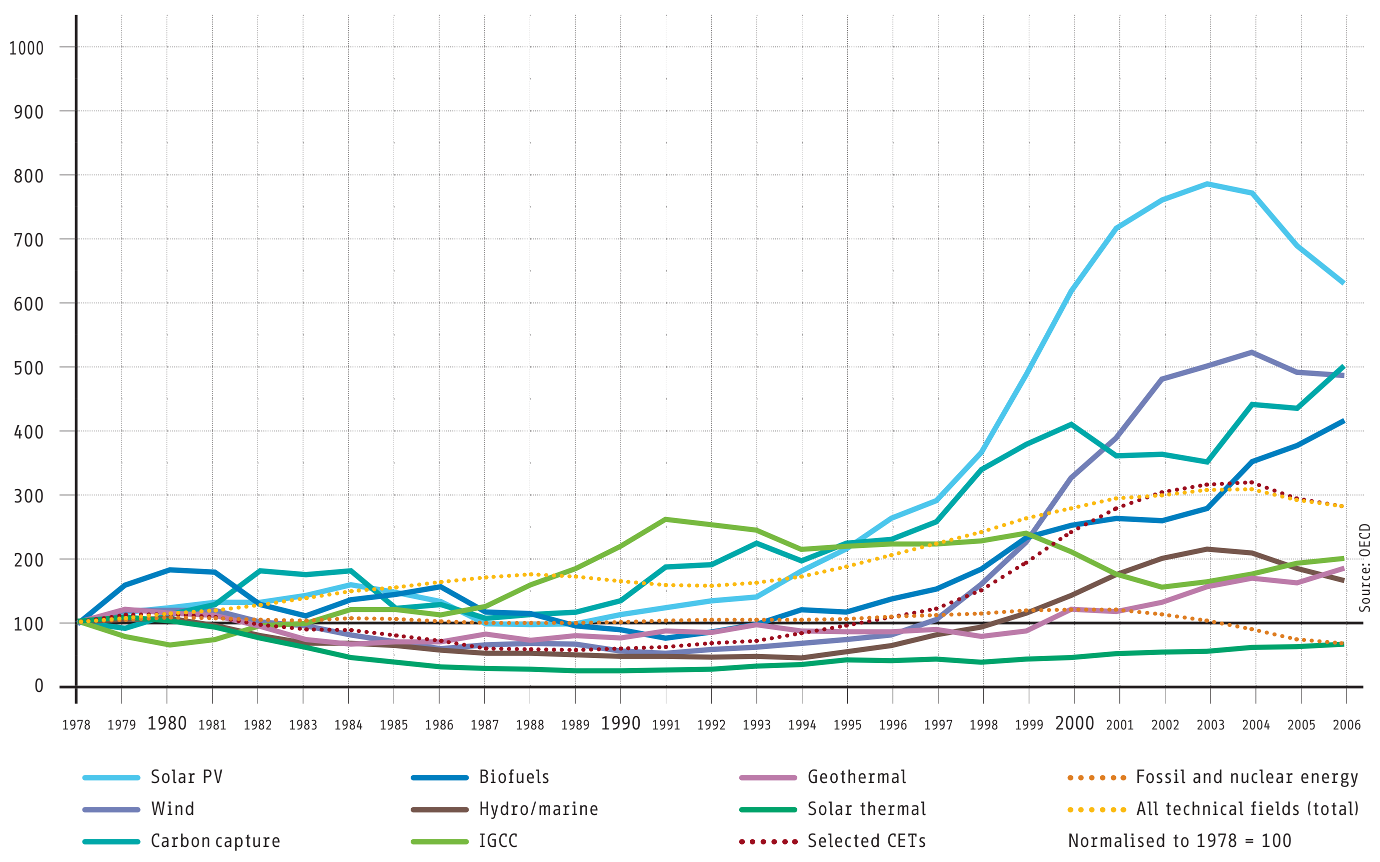
[14] For the purpose of this study equivalent patents were those with the same priority(ies) and claims.
[15] To understand the figures, note that for the purposes of the analysis the terms 'patents' and 'patenting' are respectively equivalent to 'claimed priority patents' and 'claimed priorities patenting' (or simply 'claimed priorities'). Generally, the ordinates of the graphs refer to the number of 'claimed priority' patent documents retrieved in the examined field (as either absolute or normalised values). Further, the statistical method used to calculate the data for each year is the moving three-year average. As an example, that means that the data for the year 2000 is calculated as the average of the years 1999, 2000 and 2001.[0]
[16] World Intellectual Property Organization, World Intellectual Property Indicators, 2009, available at http://www.wipo.int/ipstats/en/statistics/patents/.

Technology mapping

03 Aggregated growth rate of CET claimed priorities patenting



04 Growth rate of claimed priorities patenting for the selected CETs



Notably, when measured against the rate of patenting in traditional energy fields such as fossil fuel and nuclear, inventions relating to CETs are significantly higher. Indeed, for the past 20 years the rate of patenting in fossil fuels has remained stagnant and has even been decreasing since 2001. Another noteworthy point from Figure 03 is that from around 2001-2002, patenting rates in the CETs selected for this study have been on a par with filing activity in all other technology areas. This indicates that actors in the CET field are as active as other industries in terms of using the patent system to protect their inventions.

The downward trend around 2004, which is visible also in other figures in this chapter, is partly due to the statistical method (moving three-year average) used to calculate the data for each year. Moreover, between the first filing of a patent application and its family member in another country there is usually a time delay of one year, and not all potentially relevant patent applications were captured by the end of the period examined.

Breaking the data down further for each of the CETs studied, patenting rates in solar PV, wind and carbon capture have shown the most activity in the past ten years (Figure 04). Patent activity in the areas of hydro/marine and biofuels has shown the second highest increase of all the CETs studied. Notably, all these areas (biofuels more recently) have shown increased activity compared with patenting and innovation in all technology fields. Patenting in IGCC increased for a short while around 1986, but has since ebbed and flowed. Of all the CETs studied, patenting in solar thermal has not seen any relevant detectable growth since 1978.

The dominant patenting activity in the areas of solar PV and wind suggests that these technologies are extensively used in the marketplace. Indeed, based on the findings from Phase I of the joint project (the technology mapping), it is noticeable that solar PV is already partially deployed in the field and is showing rapid growth. Indeed, according to findings from Phase I, wind energy is largely in commercial use and showing rapid commercialisation. Hydro/marine energy is shown to be at the stage of deployment, demonstration or R&D, which might indicate why patenting activity there is not as prominent as in solar PV and wind.

3.4 Leading countries

Breaking the data down even further, Figure 05 shows the countries with the most patenting activity (counting numbers of claimed priorities) in the selected CETs.[17] Japan is far ahead with the most patenting activity based on claimed priorities. The US and Germany are close together in second place, with the Republic of Korea showing a considerable increase in recent patenting. The UK and France complete the top six patenting countries in the selected CETs.

Although not in the same particular order as shown in other studies discussed in Chapter 2, the data provided in Figure 05 confirms that a few OECD countries dominate the field of CET patenting.

A closer analysis of the patenting activities of a larger sample set of countries in eight different CET categories was made using aggregate numbers of claimed priorities. For comparative purposes, claimed priorities were counted also for traditional fossil fuel and nuclear energy.

The data revealed that on aggregate, Japan has almost twice as many patents for all eight selected CETs as the US, which occupies the second place. Japan is by far the most dominant country in terms of patenting in solar PV technology. However, Japan's total patenting in traditional fossil fuel and nuclear technology still exceeds its patenting activities in CETs.

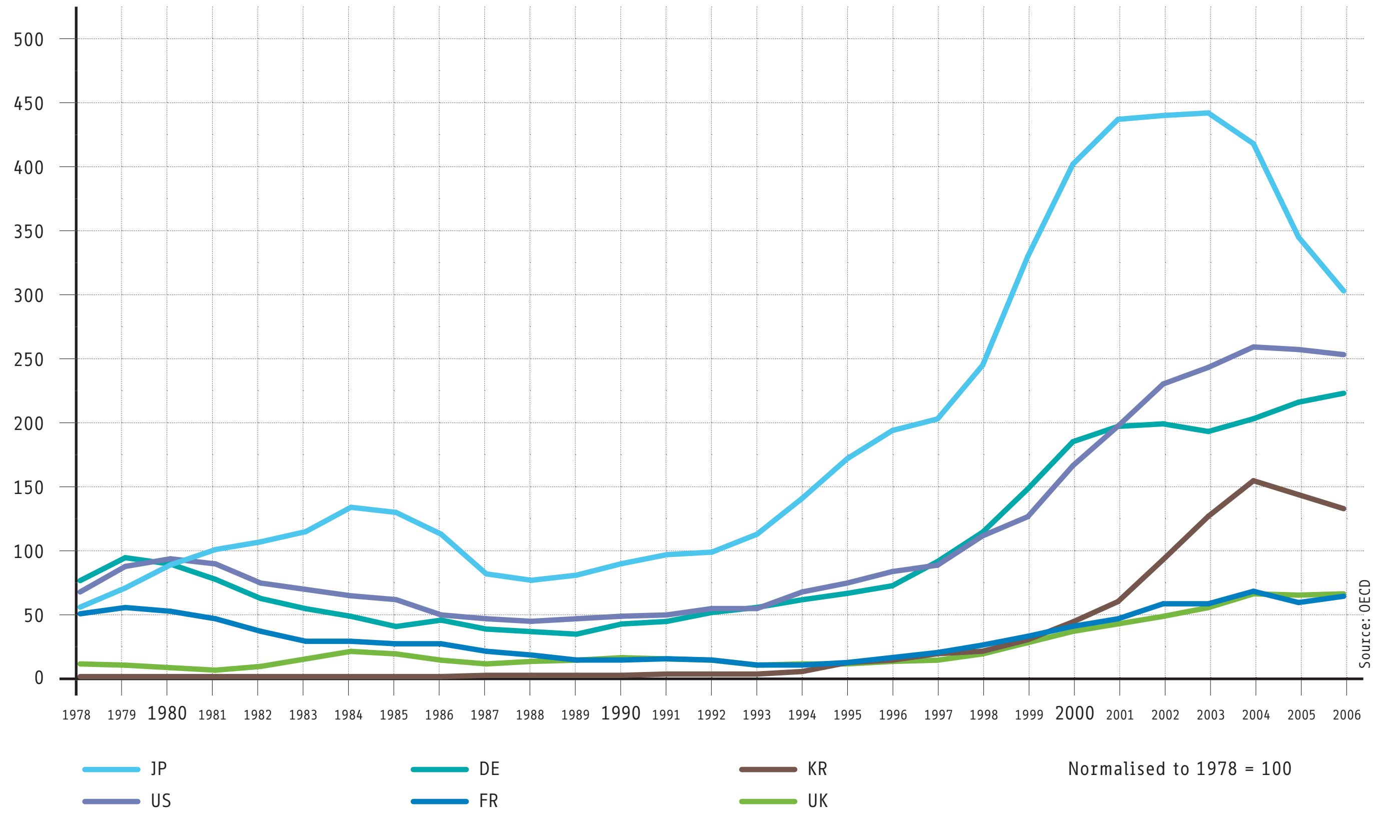
The US on the other hand has patent activity more evenly spread across all fields, with significantly more activity in solar PV followed by hydro/marine. Notably, with the exception of solar PV, the US has higher numbers of claimed priorities in all the other technology areas. However, the total number of US claimed priorities in fossil fuel and nuclear energy is double those in the selected CETs. Indeed, Germany, France and the UK also have higher numbers of claimed priorities in fossil fuel and nuclear energy.

Germany leads the way in wind technology patenting, with over twice as many counts as the US and three times as many as Japan. Other areas where Germany shows strong patenting activity are solar PV, solar thermal, hydro/marine and biofuels. The areas of least activity for Germany as an inventor country are carbon storage and IGCC.

Breaking into the top five developed countries of Japan, US, Germany, France and the UK is the Republic of Korea. The Republic of Korea's patenting focuses largely on the area of solar PV, with little activity in the other fields. In contrast to the other leading patenting countries, the Republic of Korea's patenting in CETs is higher than in fossil fuel and nuclear energy.

[17] It should be borne in mind that there is likely to be a bias towards the inclusion of documents filed at the EPO, as ECLA classification codes were used for the searches. Also, the keyword searches picked up titles and abstracts in English only, so some patents from Japan may not have been picked up.

05 Countries leading patenting activity in CETs



Of the emerging economies, China has the highest number of claimed priorities in CETs, predominantly in the area of solar PV. However, what is noticeable from the patent data is that Chinese companies have very little patenting activity in the area. Indeed, this trend is repeated with respect to the leading Chinese wind turbine manufacturers. This suggests that while such companies are leading manufacturers and producers in the field, they are not holders of a significant amount of technology. Either they may be heavily reliant on technology transfer to develop their products or they are largely manufacturing-based.

A similar story can be told for India, which appears just outside the top 20 patenting countries for aggregate activity in all eight CET categories. Patentees from India show the highest activity in solar PV. Most noticeable is that in the area of wind power, patentees of Indian origin have little activity. One explanation for why Indian companies do not show a higher patenting rate in this area is that the few patents recorded were filed in the name of foreign subsidiaries. The pertinent question that arises here is whether Indian parent companies still license these technologies. Further research on corporate structure and IP ownership would be required to better understand how technology transfer works under such circumstances.

The main patenting activity for Brazil lies in the area of hydro/marine and biofuels. However, compared with the rate of patenting in the leading countries, activity here is rather limited. For example, China has more patents for biofuels and as many patents in the area of hydro/marine as Brazil. In the various categories for hydro/marine, the data shows a number of actors filing between one and two claimed priority patents. This suggests that the area of hydro/marine is not concentrated in a few companies in Brazil. Considering that Brazil is an ethanol-producing country, it is somewhat surprising that Brazilian companies register relatively few patents. Again, this suggests that Brazilian companies are focused more on the production process than on developing technologies for biofuels. This also raises the question of whether Brazilian companies are dependent on technology transfer in the area of biofuels.

For further details of patenting trends in different countries across selected CETs, see Annex 5.

3.5
Country comparison and innovation hubs

When examining relative performance, i.e. comparing patenting activity with respect to a benchmark, a more differentiated picture emerges. For instance, when normalising the data as a percentage of the total number of claimed priorities (all technology sectors) in a given country, a number of countries which did not appear to be significant innovators in terms of absolute numbers show significant activity.

In the photovoltaic sector, this is the case for countries like Thailand, Greece, Chinese Taipei and the Republic of Korea. Also according to this type of comparison, China does not feature in the top five patenting countries, despite having one of the largest producers and manufacturers of solar PV.

In wind technology, Denmark has the highest percentage share of claimed priority patents, followed by Thailand, Spain, Ukraine and Greece. Again, patentees from India do not figure highly, despite having one of the leading producers and manufacturers. Also of note is that wind technologies do not figure so high in terms of percentage share of patenting for Germany, whereas it had the highest absolute claimed priority patent numbers.

In the hydro/marine sector, Brazil features as the fourth highest patentee in percentage terms. Portugal and Norway occupy the top positions.

In biofuels, Ukraine has the highest percentage share. This is surprising considering that previous studies have not recognised companies from the Ukraine as being active in the field. Notably, Brazil appears in second place in terms of percentage share. This is in contrast to the overall claimed priority patent numbers data discussed above, where Brazil did not feature so highly. While this suggests that Brazil may be more active in patenting biofuels technology than suggested in the overall counts, it indicates that while not a dominant actor in the field, it is an emerging one.

Annex 6 provides further details on the percentage share of claimed priorities in each selected CET sector per country as compared with the overall number of claimed priorities in the respective country for the period 1988-2007 (average values).

A clearer breakdown of how the top-ranked countries fare in each CET sector is provided in Figure 06. Japan holds a top-three ranking across all CETs. The US features in the top-two rankings for all CETs and Germany in the top four. Finland is one of a few smaller countries breaking into the top five for IGCC. Notably, despite having some of the leading manufacturers and producers in the fields of solar PV and wind technology, India and China do not appear in the top five rankings. Indeed, this table confirms that in key renewable energy technologies the OECD countries are the dominant technology holders. What is also interesting is that the above data reflects similar trends when compared with the total patent filings for all technologies by country (WIPO, 2009). The key exception is that China features in the top five countries in terms of total patent filings, whereas that is not the case for CETs. Also, the Republic of Korea ranks in third place for total patent filings in all technologies, with Germany in fourth.

Consolidating the data of the top five inventor countries, Japan, Germany, the Republic of Korea and France account for almost 80 per cent of all claimed priority patents in CETs worldwide (Figure 07; please note that the attribution of ranks 1-5 to the different countries varies from one selected CET sector to another, as indicated by Figure 06). Solar PV is the CET category with the highest concentration, the top five countries accounting for 87 per cent of all worldwide claimed priority patents in this sector, with Japan responsible for almost half of them. As already intimated above, this indicates that although countries like India and China have leading producers in the field of solar PV, they do not feature strongly as technology proprietors. The least concentrated field is geothermal, with just over 60 per cent of claimed priorities coming from the top five countries, and 20 per cent from the US as the top inventor in the field.

To better understand country specialisation in the various CET sectors for selected countries, the percentage share of claimed priorities in a particular field against all CET claimed priorities was studied.

The data showed that while some countries have a high overall percentage in one field, they barely register in others. Solar PV is the most concentrated area of all the CETs. Singapore sits in second place behind the Republic of Korea in terms of specialisation in solar PV. India features in the top five countries specialising in both solar PV and carbon capture. Brazil and Mexico share the top and second rank in the percentage share for hydro/marine. Ukraine surprisingly occupies the top position in biofuels, with Finland in second place. Aside from Japan and the Republic of Korea in solar PV, and the US and France in carbon storage, none of the top-ranked countries feature in the top five positions when it comes to the percentage share of claimed priorities in the selected CET fields.

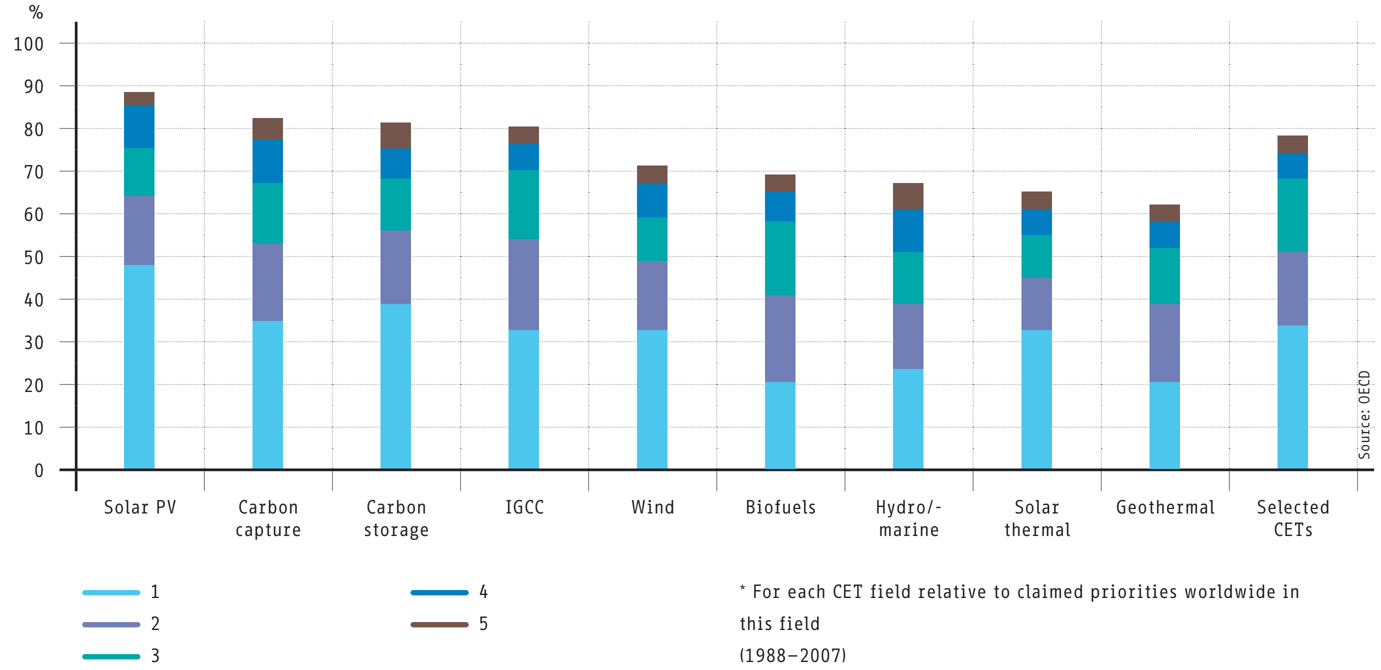
The ranking of countries in terms of their worldwide share of claimed priorities has changed over the last three decades. Germany's activity in wind has outstripped other leading countries since 1998, while its involvement in carbon capture and IGCC has decreased significantly. In the area of geothermal technology, Germany started off patenting strongly, then saw a decline, before a resurgence in the last ten years.

06 Ranking of top patenting countries in selected CETs (1988-2007)

	Selected CETs	Solar PV	Solar thermal	Wind	Geo-thermal	Hydro/-marine	Biofuels	Carbon capture	Carbon storage	IGCC
JP	1	1	3	3	3	3	3	2	3	2
US	2	2	2	2	1	1	1	1	1	1
DE	3	3	1	1	2	2	2	3	4	3
KR	4	4								
FR	5	5	4			5	4	4	2	
UK	6					4	5	5	5	4
IT	7		5							
CA	9				5				5	
DK	12			4						
ES	13			5						
AT	15				5					
SE	16									5
NO	17								5	
FI	19									5
IL	19				4					

Source: OECD

07 Proportion of claimed priorities of top five inventor countries *



* For each CET field relative to claimed priorities worldwide in this field (1988–2007)

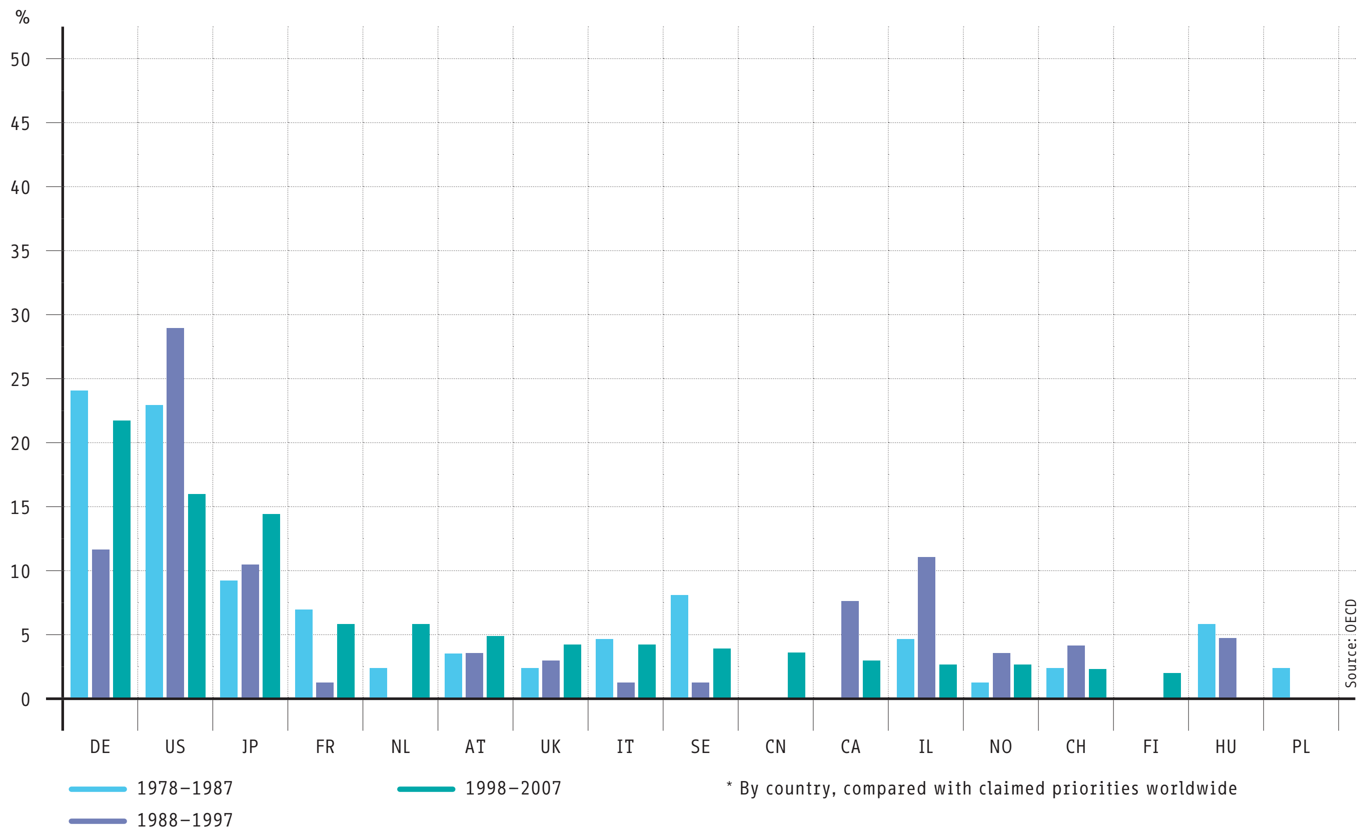
Since 1998, Japan has become more active in wind and geothermal technology. In the area of solar PV, their rate of patenting has declined, but still outstrips all other countries.

Of particular note is the emergence of China since 1998 as an innovation hub in the fields of geothermal, solar PV, wind, carbon capture and IGCC. In geothermal technology China has made a significant entry into the field, virtually matching the patenting rates of the UK, Sweden and Italy. If these trends continue, China is likely to emerge as a key patenting country in these fields.

India on the other hand does not appear to be emerging to the same extent. Of all the technologies discussed above, solar PV is the only field where India shows any activity. Interestingly, the patenting rates in solar PV by Indian companies between 1998 and 2007 are the same as between 1978 and 1987. This trend in patenting between 1978 and 1987 probably reflects the fact that the Indian government started a solar PV programme in the mid-1970s.

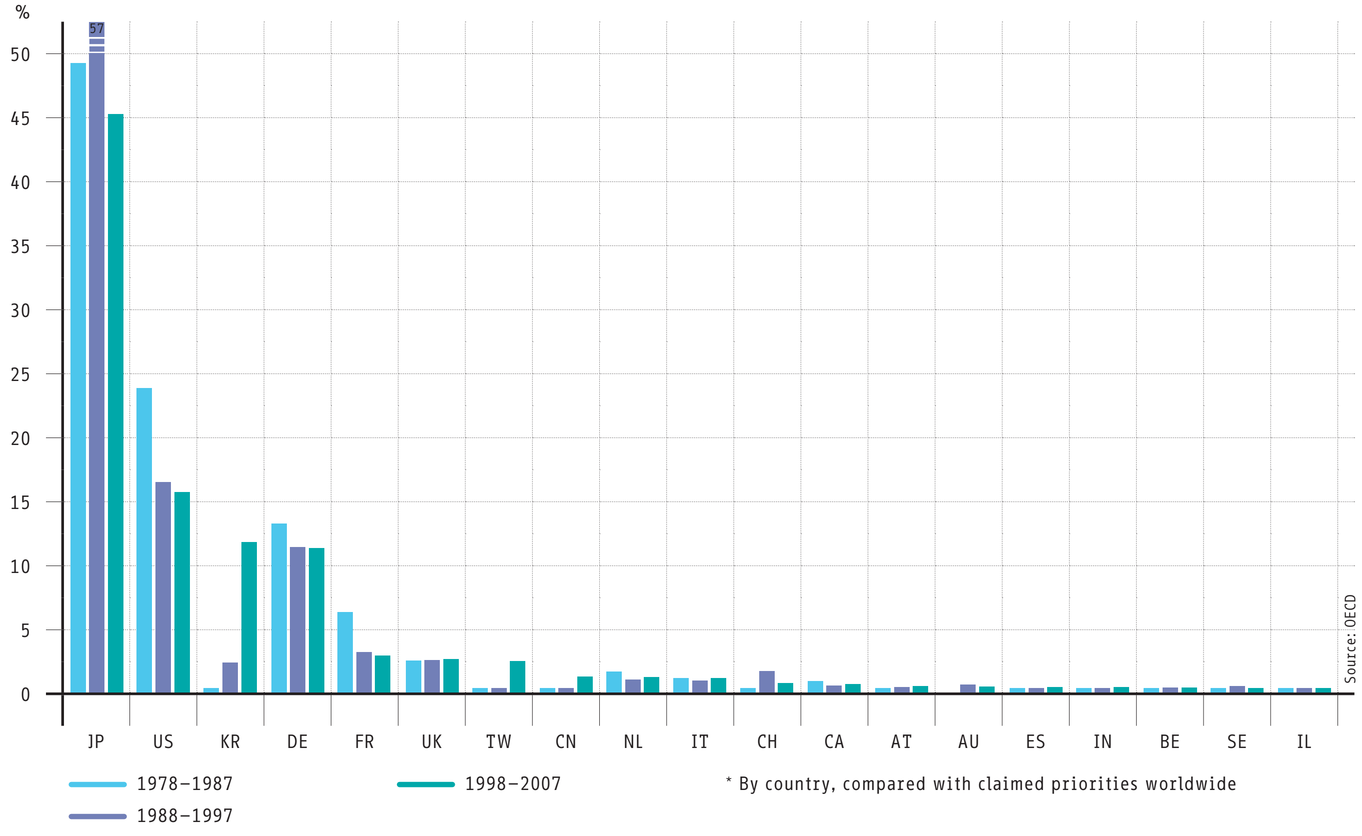
Figures 08-12 provide details of how different countries have performed in terms of patenting in the selected areas of geothermal, solar PV, wind, carbon capture and IGCC since 1978. For each country, the rate of claimed priorities patenting in the selected CET sector compared with all claimed priority patents worldwide in the same sector is listed.

08 Share of claimed priority patents in the geothermal energy sector*

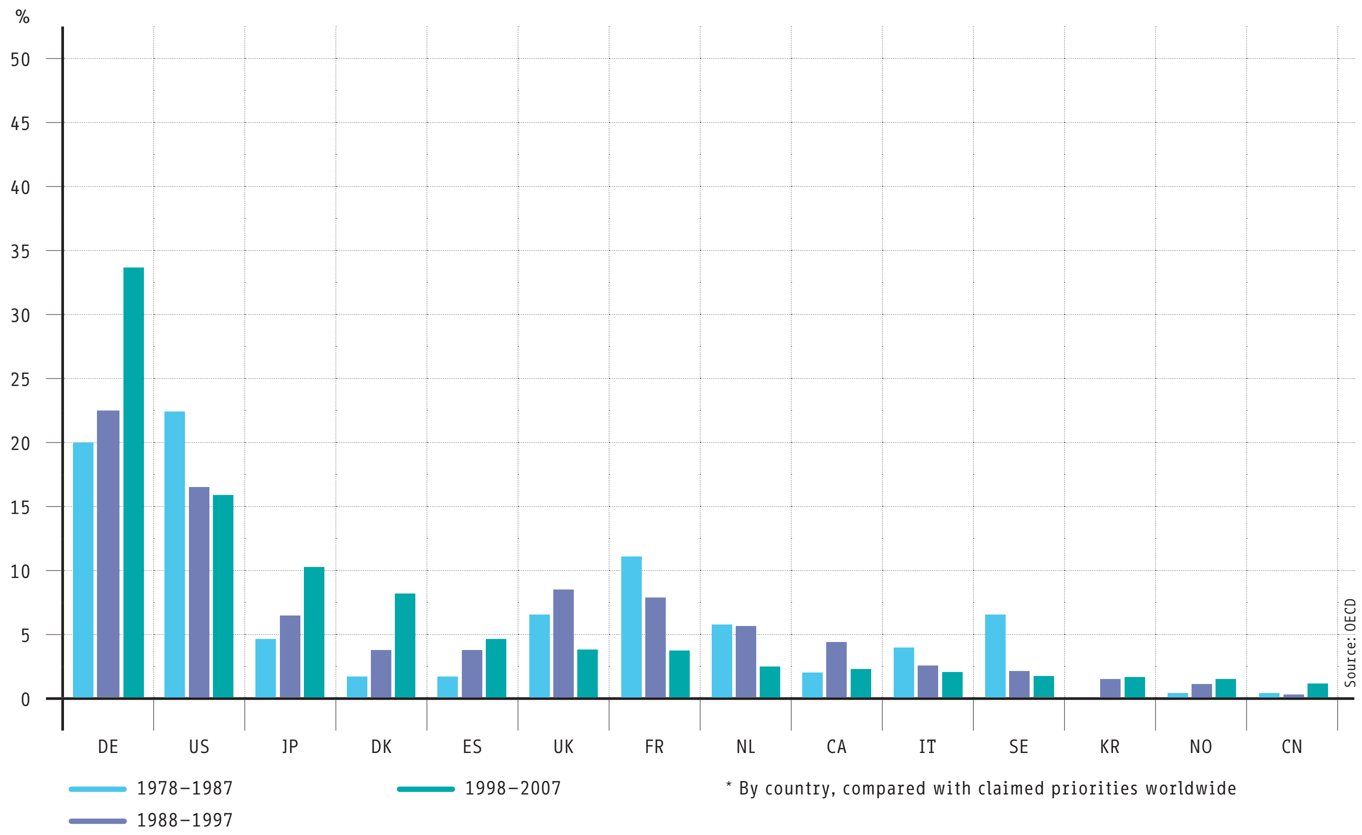


Technology mapping

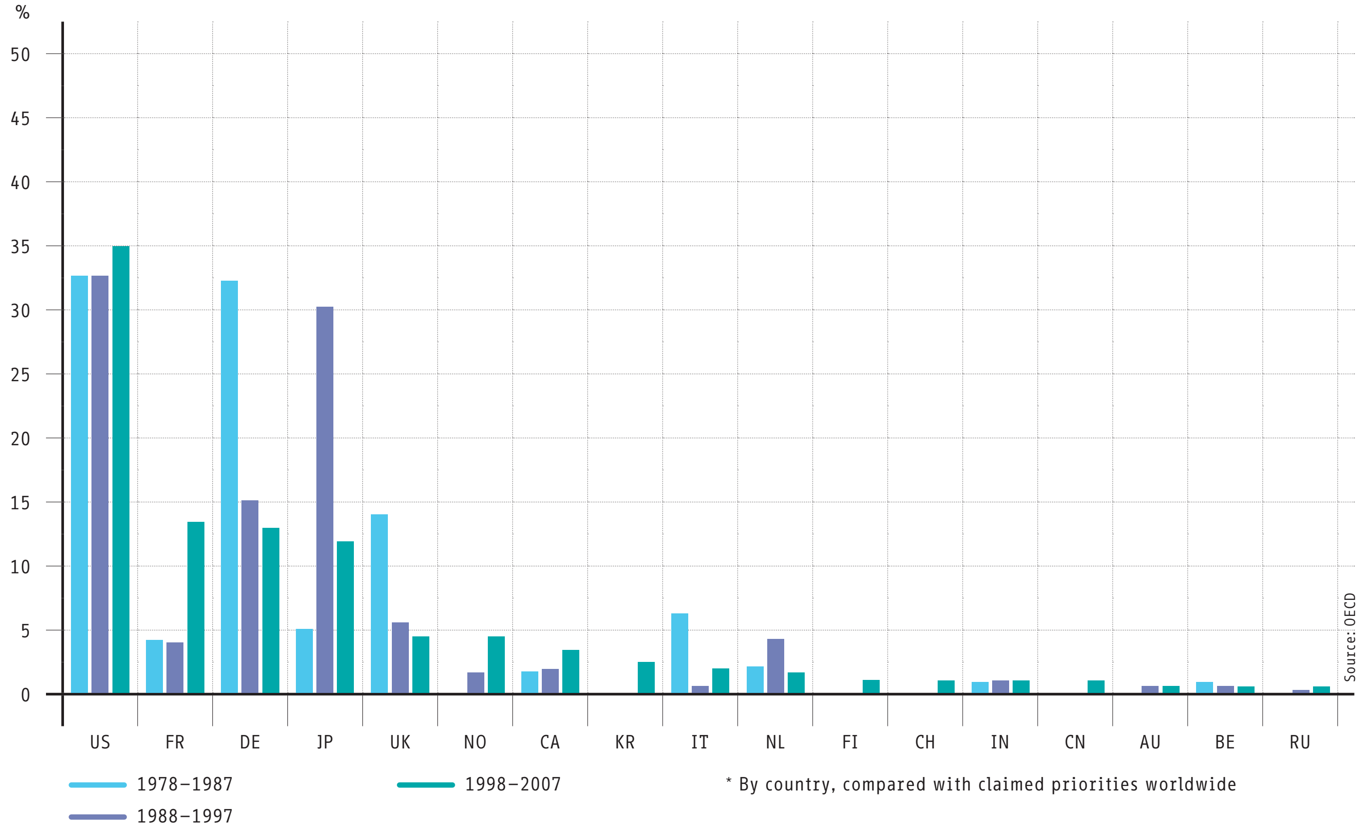
09 Share of claimed priority patents in the solar PV sector*



10 Share of claimed priority patents in the wind energy sector*

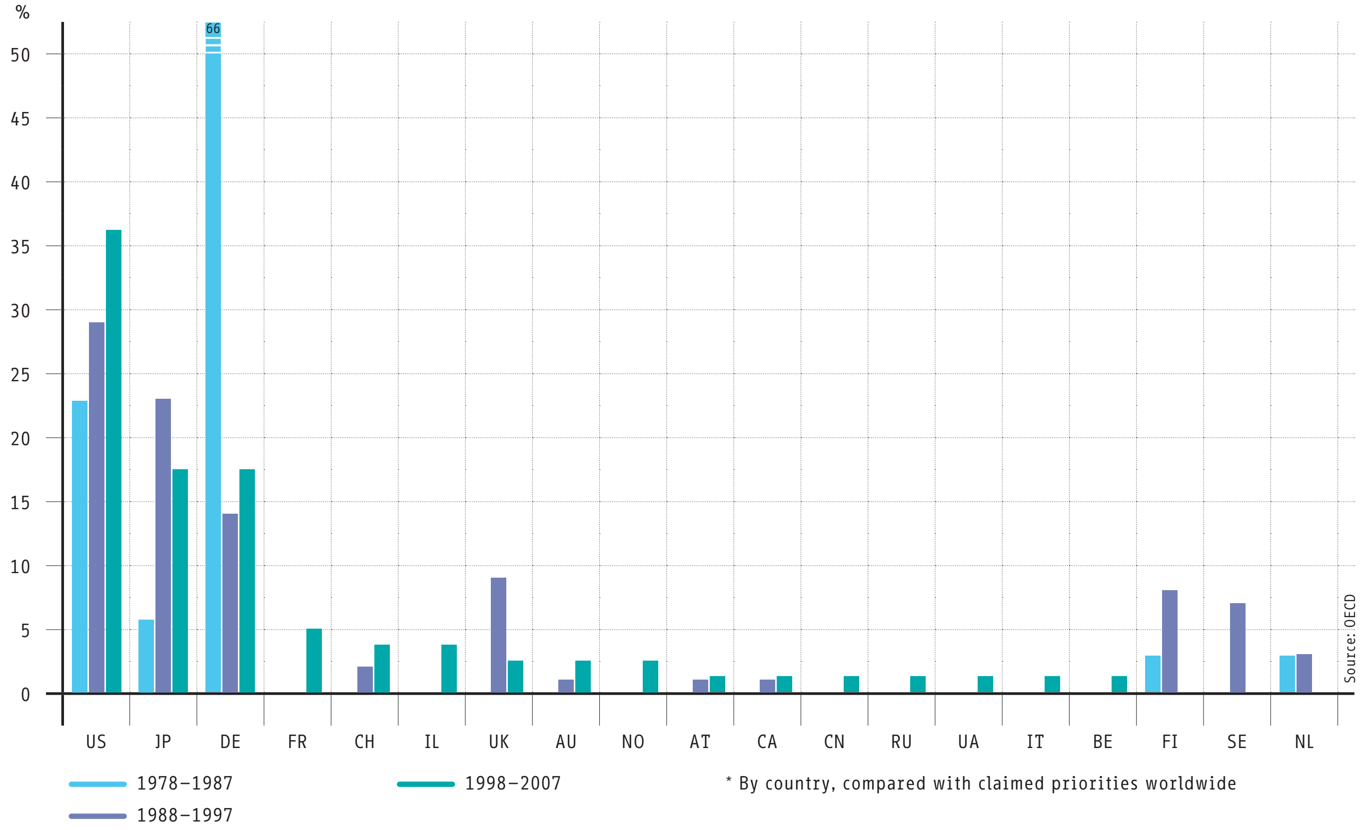


11 Share of claimed priority patents in the carbon capture sector *



* By country, compared with claimed priorities worldwide

12 Share of claimed priority patents in the IGCC sector *



* By country, compared with claimed priorities worldwide

3.6 Impact of political decisions

Reflecting back on Figures 03 and 04, which track the overall rate of claimed priorities patenting in CETs, it is worth noting that the surge in patenting activity in the selected CETs occurred around 1997, when the Kyoto Protocol was signed. To better understand the dynamics, the data for the year 1997 is now taken as a baseline (instead of 1978). Figure 13 shows the relative patenting rates before and after 1997 and confirms the marked increase in patenting after the year the Kyoto Protocol was signed. Indeed, as also demonstrated in Figure 13, shortly after Kyoto patent activity in fossil fuels sloped off.

Figure 14 disaggregates the selected CET fields. Technologies showing the steepest patent rate increase following Kyoto are wind, solar PV and hydro/marine. Patenting in biofuels and geothermal technologies also showed increased activity.

Figures 13 and 14 confirm the earlier findings by Dechezlepretre et al. that innovators react to policy changes. Public policies on energy may not be the only drivers of patenting behaviour in CETs. Figure 15 compares patenting behaviour in biofuels against oil prices up to 2006. Patenting activity in biofuels seems to grow in response to increasing oil prices. The increase in biofuels patenting is most appreciable from 2003 onwards, as oil prices hit a record at that time of $80 a barrel.

However, beyond the global scale, it is important to look in a more disaggregated manner at how individual countries have sought to encourage use and innovation in the field of CETs. Figures 16-18 show the relationship between government expenditure on energy technology R&D and the growth rate in numbers of claimed priorities for the three major inventing countries (Germany, Japan, US). The year 1978 is taken as the baseline again. This suggests that while R&D budgets dedicated to traditional energy sources have generally decreased, government R&D spending on CETs has remained more or less stable. Indeed, patenting activity in this field has been much greater than in the conventional fossil-fuel and nuclear energy sectors. However, without further analysis it is difficult to draw conclusions about the role of government R&D relative to other determinants that may encourage inventive activity.

Indeed, further disaggregated data on R&D budgets suggests that the role of R&D varies by technological field (Figure 19). While the correlation between dedicated energy R&D and patenting is rather high at the aggregated level (total energy technology, fossil fuel and nuclear, and CETs), the correlation is much lower for the individual CET sub-sectors (with the notable exception of carbon capture).

Previous empirical work undertaken at the OECD (Johnstone, Haščič and Popp, 2010) has shown that policies such as feed-in tariffs, renewable energy credits, tax credits, etc. which seek to support the development of renewable energy technologies have under given circumstances a positive effect on innovation. However, this depends upon the energy field targeted and the instrument implemented. It is beyond the scope of this report to undertake analysis at this level of detail.

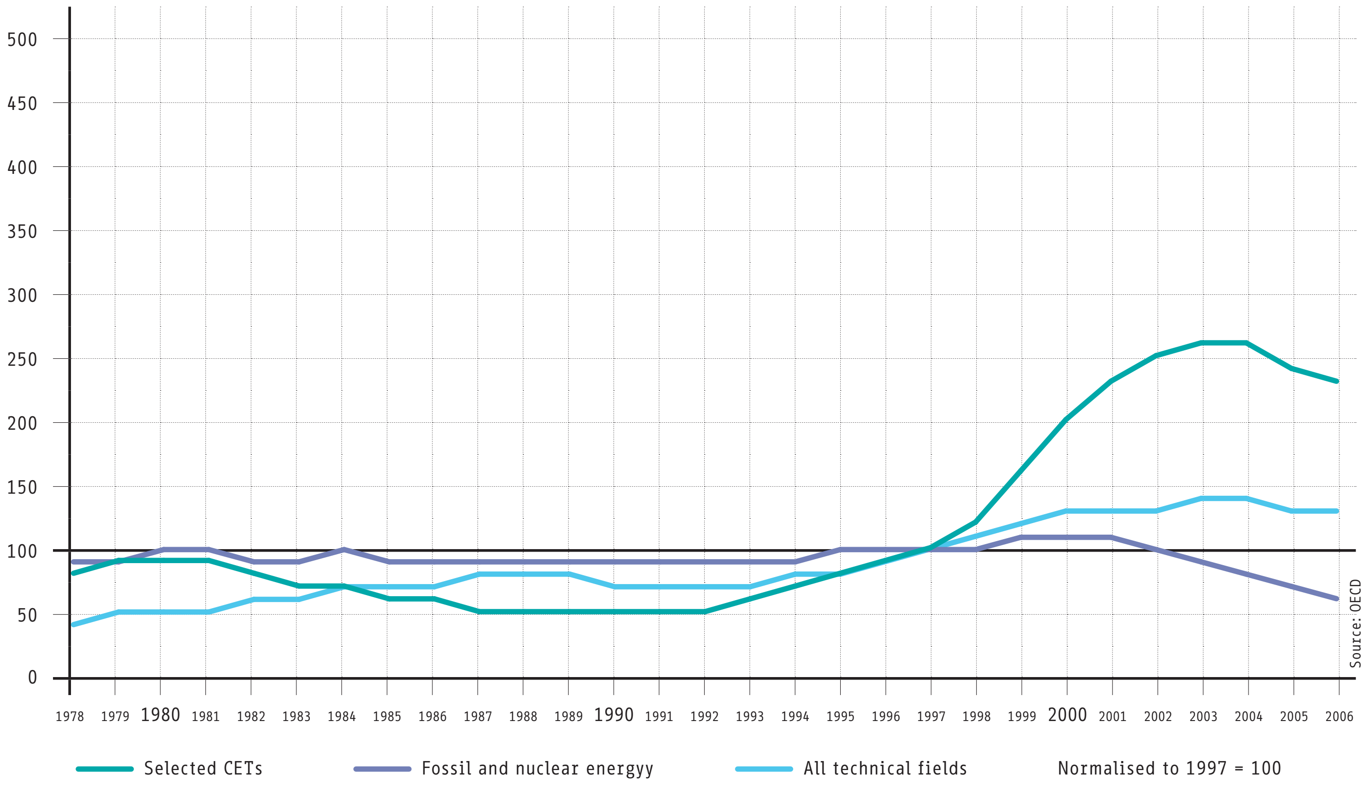
Nevertheless, some trends with respect to feed-in tariffs are presented in Figure 20. In this case the focus is on solar PV technologies for five major inventor countries. While two of them - Germany and France - have introduced preferential feed-in tariffs for electricity from solar PV, the others (UK, US and Japan) have not. There is no clear distinction between the groups of countries.

For the case of wind power, a comparison between the six major inventor countries is presented in Figure 21. Three of them - Germany, Denmark, Spain - have introduced preferential feed-in tariffs for wind power, while the others (US, Japan, UK) have not. Once again, there is no clear distinction between the groups of countries.

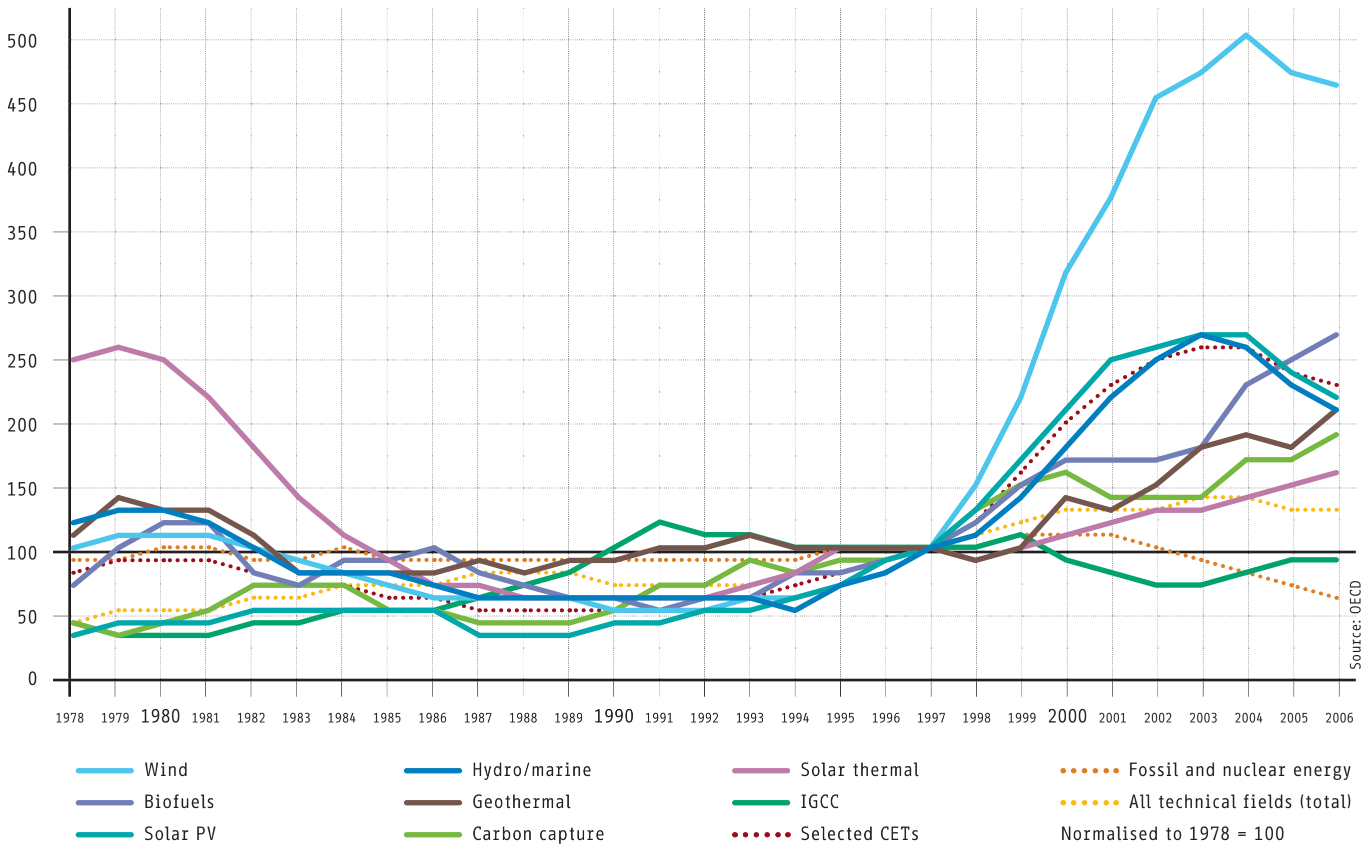
To conclude, the signing of the protocol and public policy programmes such as feed-in tariffs in Germany, France, Spain and Denmark were clearly found to be a factor in sparking potential new markets in CETs. However, the data shows that feed-in tariffs do not always have positive long-term effects. For example, Germany has seen a dip in numbers of claimed priorities in wind technology despite the existence of feed-in tariffs. Spain on the other hand has benefited from such policies in the field of wind technology. Similarly, in the area of solar PV, as feed-in tariffs in Germany for electricity from solar PV have increased, so has the rate of patenting.

The above thus highlights the importance of looking at the determinants of innovation in a more comprehensive and detailed manner, taking into account all relevant policy and market factors. For instance, general market conditions can also play an important role since in many cases the achievement of environmental objectives is complementary to efforts to improve the efficiency of production more generally.

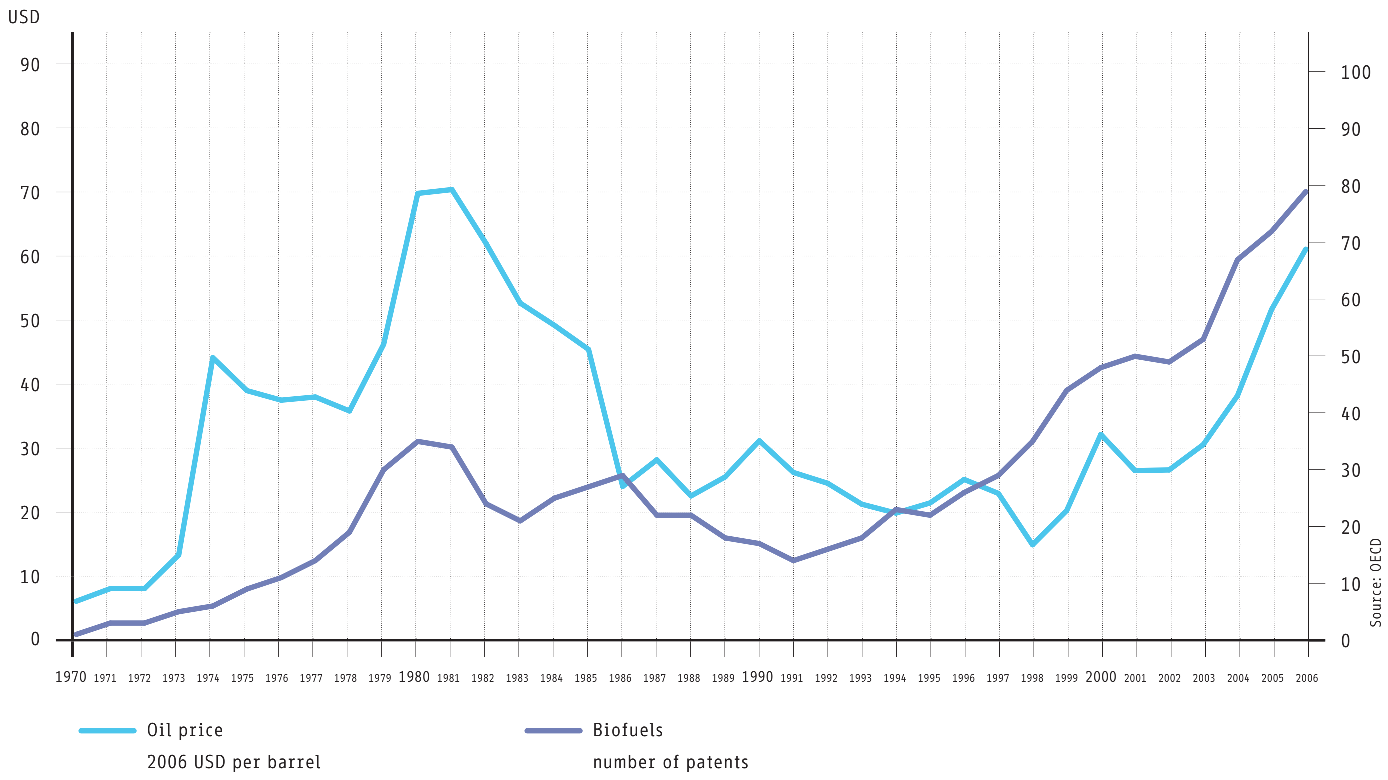
13 Post-Kyoto growth rate in claimed priorities patenting for CETs



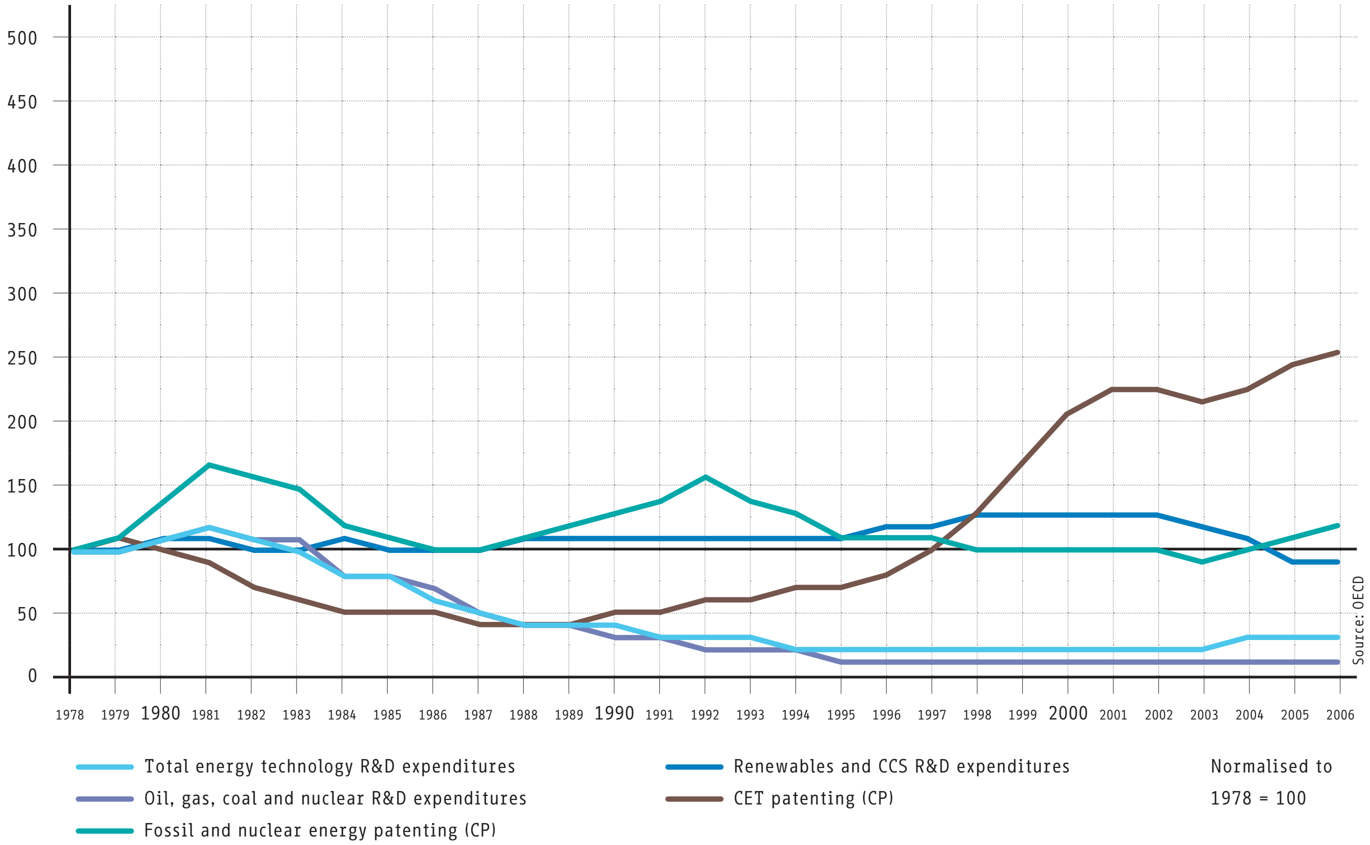
14 Disaggregated data showing post-Kyoto growth in patenting for CETs



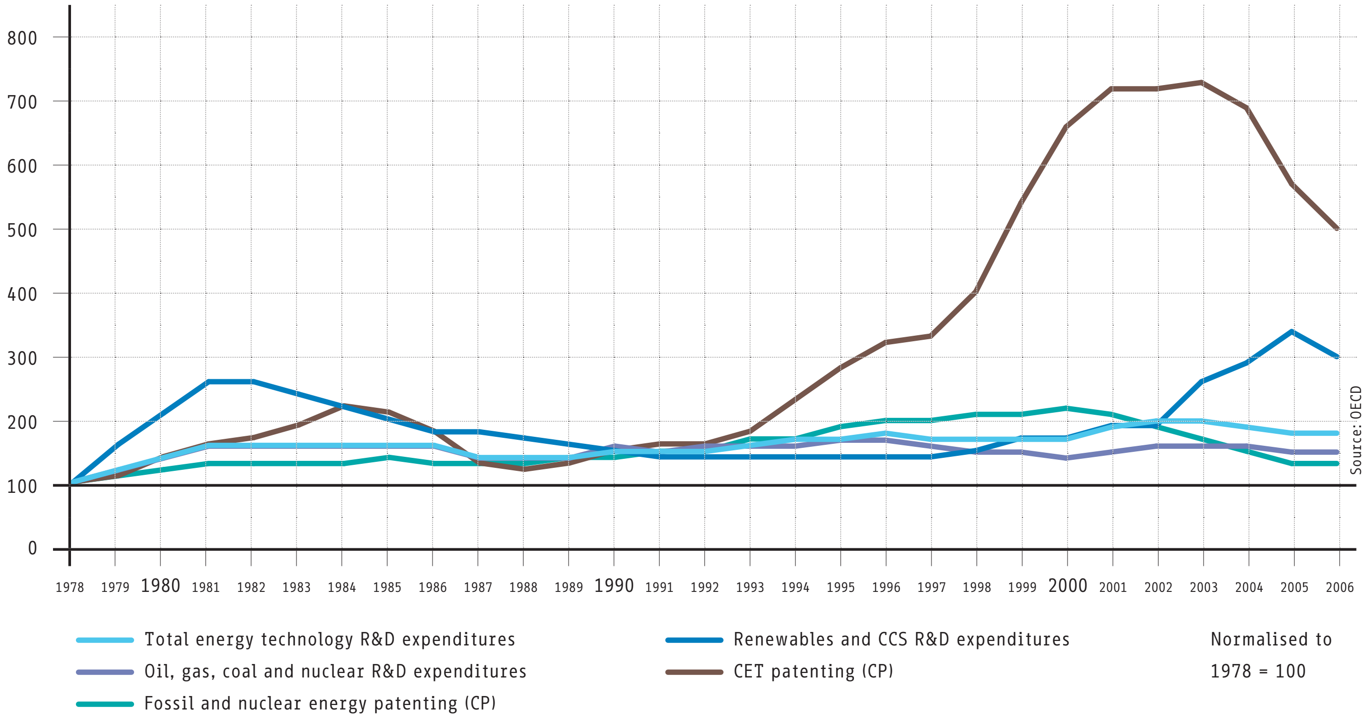
15 Comparison between crude oil prices and biofuels patenting



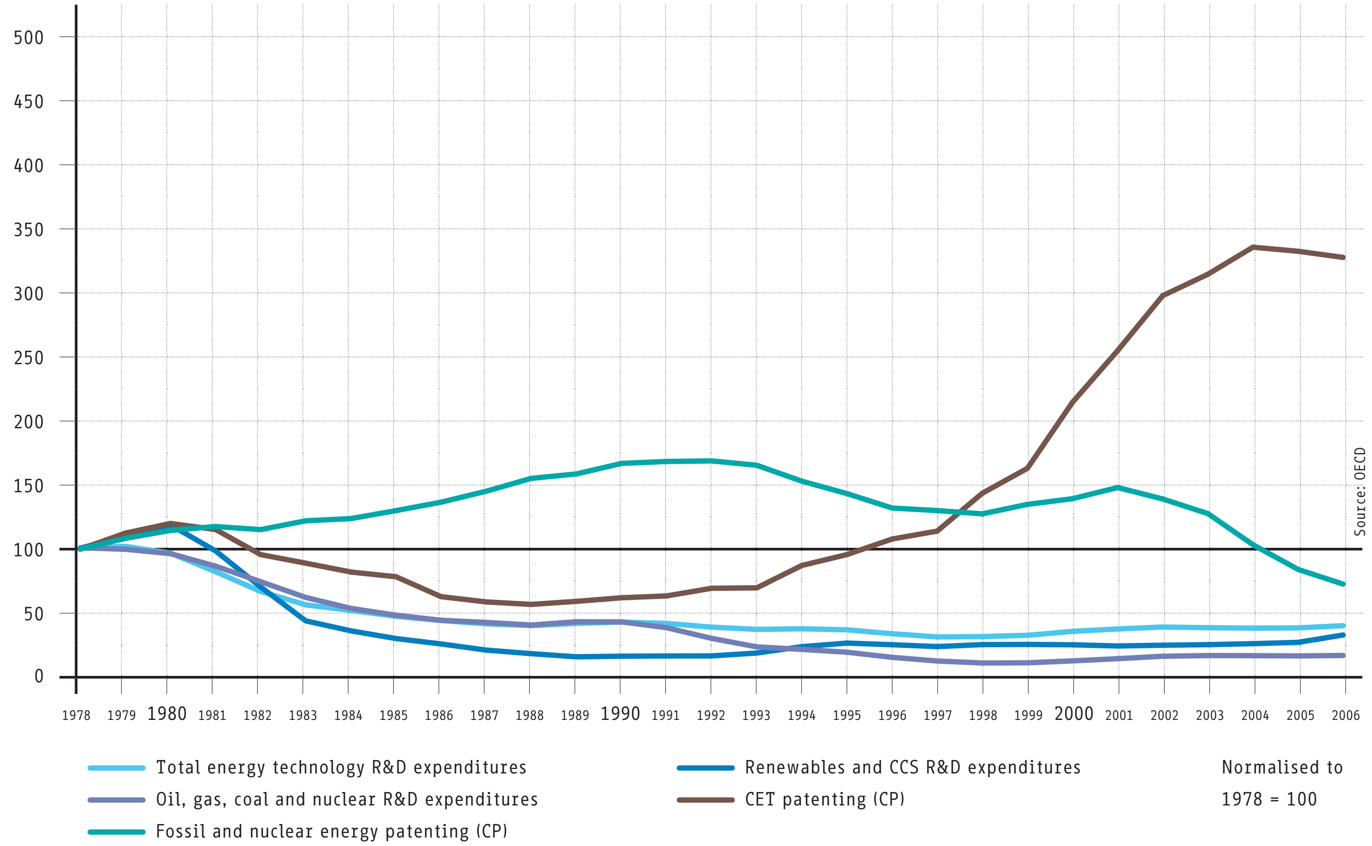
16 Patenting activity and government expenditures on energy technology R&D – Germany



17 Patenting activity and government expenditures on energy technology R&D – Japan



18 Patenting activity and government expenditures on energy technology R&D – United States



19 Correlation between CET claimed priorities patenting and specific R&D expenditure*

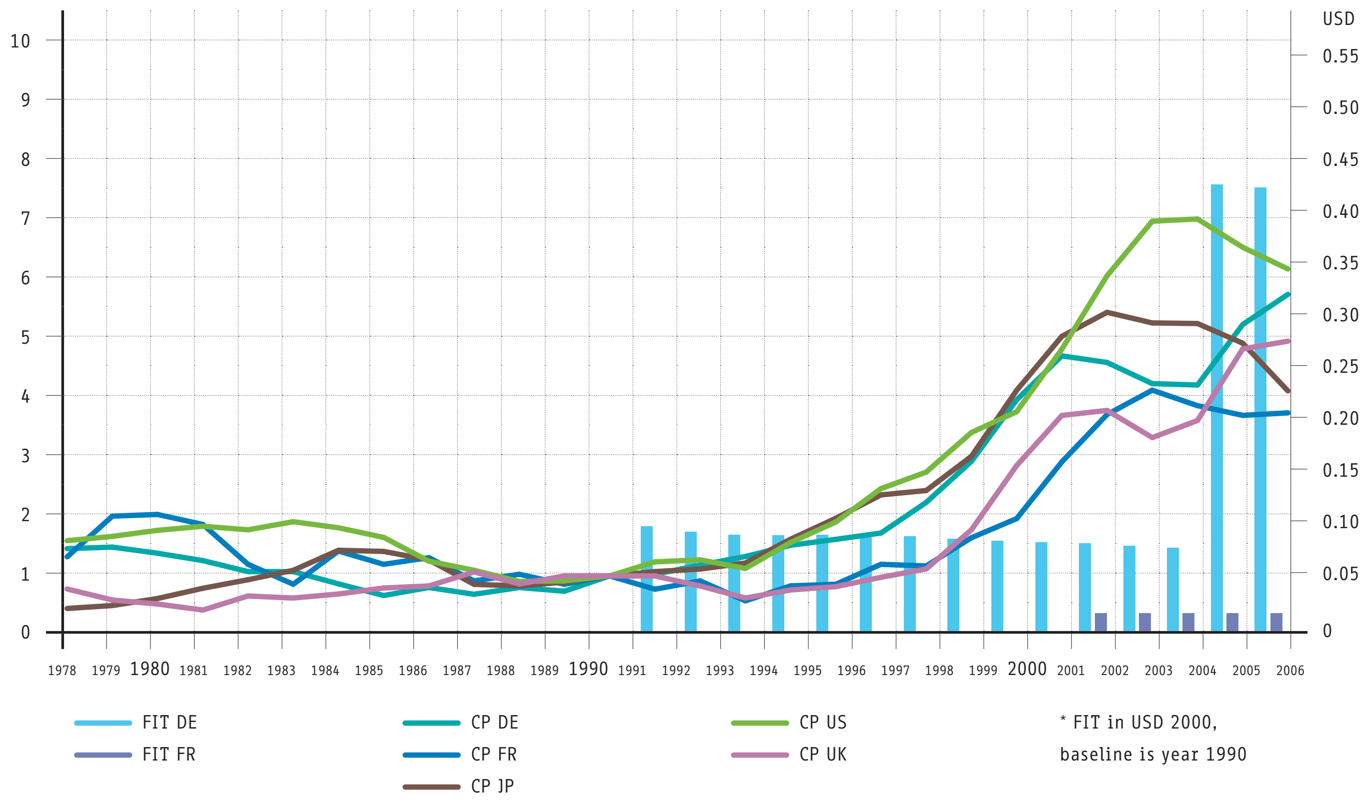
Pearson correlation coefficients

Solar PV	Solar PV R&D	0.52
Solar TH	Solar TH power R&D	0.34
Wind	Wind power R&D	0.31
Geothermal	Geothermal R&D	0.28
Biofuels	Bioenergy R&D	0.48
Carbon capture	Carbon capture R&D	0.77
Carbon storage	Carbon storage R&D	0.18
CET	Renewables R&D	0.38
CET	Total energy R&D	0.61
Fossil and nuclear	Total energy R&D	0.72
Total	Total energy R&D	0.69

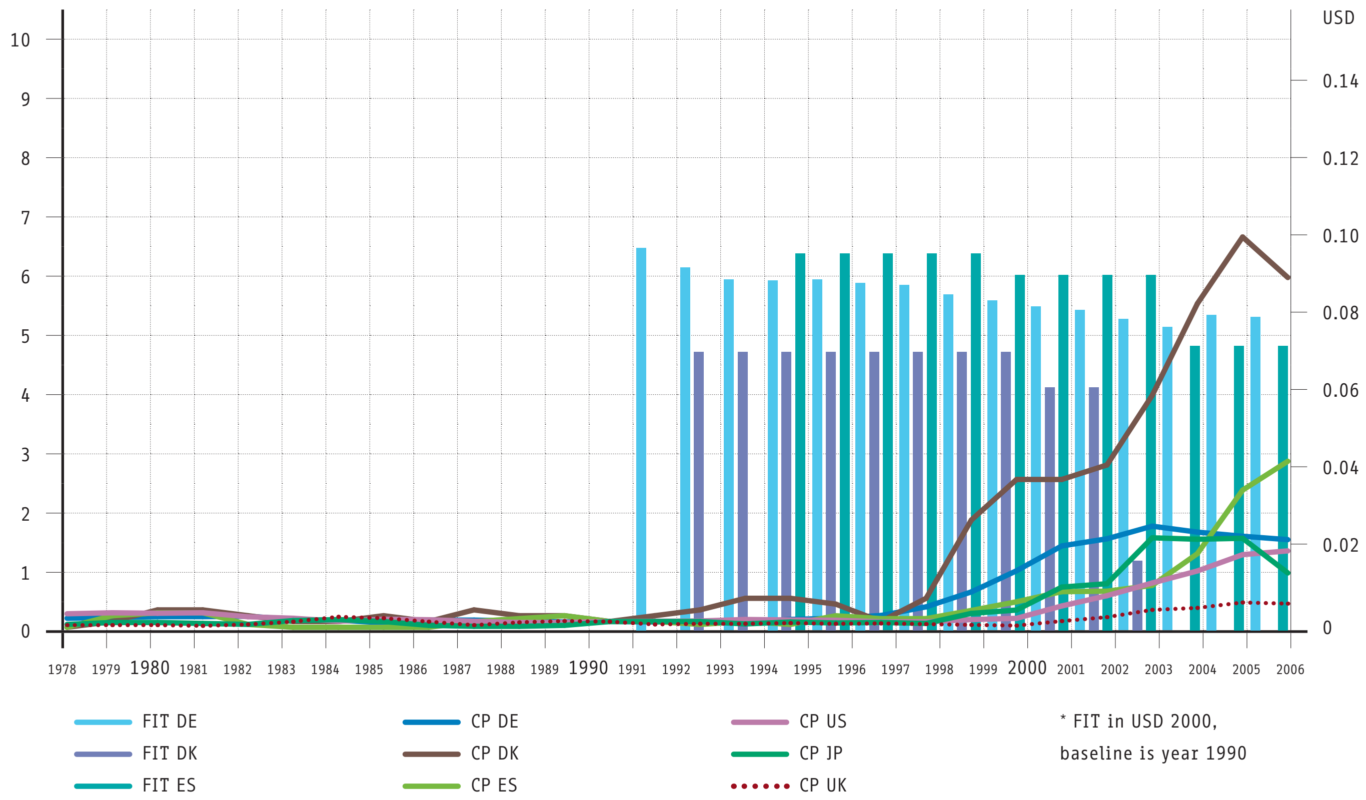
Source: OECD

* Number of CET claimed priorities worldwide by inventor country and priority year correlated with IEA's energy technology R&D expenditure by country and year.

20 Feed-in tariffs (FIT) and claimed priorities patenting in solar PV*



21 Feed-in tariffs (FIT) and claimed priorities patenting in wind power*



Technology mapping

3.7 Market concentration

This section provides data on how the degree of specialisation in claimed priorities patenting at the country level translates into market concentration in selected CET sectors.[18]

Although only few patents exist in the field of carbon storage, it does have the highest concentration, with over 36 per cent of inventions ascribed to ten firms. The fields of IGCC and wind energy show the next highest concentration of inventions, distributed amongst ten firms. Solar thermal on the other hand only has five per cent of inventions attributable to ten firms.

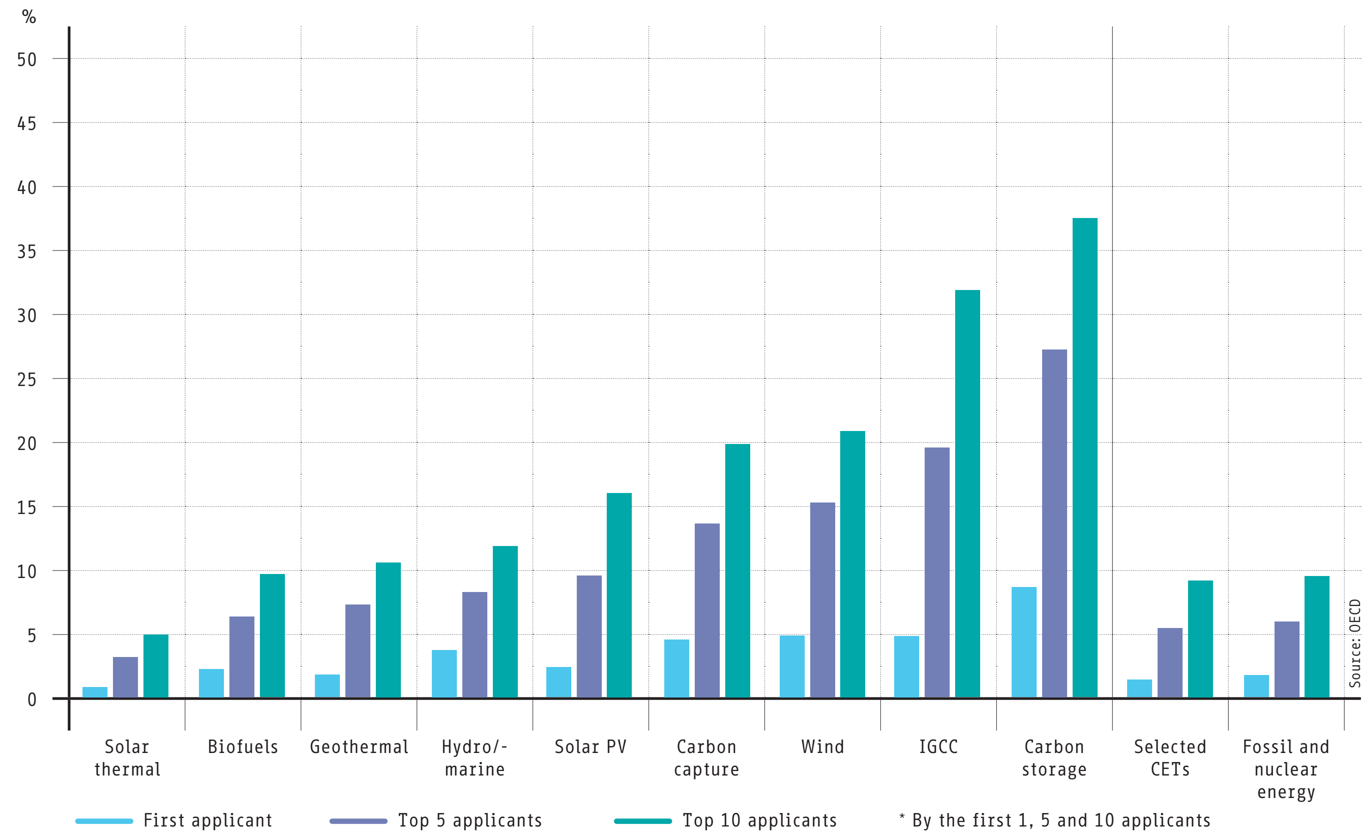
Figure 22 provides the concentration ratios for the different CET sectors using one-firm, five-firm and ten-firm concentration ratios.

[18] The data is generated on the basis of assignee/patent owner data from PATSTAT. The applicant name data has been partially cleaned and adjusted for changes in company structure such as mergers and acquisitions.

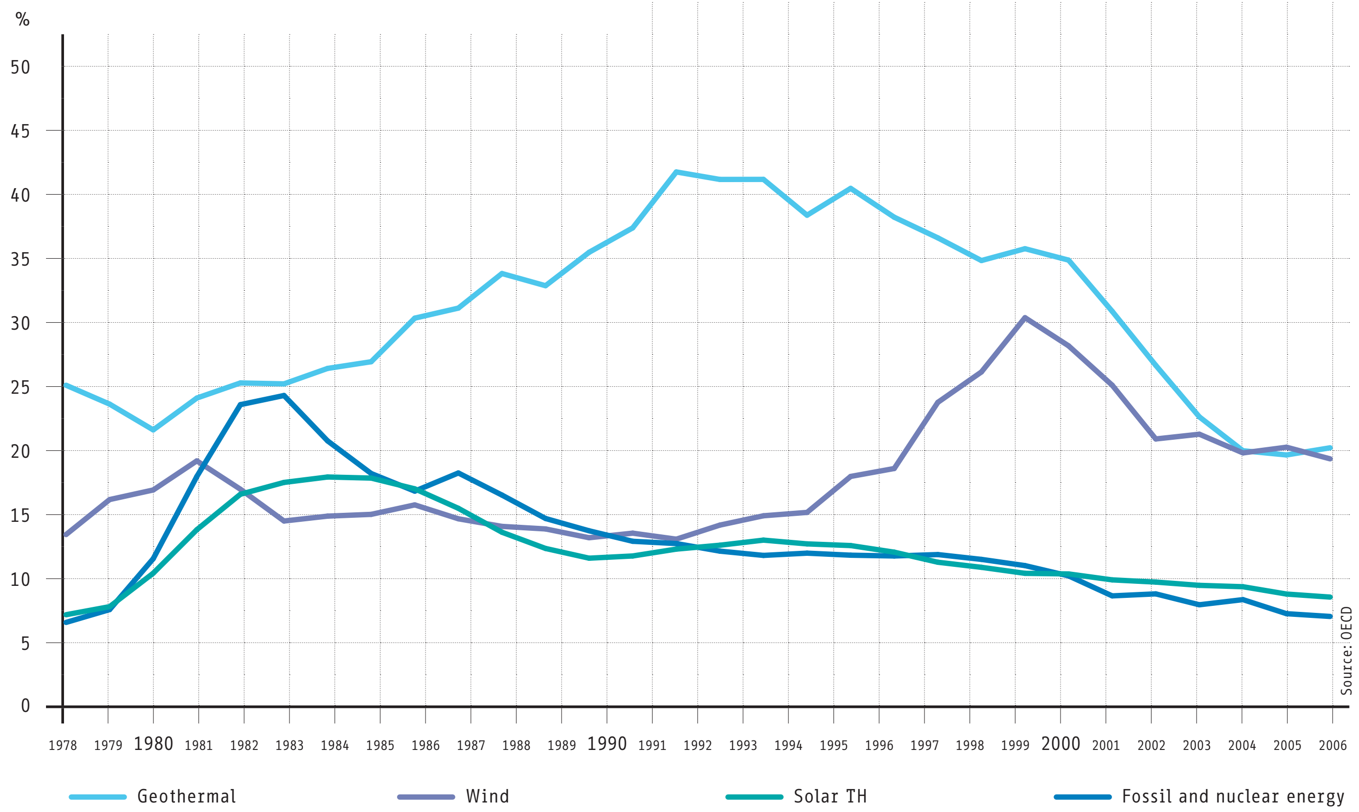
A closer look at the ten-firm concentration ratio for geothermal, wind and solar thermal shows an increase in the wind sector from the mid-1990s to the early 2000s (Figure 23). Geothermal on the other hand has seen a decrease in concentration after peaking around 1992-1994. Concentration in the solar thermal sector has declined consistently over the past 25 years, which is indicative of a mature technology and a sector with low barriers to entry.

Figure 24 sets out the names of patent applicants with the highest number of claimed priority filings and percentage share in the selected sectors of carbon capture, carbon storage and IGCC. Notably, concentration in all three sectors has decreased, although the carbon storage sector continues to be dominated by a handful of firms. This suggests that there is an emergence of new actors in these sectors, although it is noticeable that all the applicants appear to be from OECD countries, a situation replicated in almost all technology areas. As such this raises the question of whether any technology transfer is taking place in these areas.

22 Percentage share of market concentration in CETs*



23 Percentage share of market share by first ten applicants for selected CET fields, compared with fossil and nuclear energy



24 Major applicants in carbon capture, carbon storage and IGCC technologies (1988-2007)

	1988-1997	n	%	1998-2007	n	%
Carbon capture	BOC	157	9.7	PRAXAIR	206	6.3
	MITSUBISHI	138	8.6	AIR LIQUIDE	162	5.0
	AIR PRODUCTS	93	5.8	AIR PRODUCTS AND CHEMICALS	141	4.3
	KANSAI	78	4.8	BOC	113	3.5
	AIR LIQUIDE	58	3.6	SHELL	100	3.1
	PRAXAIR	53	3.3	MITSUBISHI	96	3.0
	UNION CARBIDE	45	2.8	EXXON	81	2.5
	UOP	34	2.1	CECA	70	2.2
	LINDE	32	2.0	GENERAL ELECTRIC	59	1.8
	UNITED TECHNOLOGIES	28	1.7	INSTITUT FRANÇAIS DU PÉTROLE	57	1.8
	Total		44.0	Total		33.0
Carbon storage	MITSUBISHI	18	38.0	SHELL	98	21.0
	AGRICULTURAL GAS	9	19.0	INSTITUT FRANÇAIS DU PÉTROLE	43	9.3
	NKK	5	10.0	TERRALOG	23	5.0
	SEEC	4.5	9.4	EXXON	20	4.2
	ELECTRIC POWER RESEARCH INSTITUTE	2.5	5.2	SCHLUMBERGER	18	3.9
	BAL	2	4.2	CDX GAS	17	3.7
	UNOCAL	2	4.2	AIR PRODUCTS	15	3.2
	DANIEL STEWART ROBERTSON	1	2.1	DIAMOND QC TECHNOLOGIES	14	3.0
	HEINZ SEBASTIAN	1	2.1	DROPSCONE	11	2.4
	GAZPROM	1	2.1	BHP BILLITON	8.5	1.8
	Total		96.0	Total		57.0
IGCC	MITSUBISHI	90	9.3	MITSUBISHI	57	7.8
	AIR PRODUCTS	82	8.5	SIEMENS	56	7.7
	EBARA	80	8.3	GENERAL ELECTRIC	54	7.4
	HITACHI	52	5.4	TEXACO	46	6.2
	FOSTER WHEELER	47	4.9	HITACHI	39	5.3
	TEXACO	42	4.4	TOSHIBA	27	3.7
	IMATRA VOIMA	32	3.3	IHI	22	3.0
	IHI	32	3.3	NORSK HYDRO	21	2.9
	SIEMENS	32	3.3	ALSTOM	19	2.7
	ALSTOM	25	2.6	ORMAT	19	2.6
	Total		53.0	Total		49.0

n = number of claimed priority filings % = percentage share in selected CET sector worldwide

3.8
Stages of maturity of technologies

The aggregate data presented in the previous sections gives some useful indications of trends in the innovation dynamics in the CET field. However, within individual sectors there can be significant variation, with different technology types being much more mature than others. This section therefore reviews the individual sectors in order to understand better the stages of maturity for each technology and its more specific applications. An example of a detailed analysis is shown for the sector of solar energy and partly for wind energy, whereas for the other sectors only the main conclusions are mentioned.

Solar PV versus solar thermal

The difference in degree of maturity can be seen clearly in Figure 25 below, where data on solar thermal and solar PV technologies are compared. Solar thermal (a much more mature technology) reached its peak in the late 1970s, while solar PV experienced rapid growth in the late 1990s. To better capture this specific event, 1970 was chosen as the base year for the counting of claimed priority patents for solar technologies.

An understanding of the relative maturity of different technologies can be important in policy design. For instance, Johnstone, Haščič and Popp (2010) find that price-based measures are more effective in inducing innovation in renewable energy sources which are close to being competitive, while public expenditure on R&D is more effective for less mature technologies.

Moreover, different countries have specialised with differing intensity in the two fields. While Japan and the US are dominant in solar PV, Germany has played a leading role in solar thermal. Most of the smaller countries have also been more active in solar thermal (e.g. Israel, Switzerland and the Netherlands). Interestingly, China and India are amongst only four countries in which solar PV inventions exceed solar thermal. Figure 26 shows the share of claimed priorities in the solar sector from 1978 to 2007 for selected countries, relative to all claimed priorities in this sector worldwide.

Disaggregating still further, one can see trends within PV technologies. In particular, dye-sensitised solar cells and PV systems with concentrators have been growing very rapidly in recent years.

Looking in more detail at solar thermal technologies, the most evident trend is the fall in the proportion of claimed priority patents which relate to heat exchange systems, with mechanical technologies (mounting and tracking) showing growth (see Annex 7).

To conclude this solar technology maturity investigation, the evidence presented shows that solar thermal has already peaked and is a mature field of technology. Disaggregating the trends within the sub-technologies falling under solar thermal, mechanical mounting and tracking technologies are showing growth, while heat exchange systems are showing a fall in the proportion of claimed priorities patenting. Other areas within solar thermal are relatively stagnant.

Wind power

The wind power sector shows very little difference in the maturity of onshore and offshore towers (Figure 27), and this is the case across all the sub-sectors of wind power.

However, there is a tendency for different countries to specialise in different areas. Germany, the UK and the Netherlands are more specialised in offshore tower technologies, Japan and the US in onshore technologies (Figure 28). Germany is very active in both onshore and offshore technologies.

Other sectors

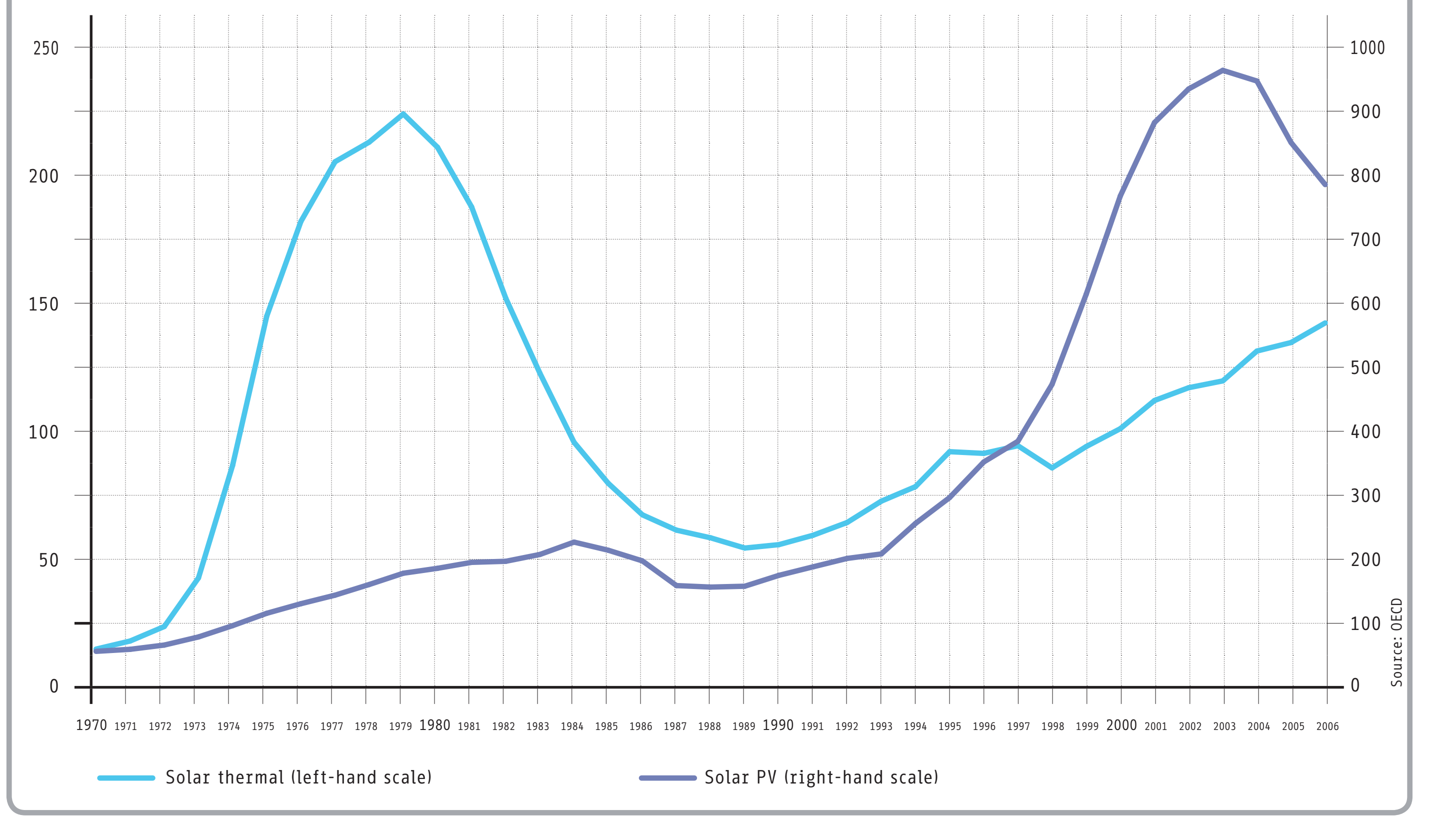
The investigation reveals that the key growth area in geothermal is in material technologies, while drilling technologies have peaked and are now declining.

In the hydro/marine technology sectors, conventional hydro technologies have become less important. Stream and wave technologies have shown growth.

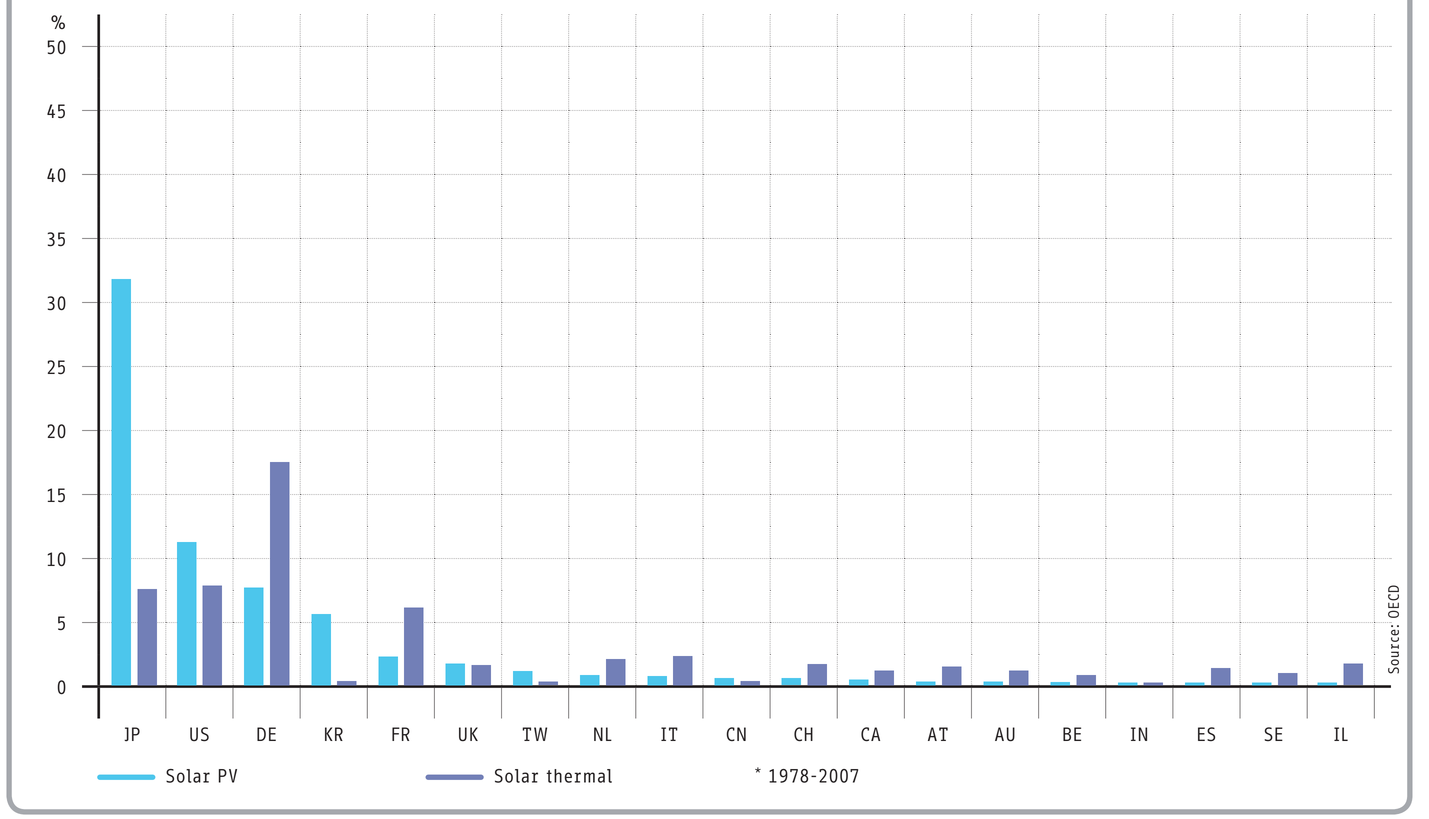
In the biofuels sector, claimed priorities patenting in diesel technology is showing the greatest growth.

Finally, within carbon capture, adsorption technologies and chemical capture are showing an increase in claimed priorities patenting. Absorption and condensation are showing a decline in activity.

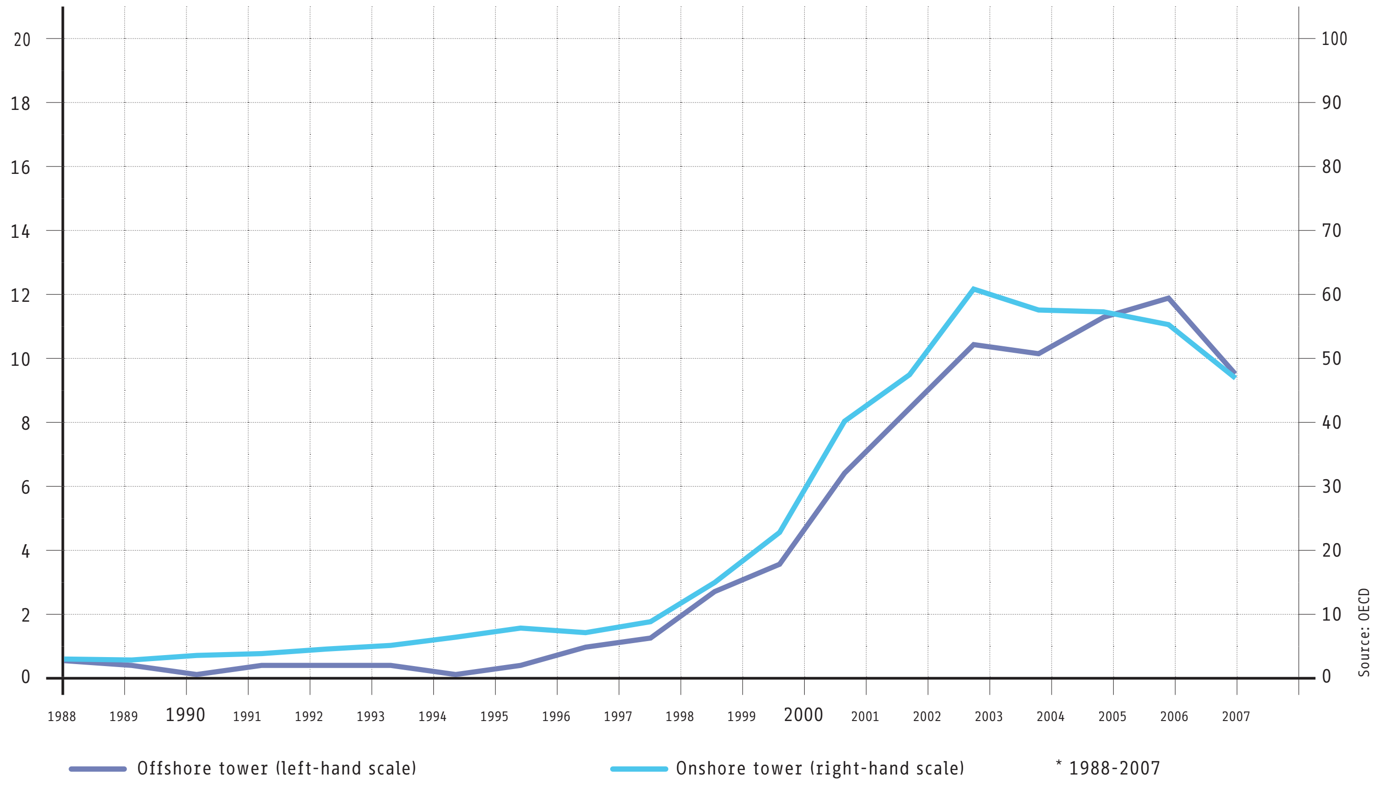
25 Number of claimed priority patents worldwide in solar thermal versus solar PV



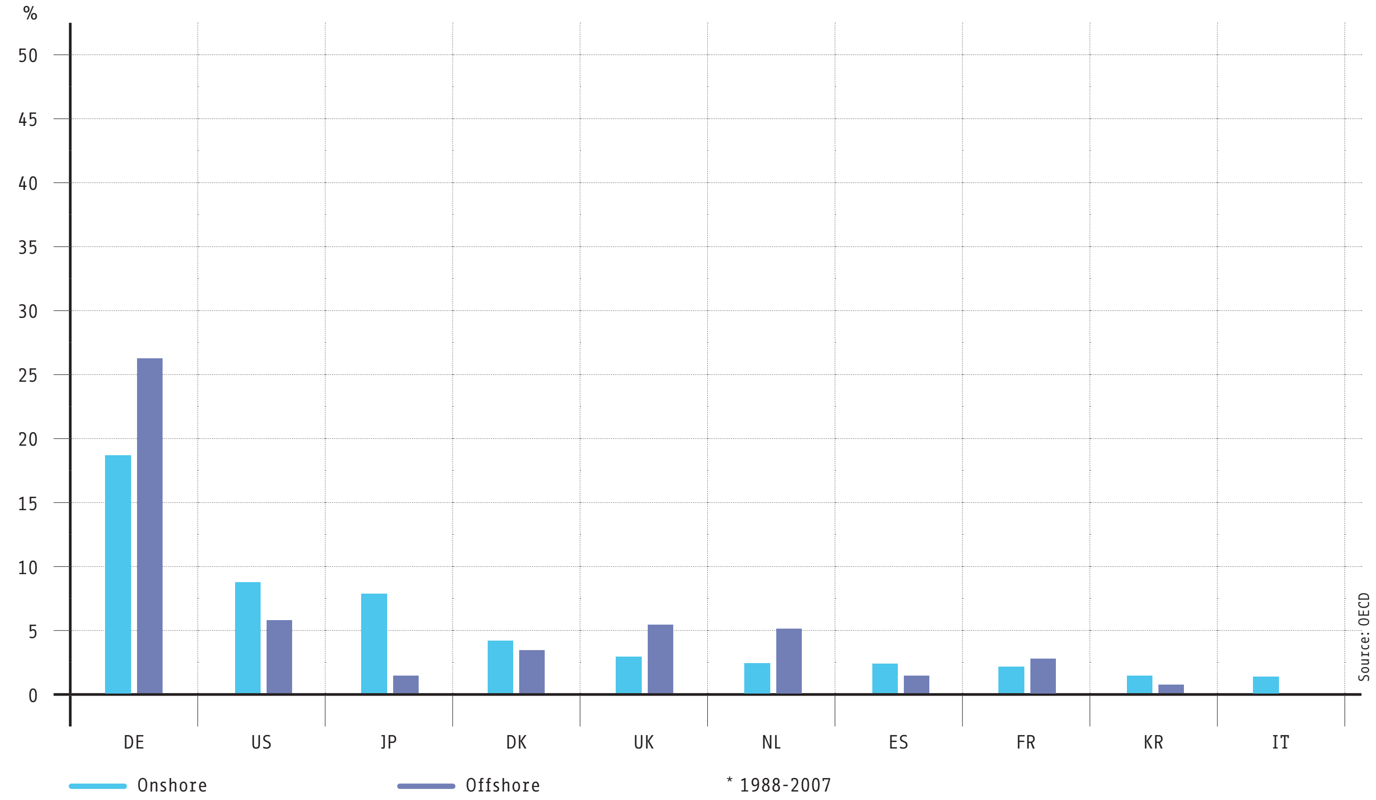
26 Share of claimed priority patents for selected countries for solar thermal and solar PV relative to all worldwide claimed priorities in this sector*



27 Numbers of claimed priorities patents for onshore and offshore wind towers*



28 Share of claimed priorities in onshore and offshore wind towers relative to worldwide market by country*



3.9. Patenting trends between countries

This section discusses trends in how inventors from some selected countries are patenting their inventions in other countries. Again, claimed priorities are also considered for this analysis.

Unsurprisingly, most patenting activity takes place between the top patenting countries (Japan, the US, Germany, the Republic of Korea, France and the UK).

Outside this group, inventors from Japan and the US have the largest numbers of claimed priority patents filed also in China. Inventors from Germany, the UK, France and the Republic of Korea are the next largest patent filers in China. This indicates that China is considered an important market, but also a potential competitor. Inventors from China on the other hand do not have a high number of patents filed first in China and then in any of the leading patenting countries. Indeed, most of China's patenting activity takes place at home. This trend reflects general patenting behaviour by China in all technology sectors (WIPO, 2009).

Inventors from the US and Germany are the highest filers of claimed priority patents in Brazil. Comparatively, inventors from Japan file very few patents in Brazil. There are only two CET patents of Chinese origin filed subsequently also in Brazil, suggesting that even emerging economies are not of particular importance in this context.

A review of patenting trends in the areas of solar PV and solar thermal by 'Annex I countries' in 'non-Annex I countries' ('Annex I' refers here to the Kyoto Protocol) reveals that China, the Republic of Korea and Taiwan are the biggest recipient countries for the examined patent flow, followed by Israel, Brazil, Mexico, South Africa and Morocco.

Inventors from Japan are the most active filers of solar PV inventions in China, followed by US and German inventors. US inventors file the highest number of claimed priority patents in China in relation to solar thermal. In contrast, India receives very few claimed priority patents. Annexes 8, 9 and 10 provide more detailed information about these patent flows.

Some studies, notably Dechezlepretre et al., have attempted to show trends in technology transfer by analysing the share of inventions patented in at least two countries. At best, the use of patent filings in other countries as an indicator of technology transfer is a crude measurement. Moreover, the disclosure of a patent or even the sale of a patented technology in a country is unlikely to equate to technology transfer in the traditional sense. In the case of patent filings, these are often made in another country for defensive purposes, such as to preserve competitive advantage in a particular market or to be able to license the technology. Moreover, patents do not always fully disclose a technology in such a way that it can be practised, developed or improved locally (Correa, 2005).

Disclosure of a patent locally does not make the technology immediately accessible unless licensing is involved. In other words, the internationalisation of the patent system and the resultant increase in patenting generally does not automatically mean an increase in technology transfer.

4
THE LICENSING SURVEY

4.1
Designing the survey

Studies in this field until now have tried to determine the dissemination of technology by analysing global trends in patenting. Given the inherent limitations of such a methodology, the third component of the project focused on conducting a global survey amongst technology holders to better understand their licensing activities. Indeed, this is the first large-scale CET licensing activity survey.

Technology holders were identified through the patent landscape process described in the previous chapter and with assistance from industry and business associations.

Structured in three parts (see Annex 11), the first part of the survey addressed more general elements of respondents' licensing practices and activities, including:

- the proportion of CET-related patents in the respondent organisation's overall patent portfolio;
- the importance of CET out-licensing and in-licensing;
- whether there had been a shift in the organisation's business strategy towards CET licensing within the past three years;
- identifying activities based on additional collaborative IP mechanisms (patent pools, cross-licensing, joint ventures, strategic alliances, etc.); and
- the relative importance of different IP-related activities to the respondent organisation's overall business strategy.

The second part of the survey focused on the following aspects of CET licensing in developing countries:

- the extent to which the respondent organisation was engaged in licensing activities in developing countries;
- the key developing countries in which licensing activities were currently taking place;
- the relative importance of different factors affecting the decision to enter into licensing agreements and other collaborative IP-based activities in developing countries (such as IP protection, scientific capabilities, infrastructure and human capital, market conditions and investment climate); and
- the willingness (and ability) of the responding organisation to provide for more flexible licensing terms (including monetary ones) in developing countries.

The final part of the survey concentrated on:

- whether the respondent was a private company, academic institution, governmental body, national laboratory, consortium, etc.;
- the location of the organisation's headquarters;
- the size of the organisation (i.e. multinational, large but focusing on domestic markets, SMEs, non-profit, etc.);
- the type of CET it dealt with (i.e. wind, biomass, biofuels, solar, ocean, wave, waste, etc.), and
- the intensity of its R&D activities.

The results of the survey were based on an aggregate analysis of all respondents without reference to individual replies. This was done to preserve confidentiality and in view of the commercial sensitivity of the information.

4.2
Profiles of survey respondents

As mentioned above, the licensing survey was distributed widely among different types of organisations. These included private companies, academic institutions, governmental bodies, national laboratories and consortia. The survey also took into account the size and geographical location of the respondent organisations. To better understand the relationship the respondent organisations had with CETs, the survey noted their particular technological fields of interest and the amount of R&D activity in them. 160 key organisations responded, and the response rate was roughly 30 per cent of the approximately 500 organisations which were approached.

Private companies were the main respondents, with 66 per cent of the replies. This figure was made up of 47 per cent multinationals and seven per cent large companies, mostly focused on domestic markets. SMEs with fewer than ten employees made up 24 per cent of the private-company respondents from the private sector.

Academic institutions, governmental bodies (including national research institutes) and other consortia of research bodies added up to 34 per cent of the total respondents.

Respondent organisations with headquarters in Germany, the US, Japan, France and the UK amounted to 74 per cent of the total respondents. The only respondents with headquarters in developing countries came from Brazil and South Africa, making up slightly more than four per cent of the total respondents. The remainder had headquarters in Europe or Canada.

The majority of respondents were active in the area of CETs, with 63 per cent focusing on biomass/biofuels (Figure 29).

29 Technology focus of respondents (Part C, Question 4)

Technology field	Percentage of responding organisations*
Biomass/Biofuels	63
Waste-to-energy	46
Solar PV	45
Wind	33
Other	25
Solar thermal	25
Hydro	15
Ocean/Wave	13
Geothermal	12

* which indicated they were active in the corresponding technolgoy field.

The largest number of respondents (42 per cent) considered themselves engaged in full-scale R&D activities, i.e. from the early stages of research up to the final stages of development, including the ability to introduce new innovative products into the market.

Approximately a third of the respondents (32 per cent) saw themselves as having significant R&D capabilities, though mostly concentrating on the early and middle phases of the process.

The remainder of the respondents categorised themselves as having limited R&D capabilities (18 per cent), focusing on improving existing technologies, or having low R&D capabilities (eight per cent), in that their business models were not focused on R&D.

Although not perfect in terms of a representative sample, the nature and type of organisations that did respond provide a useful cross-section for analysis. The remainder of the data analysis focuses on the more substantive findings of the survey in the following order:

- General practices and perceptions of the respondent organisations in respect of licensing;
- Participation in collaborative IP mechanisms and R&D activities;
- Licensing practices in CETs towards developing countries (non-OECD countries).

4.3
Licensing practices

Almost half (48 per cent) of the respondent organisations said CET-related patents constituted either a substantial or a significant part of their overall patent portfolio.[19] Organisations reporting a low share of CET-related patents amounted to 37 per cent. The remainder of the respondents (15 per cent) said CET-related patents constituted a negligible share of their overall portfolio.

Organisations were asked to rate the importance of licensing activities. For the purpose of the survey, licensing activities were broken down into out-licensing (where the owner of the technology licenses it out for a financial return) and in-licensing (where an organisation seeks access to a proprietary technology for its own purposes and activities). Organisations that considered out-licensing important amounted to 73 per cent of the respondents. Figure 30 provides a more detailed breakdown of responses relating to the importance of out-licensing to the business of the organisations surveyed.

A closer review of the data (Figure 31) showed that organisations for which CET-related patents constituted a substantial or significant part of their overall patent portfolio (CET-intensive sub-group) gave greater importance (84 per cent) to out-licensing activities compared with overall respondents. Entities rating out-licensing as very important or fundamental amounted to 53 per cent of respondents.

Further analysis showed that public bodies and academic institutions placed the greatest importance on out-licensing activities (Figure 32). Notably, 96 per cent of public bodies and 86 per cent of academic institutions replied that out-licensing was an important part of their business. Private companies placed a lesser degree of importance on out-licensing, with only 35 per cent recognising it as being a very important or fundamental part of their operations.

Disaggregating the data further, 45 per cent of responding multinational companies and 36 per cent of SMEs attached importance to out-licensing. However, over 50 per cent of multinationals and SMEs considered out-licensing to be of moderate importance.

With respect to in-licensing activities, only 53 per cent of respondent organisations attached importance to this type of activity, with 21 per cent giving it the status of very important or fundamental.[20]

Looking more closely at the data, CET-intensive organisations also attached greater importance to in-licensing activities compared with the rest of the respondents. However, the importance was not as striking as for out-licensing, with 67 per cent of CET-intensive organisations attaching importance to this type of activity. Only 31 per cent of CET-intensive organisations said in-licensing was very important or fundamental to their operations.

Different entities viewed in-licensing from their own perspectives: for example, academic institutions and public bodies attached less importance to in-licensing, given that their organisational model is more weighted to out-licensing (Figure 33).

SMEs gave slightly more importance to in-licensing than multinational companies (30 per cent and 25 per cent respectively). However, a larger share of multinationals (46 per cent) reported that in-licensing was of moderate importance, compared with 31 per cent of SMEs.

Aside from understanding the importance respondents attached to out-licensing and in-licensing, the survey also sought to gauge their attitudes towards CET licensing in the past three years.

Overall, 39 per cent of respondents reported that their business strategy had become more supportive of licensing compared with three per cent stating the opposite. However, 54 per cent stated that there had been no change in their business practice with respect to licensing in CETs.

Of the CET-intensive organisations, 34 per cent reported that their business strategy had become more supportive of licensing, compared with four per cent stating the opposite. As with the response of respondents overall, 60 per cent indicated there had been no change to existing practices.

Figure 34 provides responses to the above question by organisation type. Notably, public bodies reported the greatest shift towards licensing (54 per cent), followed by academic institutions (44 per cent) and private companies (33 per cent).

Deeper analysis of the responses by private companies showed 40 per cent of multinational companies were more supportive of licensing, compared with only 25 per cent of SMEs.

[19] For the purpose of this survey, the term 'substantial' represents a share of climate change mitigation technology-related patents that is greater than 50 per cent of the overall portfolio. The term 'significant' refers to a share of patents that is between 15 and 50 per cent of the overall portfolio.

[20] It should be noted that given the general focus of the survey questions on out-licensing (particularly in Part B), a selection bias may have occurred in the responses received.

30 Importance of out-licensing activities to respondent organisations (Part A, Question 2a)

	Percentage of total respondents
Negligible	27
Moderately important	33
Very important	31
Fundamental	9

31 Importance of out-licensing – CET-intensive organisations relative to all respondents in per cent

	All respondents	CET-intensive
Negligible	27	16
Moderately important	33	31
Very important	31	43
Fundamental	9	10

32 Importance of out-licensing – according to type of organisation in per cent

	Private companies	Academic institutions	Public bodies
Negligible	35	14	4
Moderately important	28	41	46
Very important	30	26	42
Fundamental	5	19	8

33 Importance of in-licensing – according to type of organisation in per cent

	Private companies	Academic institutions	Public bodies
Negligible	33	74	71
Moderately important	41	11	21
Very important	22	15	4
Fundamental	4	0	4

34 Change in business strategy towards licensing – according to type of organisation

	Private companies	Academic institutions	Public bodies
Less supportive	3	4	0
No change	57	52	46
More supportive of licensing	33	44	54
CET licensing is not part of my business strategy	7	0	0

4.4
Participation in collaborative IP mechanisms and R&D activities

In addition to understanding licensing activity, the survey sought to identify the level of involvement in collaborative IP-based mechanisms and co-operative R&D efforts. Collaborative IP-based mechanisms were categorised mainly as patent pools and cross-licensing, co-operative R&D efforts as strategic partnerships.

In terms of collaborative IP arrangements, 52 per cent reported that they rarely or never engaged in such mechanisms, whereas 48 per cent of organisations said they had occasionally or frequently been involved in collaborative IP-based arrangements.

As for co-operative R&D agreements, 83 per cent responded that they were occasionally or frequently engaged in such efforts.

Figure 35 provides a more in-depth view of how respondents replied when asked to rank the intensity of their various IP-based collaborations in relation to CETs. Notably, 68 per cent considered collaborative R&D agreements to be of high intensity in terms of their use of this mechanism as compared with all other IP-related activities. Other IP-based activities showing a high intensity in terms of their use were patent out-licensing (35 per cent), joint ventures or alliances (33 per cent), consulting and services (33 per cent) and technology out-licensing (31 per cent).

Further data showed that CET-intensive organisations used collaborative IP-based mechanisms slightly more than other respondent organisations, with 41 per cent indicating they were employed occasionally or frequently. This trend repeated itself in relation to co-operative R&D efforts, with the vast majority (93 per cent) of CET-intensive respondents stating they occasionally or frequently used the process.

35 Share of responding organisations reporting a high intensity in their use of different IP-based activities relating to CET patents and technology (Part A, Question 5)

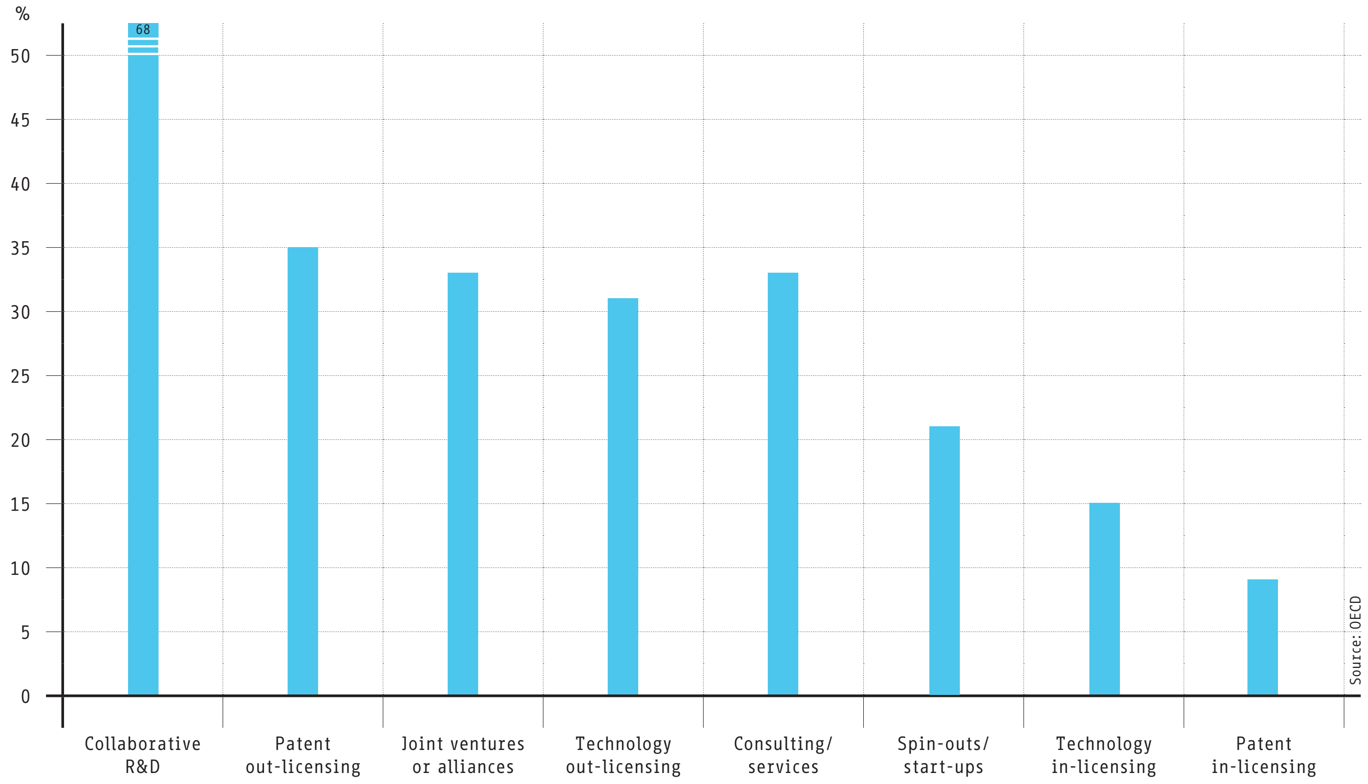


Figure 36 breaks down the share of CET-intensive organisations which indicated that they frequently engaged in the use of IP-based activities. Of all the activities, collaborative R&D (76 per cent) was the most frequently used option. This was followed by patent out-licensing (48 per cent) and joint ventures or alliances (42 per cent).

36 Share of responding organisations reporting a high intensity in their use of different IP-based activities relating to CET patents and technology (CET-intensive organisations relative to all respondents) in per cent

Type of IP-based activity	All respondent organisations	Responding CET-intensive organisations
Collaborative R&D	68	76
Patent out-licensing	35	48
Joint ventures or alliances	33	42
Technology out-licensing	31	39
Consulting/services	33	29
Spin-outs/start-ups	21	26
Technology in-licensing	15	20
Patent in-licensing	9	10

Compared with academic institutions, public bodies and private companies were more actively engaged in collaborative IP-based mechanisms. In comparison, all types of organisation reported an equally high level of involvement in co-operative R&D efforts.

Notably, multinational companies were more engaged in collaborative IP-based mechanisms than SMEs. SMEs occasionally or frequently used such mechanisms (19 per cent compared with 53 per cent for multinational companies). In contrast, there was a greater degree of similarity between the two types of organisation in the use of co-operative R&D efforts. Indeed, both multinationals and SMEs used collaborative R&D efforts more frequently than any other IP-based mechanism.

4.5 Licensing practices in relation to developing countries

One of the key objectives of the survey was to obtain insights into whether technology holders were actively involved in licensing CETs to firms and institutions in developing countries (non-OECD countries). Questions relating to the role of IPRs, scientific capabilities of licensees, market conditions, infrastructure and human capital and investment climate were presented in order to obtain a better sense of how important these factors were to licensors when making decisions. Finally, organisations were asked whether they would be more willing to offer more flexible licensing terms (including monetary ones) to entities based in developing countries.

The majority (58 per cent) responded that in the past three years they had not entered into licensing agreements with entities based in developing countries. Respondents that replied they had rarely entered into licensing agreements with developing country entities constituted 25 per cent of the sample. Only 17 per cent of organisations stated they frequently (five per cent) or occasionally (12 per cent) entered into licensing agreements with developing countries.

However, these numbers have to be seen in the broader context of reality in the field of technology out-licensing in general. Findings from other industries indicate that there are several hurdles to overcome in out-licensing due to a number of factors such as transaction costs, and challenges in identifying a suitable partner and mutually agreed licensing conditions (i.e., pricing and the geographical or exclusive scope of the agreement). Indeed, the willingness to out-license does not tend to reflect the level of licensing (Zuniga and Guellec, 2009).

Figure 37 highlights the developing countries where respondents have engaged in licensing or other IP-based activities. Notably, China, India, Brazil and Russia all constitute fertile markets and are likely competitors.

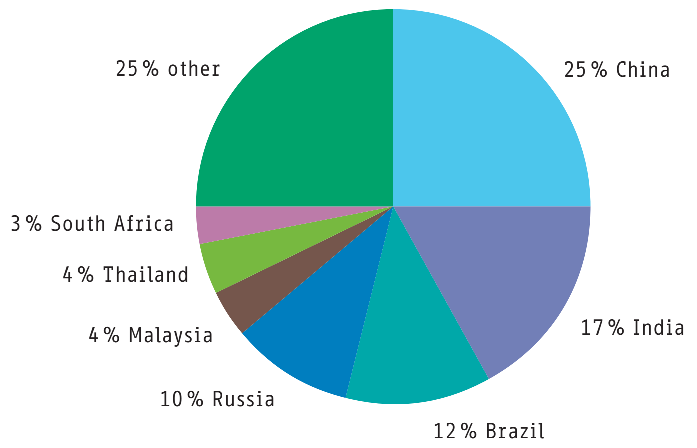
The survey asked respondents to rank the impact of various macroeconomic factors on their decision to enter into licensing agreements with recipients based in developing countries.

An aggregate analysis of the overall importance that respondents attached to four different macroeconomic factors influencing licensing activities is presented in Figure 38.

Protection of IP in the recipient country is of importance to respondents when considering whether to enter into licensing agreements. It is considered an important factor by 82 per cent of organisations, with 54 per cent stating that it was either a significantly attractive condition or a compelling reason for an agreement.

However, the protection of IP alone, as generally recognised in the relevant literature, was not the only important factor in deciding whether to license to developing country entities. In line with findings in literature as well as empirical studies (see Chapter 2 above), scientific capabilities, infrastructure and human capital, favourable market conditions and investment climate were actually considered slightly more important, with between 85 and 87 per cent of respondents stating so.

37 Developing countries with which respondent organisations have been most involved with regard to licensing agreements or other IP-based commercialisation activities involving CETs (Part B, Question 2)



Source: OECD

The licensing survey

Viewing Figure 38 from different perspectives, respondents did see protection of IP as being a more compelling reason to enter into a licensing agreement than all the other factors (25 per cent against an average of 15 per cent for the other conditions). Yet organisations also considered IPRs to be less of a factor compared with all the other conditions.

A separate analysis of the data in Figure 38 was also done with respect to organisations that had during the last three years occasionally or frequently entered into licensing agreements which involved recipients based in developing countries. For the purpose of this analysis these entities are called 'licensing-intensive' respondents.

Figure 39 compares the general response in the sample in Figure 38 with licensing-intensive respondents (shaded in grey). Notably, 89 per cent of licensing-intensive respondents attached greater importance to IP protection as compared with 82 per cent of the general respondents. Also, IP protection carries slightly greater weight amongst licensing-intensive organisations than the other factors. For example, 87 per cent of licensing-intensive respondents saw scientific capabilities, infrastructure and human capital as important. It would seem that IP protection is a more important factor for organisations which have previously engaged in licensing agreements in which a proprietary technology is ready to be licensed to a developing country.

38 Impact of different macroeconomic factors on the decision to enter into licensing agreements (and other collaborative IP-based activities) with recipients based in developing countries in per cent (Part B, Question 3)

	Protection of IP	Scientific capabilities, infrastructure and human capital	Favourable market conditions	Favourable investment climate
Not a factor	18 (of all respondents)	13	16	15
A basic precondition for doing business, but not a driving factor	28	37	26	27
Significantly attractive condition, would encourage negotiation	29	37	44	42
Compelling reason for an agreement	25	13	14	16

39 Importance of macroeconomic factors in the decision to enter into licensing agreements (and other collaborative IP-based activities) with recipients based in developing countries – licensing-intensive organisations relative to all respondents in per cent

	Protection of IP	Scientific capabilities, infrastructure and human capital	Favourable market conditions	Favourable investment climate
Not a factor	18	13	16	15
	11	13	14	13
A basic precondition for doing business, but not a driving factor	28	37	26	27
	34	36	29	29
Significantly attractive condition, would encourage negotiation	29	37	44	42
	31	38	42	40
Compelling reason for an agreement	25	13	14	16
	24	13	15	18

After analysis of the various factors that are important to organisations when deciding whether to enter into licensing agreements with entities from developing countries, the final question asked was whether proprietors would be more willing to provide more flexible licensing terms in such circumstances where the country had limited financial capabilities.[21]

Overall, the majority of the sample (70 per cent) indicated they would be willing to provide more flexible licensing terms to recipients from developing countries. Respondents stating they would be willing to offer 'substantially' more accommodating terms amounted to five per cent, with 15 per cent prepared to offer 'much more' accommodating terms.

Comparing the general responses with licensing-intensive organisations, the latter group would be more prepared to offer more flexible terms to licensees from developing countries (78 per cent). **Figure 40** provides further analysis of the comparison between general respondents and licensing-intensive respondents.

Further analysis showed that academic institutions that responded were the most willing to provide more flexible terms to developing country recipients with limited financial capacity. Public bodies were the next most likely. SMEs were slightly more likely than multinationals to offer more flexible terms.

40 Willingness of CET patent owners to provide more flexible licensing terms in per cent (including monetary ones) to entities based in developing countries – licensing-intensive organisations relative to all respondents

Willingness to provide more flexible licensing terms	of total respondents	of licensing-intensive respondents
No difference in licensing terms	30	22
Licensing terms are more flexible	50	58
Licensing terms are much more accommodating	15	16
Licensing terms are substantially more accommodating	5	4

21 The survey did not make a distinction between willingness to provide more accommodating licensing terms and the actual granting of such terms. The reasons for this included: organisations being sensitive to questions that may seem 'probing' into confidential information, and the desire to elicit a response from respondents which had yet to be involved in such licensing deals.

5 LOOKING FORWARD

Looking forward

5.1 Recapitulation of main findings and activities

According to the patent landscaping data and the statistical analysis, claimed priorities patenting rates in the selected CETs have increased at a rate of roughly 20 per cent per annum since 1997. In that period, patenting in CETs has outpaced the traditional energy sources of fossil fuels and nuclear energy. Since this surge of patenting activity in CETs coincided with the adoption of the Kyoto Protocol in 1997, there is a strong signal that political decisions setting adequate frameworks do matter for the development of clean energy technologies. The fields experiencing the most intensive growth include solar PV, wind, carbon capture, hydro/marine and biofuels.

Patenting in the selected CET fields is currently dominated by OECD countries. However, a number of emerging economies are showing specialisation in individual sectors, providing further competition in the field and maybe ultimately changing the future of the CET patent landscape in CETs.

The leading six countries with actors innovating and patenting CETs are Japan, the US, Germany, the Republic of Korea, the UK and France. This reflects patenting trends in other technology sectors (WIPO, 2009). Aside from the geothermal field, concentration in all sectors is relatively high. Notably, the top five countries account for almost 80 per cent of all claimed priority patent applications in the CETs reviewed. Interestingly, each country shows leadership in different sectors. For example, Japan is currently responsible for half of the claimed priority patents covering solar PV, while Germany has the most activity in the wind sector.

Although at first glance it appears that the top five countries dominate patenting in CETs, a number of other countries appear as relevant actors. For example, if the data is normalised as a percentage of the total number of claimed priorities (all technology sectors) in a given country, India features within the top five countries for solar PV, while Brazil and Mexico occupy the top two positions in hydro/marine.

In terms of patent filing trends between countries (i.e. filings concerning the same invention and submitted in several countries/regions), most activity is, not surprisingly, taking place in the top five individual patenting countries. However, China is the next most important destination for filing claimed priority patents for actors in the top five countries.

Finally, the patent landscape also identified which technologies, including their sub-groups, have peaked in maturity and where future activity might be concentrated. Of all the technologies studied, solar thermal appears to have already peaked and is an area with low technical barriers to entry. One area within solar thermal showing growth is that of technologies used for mounting and tracking devices. The wind sector does not show any signs of maturity yet, with patent numbers for onshore and offshore towers still growing.

The licensing survey revealed that whereas there is overall little CET out-licensing activity towards developing countries, the general level of such activity is no lower than in other industries. Moreover, there are difficulties with out-licensing due to a number of factors such as transaction costs, identifying a suitable partner and mutually agreed licensing conditions. Indeed, the results of the present survey show that the willingness to out-license does not tend to reflect the level of licensing. As the results of the present survey show, this trend seems to be even greater for CETs.

However, this overall difficulty with markets for licensing may create particular challenges in the case of CETs, where rapid diffusion is critical. Thus there is a need for improving market conditions and encouraging licensing in the context of efforts to enhance transfer of technology to developing countries. For the time being, where licensing agreements have been entered into, the main beneficiaries are China, India, Brazil and Russia.

The survey results also provide some useful insights as to the perceptions of technology holders in undertaking out-licensing activity. Generally, IP protection in the country of the licensee was an important consideration when determining whether to enter into a licensing agreement. However, IP protection in the recipient country was not found to be the only significant factor for licensing agreements in developing countries. Overall, respondents attached slightly more weight to factors such as scientific infrastructure and human capital, favourable market conditions and investment climates. However, licensing-intensive respondents attached somewhat greater importance to IP protection than to the other above-mentioned factors.

At the same time, 70 per cent of respondents said they were prepared to offer more flexible terms when licensing to developing countries with limited financial capacity. Notably, academic institutions and public bodies were slightly more willing than private enterprises to provide accommodating licensing terms to developing country recipients. SMEs were slightly more likely than multinationals to offer more flexible terms. Another useful finding was that the majority of organisations preferred collaborative R&D activities, patent out-licensing and joint ventures to mechanisms such as patent pooling and cross-licensing.

5.2 A new classification scheme for clean energies

Patent offices systematically classify patent documents and also non-patent literature in order to assist with administration and patent searching. Patent classification systems are arranged in a hierarchical structure and provide different technologies with different alphanumeric codes. This hierarchical structure is typically arranged into sections, subsections, classes, subclasses, groups and subgroups. Figure 41 gives an example of how wind motors would be classified under the most commonly used classification system, the International Patent Classification (IPC).

While the IPC is the most widely used classification system, with approximately 70 000 subdivisions (covering documents published after 1968), it is not the most extensive, as patent offices often define further subdivisions internally. For example, the European Classification system (ECLA) developed by the EPO builds on the IPC and includes approximately 135 000 subdivisions.

Since it may be assumed that almost all CETs have been involved in the patent system at a certain moment (this does not mean they are all still patented everywhere, as patents are time-limited territorial rights), the public information stream established by the patent system could in principle deliver quite a complete inventory of CETs.

However, a major difficulty for research in the field of CET patenting is that the current patent classification schemes often do not correlate with the type of information sought by the policy-makers in UNFCCC debates and negotiations. For instance, they are currently unable to provide the type of information suggested by scholars like Peter Drahos (Drahos, 2010), with a view to establishing a 'technology platform that searches all the world's patents, allowing users to organize that information in various ways (around ownership, technologies, countries etc.)'. In addition, new technology areas may not be easily classifiable in the existing schemes as a consequence of their overlapping nature or because of disagreements on terminology.

This makes it challenging for policy-makers and others to retrieve the patent information and produce patent technology landscapes without expending considerable resources and expertise. Moreover, even if the necessary resources and expertise are available, the data retrieved in such analyses may be of limited value as it reflects only the current snapshot of dynamically changing, transient landscapes.
The prevailing trends of today would not necessarily reflect tomorrow's realities, in particular in the CET field. Responding to this need for sound data and evidence was the main objective that led to the current UNEP-EPO-ICTSD project.

The question was therefore how the classification procedures applied by patent offices might be used in order to generate a reliable, transparent and continuously updated patent-related information platform for climate change mitigation (and possibly also adaptation) technologies.

The EPO undertook a similar project with the introduction of a new classification scheme in the field of nanotechnology. In the nanotechnology case it was necessary to define 'only' one consistent criterion. Nonetheless, this proved to be more difficult than expected. After having looked into different existing definitions, Scheu et al. (Scheu et al., 2006) conclude: 'A survey of opinions of European researchers also confirms a lack of consensus on what exactly nanotechnology is.' In the case of clean energy and other climate change mitigation technologies, extending over vast technological sectors (energy, buildings, transport, industry, agriculture, etc.), the task is much more complicated. In order to deliver accurate patent data, a patent classification system must go beyond the level of the industrial sector (in classification language, the subclass level) to also consider the applications of a technology, such as apparatuses and even components and subcomponents (including hardware and software).

This required hundreds of new categories to be defined in a formal, technical vocabulary (compared with just six in the case of nanotechnology) and introduced into the patent examiner's workflow. A reclassification on this scale was unprecedented.

Moreover, in contrast to the nanotechnology reclassification exercise, relying only on the European classification collection to retrieve the related patents was not considered sufficient in the context of CETs. An additional effort (e.g. using a combination of the IPC with keywords, even if no ECLA code exists) made it possible to capture documents from the Republic of Korea or Japan as well without having a family member already captured by the European classification.

Despite these challenges, the EPO under the current project was able to establish a new patent classification for CETs and make it available to interested parties. The data will also be included in a future edition of the EPO's Worldwide Patent Statistics Database (PATSTAT) and will be regularly updated through a procedure similar to the one already put in place for the nanotech-related scheme (Scheu et al., 2006).

41 IPC structure for wind motors

Section F	Mechanical engineering, lighting, heating, weapons, blasting
Subsections to Section F	Engines or pumps, engineering in general, lighting, heating, weapons, blasting
Classes	E.g. F02 combustion engines, F03 wind, spring or weight motors
Subclasses	E.g. F03D wind motors
Groups	F03D 1/00 wind motors with rotation axis substantially in wind direction
Subgroups	F03D 1/02 with plurality of rotors

Annex 12 provides an idea of the depth and structure of the classification scheme for the carbon capture and energy generation sectors.[22] Close to 700 000 patents (not necessarily all in force) have been retrieved and tagged within the two sectors. Finally, Annex 13 offers a comparison of the new scheme with the ex-ante situation for a selected sector and gives more detailed insight into how the patent documents existing worldwide are correlated with the new classification categories.

In summary, this classification scheme offers non-expert users of patent-related information the following advantages:

- Worldwide patent coverage
- All relevant technologies gathered together in one place, i.e. no in-depth knowledge of IPC or ECLA necessary
- Detailed breakdown to component level (for example: dye-sensitised solar cells, offshore wind towers, IGCC, biomass torrefaction, direct methanol fuel cells, smart grids, etc.), all with their own separate entries
- Regularly updated with the latest patent publications

However, whether further climate change technology sectors (buildings, transport, industry, agriculture, waste management) can be addressed in the same manner is still an open question in view of the considerations highlighted above. It would be important to collaborate with experts from UNFCCC, IPCC and key stakeholders to make the necessary fine-tuning to the technology mappings undertaken by ICTSD with the support of UNEP in the remaining sectors (buildings and transport).

5.3 Future areas of research

While the project's findings are groundbreaking in many respects, further areas of research need to be explored in order to gain a better grasp of the issues involved and their implications in terms of policies and guidance for future action at the international level.

A pivotal area where more information is needed is the demand side of the debate. Currently, most studies, including the present one, were tackled from the supply-side perspective. A licensing survey capturing the views of entities in the developing world seeking access to climate change mitigation technologies is necessary. Such an inquiry could look at concerns and important factors for potential licensees when entering into agreements. This could potentially reveal a better understanding of the role of tacit knowledge in the transfer of such technologies and whether IPRs are as significant an issue. These surveys should - beyond reaching major business associations - encompass more representatives from SMEs as well as research centres and philanthropic institutions from both developed and developing countries. Further input from business associations specialising in renewable energies could also contribute to a broader understanding of the challenges ahead.

Although the survey results indicated licensors would be more willing to be flexible in their terms with developing countries, an important question that needs to be addressed more specifically is whether such conditions would be applicable to the latest technologies. Thus more specific surveys might be needed to better understand licensing behaviour and prospects for improved forms of technology transfer.

Earlier studies (e.g. Mansfield, Maskus) have documented differences across industries in relation to the role of patents and other policies in technology transfer. Some of these studies have found different trends in the type of technology transfer that occurs between industries with 'low' and 'high' technology characteristics as measured crudely by R&D and sales ratios, among other criteria. Given the considerable heterogeneity within the various sectors of climate change mitigation technologies which may fit the 'low' and 'high' technology characteristics, it would be interesting to see whether, within each sector, policies have a different impact on the tendency to follow the FDI route or enter into licensing agreements.

Regarding patent data, an important research need is to look at technologies which have matured and are off-patent. Indeed, this was one of the requests made in paragraph 9 of the Rio Declaration's 'Basis for Action', which stated:

'A large body of useful technological knowledge lies in the public domain. There is a need for the access of developing countries to such technologies as are not covered by patents or lie in the public domain.'

A number of studies (e.g. Barton) suggest that developing countries should be able to access these older technologies. It would be useful for developing country entities lacking patent landscaping resources to have access to such an information platform. Indeed, this lack of transparency is a continuing problem in the debate on access to medicines because generic producers of medicines are unclear as to whether they have the freedom to operate in countries where patent data is difficult to obtain. Given the significant transaction costs involved in patent landscaping, support from patent offices in this area is essential if local companies from developing countries could be using off-patent technologies but are apprehensive about doing so.

The patent landscape reviewed in this report indicates that for many of the sectors studied there seems to be sufficient competition in the marketplace, taking into account the market share of the major players. However, as predicted by Cahoy et al. with certain markets, such as for biofuels, we may see a level of consolidation in patent ownership by a few organisations. Monitoring assignments of patents between companies will be important as they could potentially alter the future landscape for how technology transfer occurs and whether a few companies will hold the key to important technologies.

Another constructive step would be to compile a landscape that identifies patented inventions (and their owners) that have been commercialised in the marketplace. This would give a better idea of which technologies are working and inducing technological change. Having such information would make it easier to identify whether the proprietors of such patents are involved in licensing or other technology transfer. Admittedly, this could be a difficult undertaking given that it may impinge on the confidentiality companies can attach to patent data.

While patent numbers offer an indicator of innovation in a given technological field, a more precise method of assessing innovation and the relevance of such technologies would be to review a cross-section of patents owned by leading applicants in the different CET sectors. The analysis would look at the claims of the various patents held by entities to identify whether there is a depth of innovation in the field. Such information would help identify patent quality issues and whether and how efficiently patent practices promote competition in the marketplace. Indeed, as various patent offices expedite examination of patent applications for 'green technologies', the issue of patent quality becomes more pertinent.[23]

Having a more in-depth analysis of patents filed in each CET sector would better serve our understanding of the innovation dynamics there. It would also help shed light on whether or not to consider alternative incentives to support transfer of technology to technologically less advanced countries.

Finally, a study of patenting by publicly funded institutions and universities would also be important in helping to understand the source of new technologies and the role of government funding. Such a study could also provide useful information that could help track how such organisations conduct their technology transfer and whether they provide favourable terms to developing countries.

[22] The new classification section is referenced under the European classification system by the new class code 'Y02' (title: Climate Change Mitigation Technologies). With the publication of the present report the industrial sectors Y02C (GHG capture or storage/sequestration or disposal) and Y02E (GHG emissions reduction technologies related to energy generation, transmission or distribution) are completed and rendered public via the EPO's patent information service *esp@cenet*.

[23] See for example 'UK 'Green' inventions to get fast-tracked through patent system' at http://www.ipo.gov.uk/about/press/press-release/press-release-2009/press-release-20090512.htm and 'The USPTO will pilot a program to accelerate the examination of certain green technology patent applications' at http://www.uspto.gov/news/pr/2009/09_33.jsp.

5.4
Policy implications and conclusions

By designing a rigorous methodology and creating a public platform that will produce reliable and continuously updated data for clean energy technologies, this study is intended to be a further step in contributing, in the medium and long term, to evidence-based debate on the role of IPRs in the development and deployment of technology.

The project commenced in April 2009. Along the way, and in the light of this report's findings, a number of lessons have been learnt which could help further bridge the gap between evidence and policy-making.

(1) Policy processes can have a positive impact on technology development.

There is overwhelming consensus on the need to further develop new technologies to combat the effects of climate change. As identified in this study, and confirmed by previous studies, the surge in patenting around CETs, occurring following the signing of the Kyoto Protocol, suggests that clear policy signals from climate negotiations can be effective in stimulating technology development.

(2) Accurate and publicly available information on existing and emerging clean energy technology, including IPRs and licensing, is urgently needed.

One of the significant landmarks of this project has been the EPO's creation of a new classification scheme for climate change mitigation technologies as discussed above. In terms of building on the empirical data gathered thus far and to move the debate forward, there is a need for additional research. Many of these pathways have been identified in the previous section of this chapter.

However, while improved classification systems contribute to transparency of patent data beyond the patent community, there are further, more complex issues that developing country entities tackling the issue of access to CETs have to address (e.g. costs and licensing conditions for such technologies).

The need for continuous information supply about climate change mitigation technologies has been voiced persistently since the Earth Summit and Agenda 21 in 1992. However, one of the lessons learned in this project is that gathering, analysing and providing access to information on clean energy technologies, including IPRs and licensing aspects, is a costly and complex task. It involves a wide and diverse set of actors such as governments, IP authorities, the private sector, international and regional organisations, academic experts and non-governmental organisations. There is a need to foster partnerships and collaboration between such actors in order to combine their different skills and expertise.

Ultimately, reliable and accurate patent and technology data is not an end in itself. The limitations of using such data for technology acquisition are well known. However, such information is an important component - among others - of an enabling environment for innovation and technology transfer. As stated in Agenda 21, 'the primary goal of improved access to technology information is to enable informed choices, leading to access to and transfer of such technologies and the strengthening of countries' own technological capabilities'.

In the light of the above, technology information platforms should be an essential component of the emerging new technology transfer architecture. Relevant stakeholders mentioned above could present their views on how such platforms would operate.

(3) Facilitate untapped potential in licensing of clean energy technologies to developing countries.

By conducting the first licensing survey in the field of CETs, it is hoped that the information obtained will fill some of the lacunae that exist in current UNFCCC negotiations with respect to the issue of IPRs and technology transfer. Of course, as already mentioned, further work remains to be done in order to obtain a more holistic view of the issues involved.

The data retrieved from the survey provides some much needed understanding into the thinking of potential licensors of pertinent technologies. For instance, the limited licensing activity to entities from developing countries, confined mainly to China, India and Brazil, stems from several considerations involving important macroeconomic factors but also IP-related questions. In particular, the general level of out-licensing activities with CETs does not seem to be lower than in other industries. The results of the present survey show this trend to be even greater for CETs.

On a positive note, it should be pointed out that 70 per cent of respondents said they were prepared to offer more flexible terms when licensing to developing countries with limited financial capacity. Another encouraging finding is that the majority of organisations preferred collaborative R&D activities, patent out-licensing and joint ventures to mechanisms such as patent pooling and cross-licensing.

It is important, therefore, for negotiating countries in the UNFCCC context to look beyond single factors as the cause for the lack of technology transfer and to search for collaborative solutions, but at the same time not to exclude or downgrade the importance of any one factor.

Taking into account the untapped licensing potential revealed by this study, there may be scope for making licensing more supportive of efforts to enhance technology transfer, particularly as licensing is an important channel for technology transfer and issues pertaining to licensing have figured prominently in past international negotiations on technology transfer and intellectual property.

Of course, licensing agreements vary considerably in accordance with the nature and purpose of the commercial transaction between two parties and market conditions. They are mostly of a confidential nature. It appears difficult to envisage stringent or uniform rules to regulate such dealings, and efforts in such a direction have had mixed success in the past.

It is also important to recognise that negotiating licensing agreements on a case-by-case basis can be costly and time-consuming, particularly for developing country entities that might lack adequate negotiating skills and expertise in this area. A new policy framework could thus help to lower licensing transaction costs. For instance, the Report by the Chair of the Expert Group on Technology Transfer (FCCC/SB/2009/3/Summary) suggests 'innovative licensing models'. According to this report, 'successful technology transfer requires a balanced approach to IP, ensuring that developing and developed country businesses and investors have opportunities to license IP and that effective systems are in place to protect and enforce IP rights'. It further suggests that 'consideration also needs to be given in some cases to more proactive approaches to facilitate technology access, such as proposals for subsidized technology licensing'.[24]

Some private-sector organisations such as the World Business Council for Sustainable Development (WBCSD) and the World Economic Forum (WEF) have expressed support for 'an international set of core contractual principles for business engaging in clean energy technology licensing in developing countries' (CEO Climate Policy Recommendations to G8 Leaders, July 2008, WBCSD/WEF).

The fact that there seems to be considerable untapped licensing potential towards developing countries, also taking their limited financial capacity into account, is a matter that could be better reflected upon in the current UNFCCC negotiations.

There might therefore be a need to develop models and platforms that could be used to assist companies to signal their licensing needs and preferences, including entities from developing countries. This would increase market transparency, help potential licensors and licensees to match supply and demand, and reduce transaction costs.

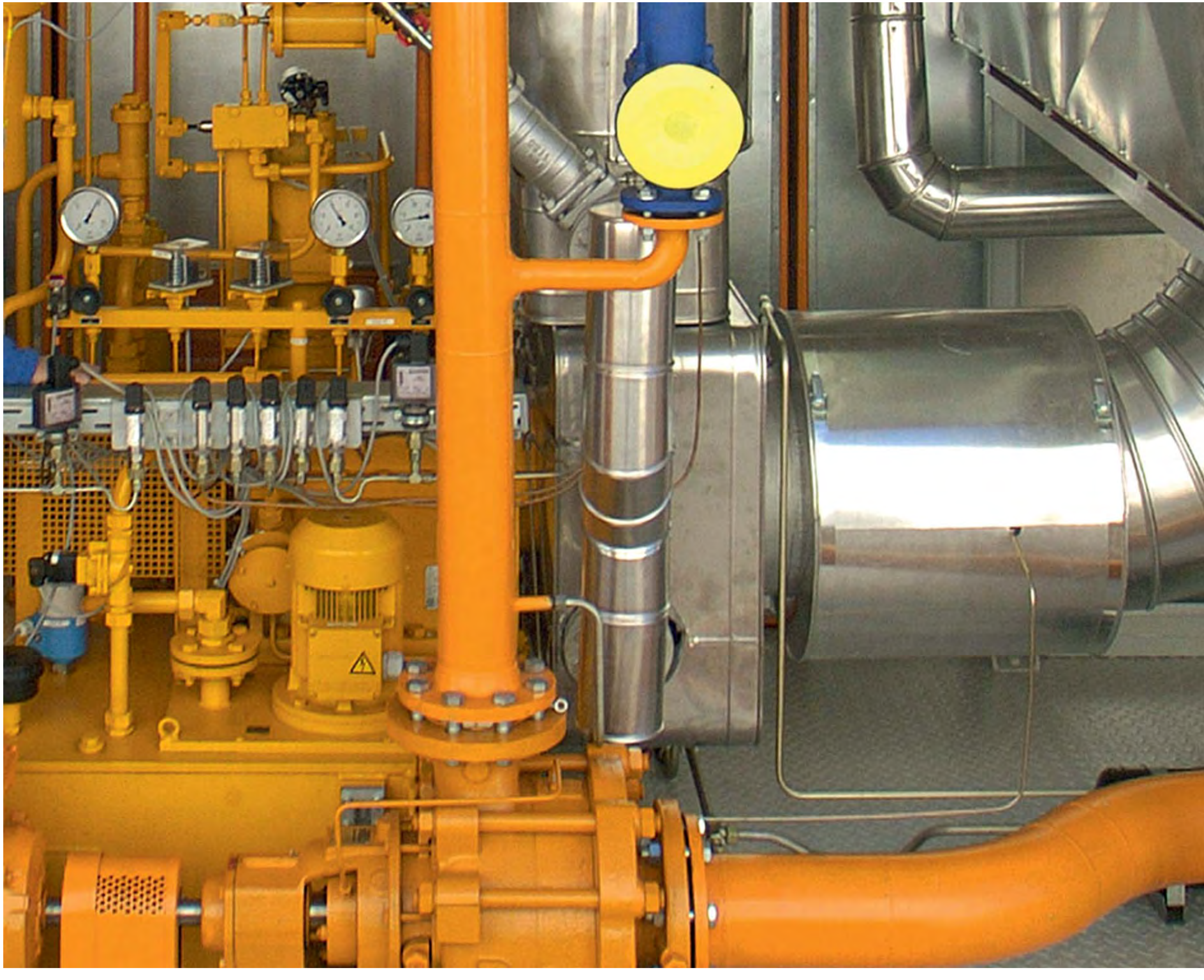
For instance, the elaboration of 'guidelines' on licensing climate change mitigation technologies on 'fair and reasonable terms' for developing countries could be envisaged. This would be particularly relevant for the diffusion of the results of publicly funded research.

In addition, expanding capacity building for developing countries in the area of negotiating technology licensing so as to maximise the benefits for their indigenous technological development is another area which could receive greater attention (Cannady, 2009).

Ultimately, greater and better availability of technological information, including on IPRs, and facilitating licensing of clean energy technologies to developing countries appear to be the most concrete and practical measures that could possibly find an immediate echo in current climate change negotiations.

[24] Page 21 of UNFCCC/SB/2009/3.

ANNEXES



Annexes

Annex 1

State of the art of renewable energy resources

Energy source	Conversion technology	Operational capacity 2007 (MW_e/MW_{th})	Stage of development	Main trends
Solar	Concentrating solar power (CSP)	354[1]	Deployment	Renewed interest with accelerating growth
	Solar heating and cooling		Commercial (partially)	Rapid commercialisation
	Photovoltaic power (PV)	9100	Deployment (partially)	Rapid growth
Wind energy		90520	Largely commercial	Rapid commercialisation
Ocean	Tidal range	260	Deployment	Feasibility investigated (UK)
	Tidal stream	<5	Demonstration	Early deployment
	Wave power	<5	Demonstration	Early deployment
	Ocean thermal		Research and development	Needs further research and development
	Energy conversion (OTEC)			Demonstration
	Salinity gradient		Research and development	Needs further research and development
Geothermal	Geothermal power	8590	Commercial (partially)	Small-scale and deep geothermal need research and development
	Geothermal heat	15145[2]	Commercial	Further growth
	Ground-source heat pump		Deployment	Rapid commercialisation
Hydropower	Mini hydro (<1 MW_e)	~73000[1]	Commercial	Further growth
	Small hydro (1-10 MW_e)			
	Large hydro (>10 MW_e)	~870000[2]	Commercial	Further growth
Biomass	Combustion	>9700	Commercial (partially)	Rapid commercialisation
	Gasification		Deployment (partially)	Needs further research, development and demonstration
	Digestion		Commercial (partially)	Rapid commercialisation
	Biofuels		Deployment (1st generation)	Needs further research, development and demonstration (2nd generation)

[1] At the end of 2006
[2] At the end of 2000

Source: Lako 2009

Annexes

Annex 2

Overview of renewable energy technologies in the (pre-) commercial stage and worldwide application

Energy source	Main application	Technology/Good	Europe	North America	Former Soviet Union	Middle East	China	India	Other Asia and Pacific	Latin America	Africa
Solar	Solar thermal	Solar concentrator, mirror-based	●	●							●
		Fresnel lens-based									
	Solar heating and cooling	Hot water, room heating and cooling	●	●	○	●	●	●	●	○	○
	Photovoltaic power (PV)	Current types of PV	●	●	○	●	●	●	●	○	○
		Thin-film-based	●	●				●	●		
Wind	Onshore wind		●	●	●	●	●	●	●	●	●
	Offshore wind		●								
Ocean	Wave power	Pelamis energy converter	○								
		Other, e.g. Archimedes Wave Swing	○	○				○			
	Tidal power	Tidal barrier	●	●							
		Tidal stream	○	○							
Geothermal	Geothermal power		●	●			●		●	●	●
	Geothermal heat		●	●	●		●	●	●	●	
	Geothermal heat pump		●	●					●		
Hydropower	Hydraulic turbines	Less than 1 MW	●	●	●	●	●	●	●	●	●
		1–10 MW	●	●	●	●	●	●	●	●	●
		In excess of 10 MW	●	●	●	●	●	●	●	●	●
Biomass	Biomass-based power/heat	Combustion	●	●	●		●	●	●	●	●
		(Small-scale) gasification	●	●			●	●			
		Digestion (anaerobic)	●	●	●	●	●	●	●	●	●
		Co-combustion/co-gasification	●	●			●	●			
	First-generation biofuels	Pure plant oil (extraction)	●	●			○	○	○	○	○
		Bio-ethanol	●	●			●		●	●	
		Bio-diesel	●	●			●	●	●	●	○

Source: Lako 2009

Note: In some regions, application of specific technologies has been marginal until now, which is denoted by ○.

Annex 3

Renewable energy technologies/goods currently in the research and development stage but with strong prospects for commercialisation in the near to medium term

Energy source	Main application	Technology/Good	Commercialisation projected before 2015	Commercialisation projected beyond 2015	Main components
Solar	Solar heating and cooling	Solar heating systems and seasonal storage	●		Solar collectors and seasonal storage
		Cooling	●		Solar collectors and cooling system
	Photovoltaic power (PV)	PV based on nanotechnology	●		Nanotechnology PV
Wind	Floating offshore wind		●		Offshore wind turbines based on floating structures
Ocean	Ocean thermal energy conversion (OTEC)			●	Piping system, turbine-generator set, floating structure
	Salinity gradient			●	Piping systems, membranes and electric generators
Geothermal	Geothermal power	Small-scale geothermal power	●		Drilling technology, organic Rankine or Kalina cycle
		Hot dry rock		●	Drilling and electrical conversion
Biomass	Biomass-based power/heat	Large-scale gasification	●		Gasifier, adapted combined cycle system
		Pyrolysis	●		Pyrolysis process, upgrading of oil and gas
		Torrefaction	●		Feed system and torrefaction reactor
	Second-generation biofuels	Cellulosic ethanol (CELEtOH)	●		New enzymes and ethanol production processes
		Second-generation biodiesel	●		Biomass gasification and Fischer-Tropsch synthesis
		DME (based on gasification)		●	Biomass gasification and DME synthesis
		Bio-refinery		●	Bio-refinery processes
		Algae		●	Reactors

Source: Lako 2009

Annex 4

First EPO taxonomy of CET data used by OECD Environment Directorate for the analysis in Chapter 3.3

Sector	Sub-sector, application, apparatus, component
Geothermal energy	Earth coil heat exchangers Systems injecting medium directly into ground (hot dry rock system, underground water) Geothermal heat pump (for buildings) Pipes and other hardware
Hydroenergy	Conventional (e.g. with dams, turbines and waterwheels) Ocean thermal energy conversion (OTEC) Oscillating water column (OWC) Salinity gradient Tidal stream and damless hydropower (e.g. sea flood and ebb, river, stream) Wave energy (e.g. Pelamis)
Solar thermal energy	Dish collectors Fresnel lenses Trough concentrators Tower concentrators Heat exchange systems Mountings or tracking
Photovoltaic (PV) energy	Amorphous silicon PV cells CuInSe2 material PV cells PV systems with concentrators Dye-sensitised solar cells Solar cells from Group II-VI materials Solar cells from Group III-V materials Microcrystalline silicon PV cells Polycrystalline silicon PV cells Roof systems for PVC cells
Thermal-PV hybrids	
Wind energy	Blades or rotors Components or gearbox Control of turbines Generator or configuration Nacelles Offshore towers Onshore towers
Biofuels	Combined heat and power (CHP) turbines for bio-feed Gas turbines for bio-feed Bio-diesel Bio-pyrolysis Torrefaction of biomass Cellulosic bio-ethanol Grain bio-ethanol Bio-alcohols produced by other means than fermentation
Carbon capture	Capture by absorption Capture by adsorption Capture by biological separation Capture by chemical separation Capture by membrane diffusion Capture by rectification or condensation
Carbon storage	
Combined combustion	Integrated Gasification Combined Cycle (IGCC) IGCC combined with CCS

Annex 5

Country trends for selected CETs (1988-2007)*

	Solar PV	Solar thermal	Wind	Geo-thermal	Hydro/-marine	Biofuels	Carbon capture	Carbon storage	IGCC	Selected CETs	Fossil and nuclear energy	All sectors (total)
JP	**3 941**	**142**	**196**	**32**	**199**	**112**	**104**	**6**	**37**	**4 672**	**5 751**	**691 751**
US	**1 303**	**172**	**320**	**50**	**387**	**135**	**199**	**19**	**56**	**2 508**	**5 543**	**423 187**
DE	**931**	**450**	**649**	**44**	**259**	**133**	**79**	**4**	**27**	**2 391**	**5 840**	**334 119**
KR	**802**	13	32	1	26	11	10			**885**	584	**107 001**
FR	**242**	**88**	84	10	**104**	**45**	**60**	**9**	4	**607**	**2 795**	**126 924**
UK	212	47	87	9	**174**	**27**	**28**	**3**	**11**	560	**1 039**	84 062
IT	87	**53**	41	8	75	27	9		1	272	849	46 492
NL	96	51	56	9	22	13	14	1	3	236	539	29 009
CA	51	39	49	**11**	59	22	17	**3**	2	233	549	35 528
TW	160	11	9	2	14	4				195	122	20 850
CH	75	35	16	7	39	12	4	1	5	179	600	27 081
DK	5	5	**152**	2	17	4	1			177	175	7 929
ES	29	42	**90**	1	25	6	2	1		174	176	10 738
CN	80	13	20	6	14	11	4		1	143	108	18 892
AT	39	35	20	**11**	37	11	1		2	137	416	19 144
SE	23	18	34	7	35	6	1		**7**	122	719	27 986
NO	13	12	28	7	54	0.2	20	**3**	2	119	165	6 362
AU	41	43	11	1	22	7	3		3	112	132	10 150
FI	11	8	18	3	10	25	4		**7**	82	399	20 178
IL	19	38	9	**14**	16	3	2		3	82	59	11 441
BE	31	12	19	1	7	11	3		1	79	212	13 207
IN	28	1	3		1	6	6	0.3	1	45	22	4 584
RU	12	9	7		7	2	2		1	35	150	4 617
GR	8	10	5		8				1	24	8	990
BR	0.3		4		14	5				24	30	2 322
PT	3	7	2	1	6	1		1		19	17	565
IE	5	1	2		9	3				18	17	2 651
HU	1	10	1	4	3	1				16	32	2 102
SG	13	1	1	1	2					15	16	2 720
UA	1	2	4		1	5	1		1	14	34	777
NZ	3	5	1	1	3	1	2			13	11	1 388
HK	4	4	3		3		1			12	17	1 976
TR	3	3	2		3		1			10	8	566
TH	6	5	4							10	4	253
CZ	2	2	1	1	3	2				8	63	1 788
PL	0.2	3	2		3					7	26	1 149
MX	1	1			3	0.3	1			5	15	998
World Total	8 972	1 639	2 232	285	1 902	731	616	54	190	15 755	30 235	2 310 472

Source: OECD/EPO

* The top five are indicated in bold.

Annex 6

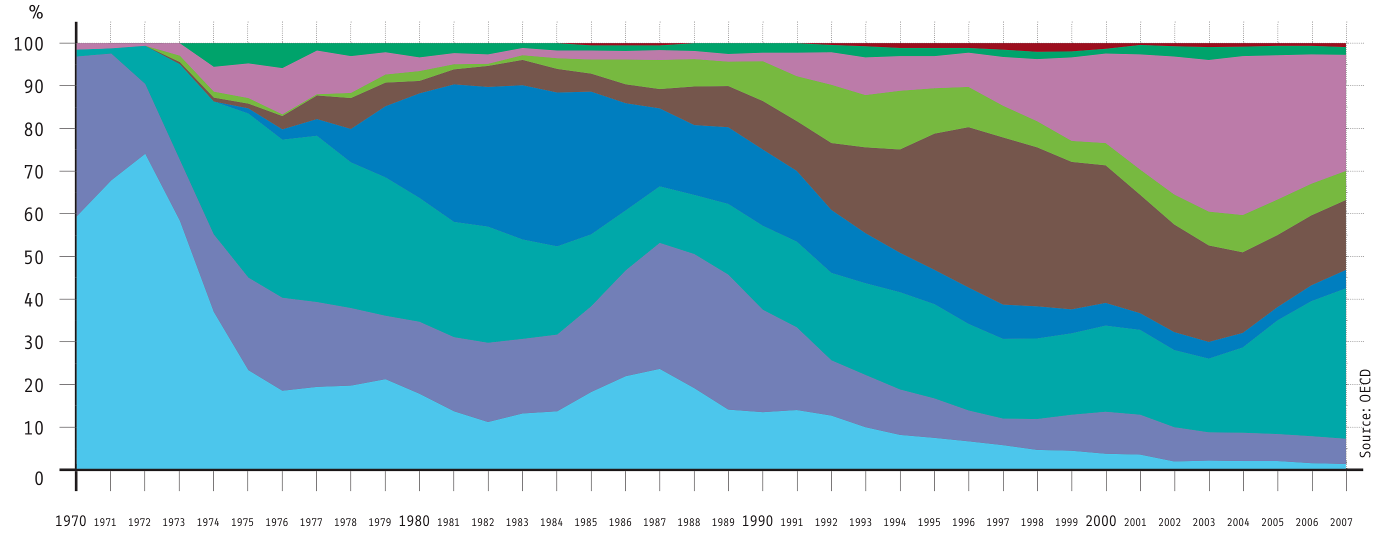
Percentage share of patenting in a CET field relative to patenting overall (1988-2007)

	Solar PV	Solar thermal	Wind	Geo-thermal	Hydro/-marine	Biofuels	Carbon capture	Carbon storage	IGCC	Selected CETs	Fossil and nuclear energy
JP	0.57	0.02	0.03	0.00	0.03	0.02	0.02	0.00	0.01	0.68	0.83
US	0.31	0.04	0.08	0.01	0.09	0.03	0.05	0.00	0.01	0.59	1.31
DE	0.28	0.13	0.19	0.01	0.08	0.04	0.02	0.00	0.01	0.72	1.75
KR	0.75	0.01	0.03	0.00	0.02	0.01	0.01	0.00	0.00	0.83	0.55
FR	0.19	0.07	0.07	0.01	0.08	0.04	0.05	0.01	0.00	0.48	2.20
UK	0.25	0.06	0.10	0.01	0.21	0.03	0.03	0.00	0.01	0.67	1.24
IT	0.19	0.11	0.09	0.02	0.16	0.06	0.02	0.00	0.00	0.59	1.83
NL	0.33	0.17	0.19	0.03	0.07	0.04	0.05	0.00	0.01	0.81	1.86
CA	0.14	0.11	0.14	0.03	0.17	0.06	0.05	0.01	0.01	0.66	1.55
TW	0.77	0.05	0.04	0.01	0.07	0.02	0.00	0.00	0.00	0.93	0.59
CH	0.28	0.13	0.06	0.03	0.15	0.04	0.01	0.00	0.02	0.66	2.22
DK	0.06	0.06	1.92	0.03	0.21	0.04	0.01	0.00	0.00	2.23	2.20
ES	0.27	0.39	0.84	0.01	0.24	0.05	0.02	0.01	0.00	1.62	1.64
CN	0.42	0.07	0.10	0.03	0.07	0.06	0.02	0.00	0.01	0.76	0.57
AT	0.21	0.18	0.10	0.05	0.19	0.06	0.01	0.00	0.01	0.72	2.17
SE	0.08	0.06	0.12	0.03	0.13	0.02	0.00	0.00	0.02	0.44	2.57
NO	0.20	0.18	0.43	0.11	0.84	0.00	0.32	0.04	0.03	1.88	2.60
AU	0.40	0.42	0.10	0.01	0.21	0.07	0.03	0.00	0.02	1.10	1.30
FI	0.05	0.04	0.09	0.01	0.05	0.12	0.02	0.00	0.03	0.41	1.98
IL	0.17	0.33	0.08	0.12	0.14	0.03	0.02	0.00	0.03	0.71	0.51
BE	0.23	0.09	0.14	0.01	0.06	0.08	0.02	0.00	0.01	0.60	1.61
IN	0.61	0.02	0.07	0.00	0.02	0.13	0.12	0.01	0.01	0.98	0.49
RU	0.25	0.19	0.16	0.00	0.15	0.04	0.05	0.00	0.01	0.76	3.26
GR	0.79	1.01	0.50	0.00	0.81	0.00	0.00	0.00	0.10	2.41	0.81
BR	0.01	0.00	0.19	0.00	0.60	0.22	0.00	0.00	0.00	1.02	1.30
PT	0.47	1.24	0.32	0.18	1.06	0.18	0.00	0.18	0.00	3.45	2.98
IE	0.18	0.04	0.08	0.00	0.32	0.12	0.00	0.00	0.00	0.69	0.65
HU	0.06	0.45	0.05	0.19	0.14	0.05	0.00	0.00	0.00	0.75	1.50
SG	0.47	0.04	0.04	0.04	0.07	0.00	0.00	0.00	0.00	0.54	0.58
UA	0.13	0.24	0.51	0.00	0.13	0.64	0.13	0.00	0.13	1.78	4.42
NZ	0.24	0.32	0.07	0.07	0.22	0.07	0.11	0.00	0.00	0.92	0.77
HK	0.21	0.18	0.13	0.00	0.14	0.00	0.06	0.00	0.00	0.59	0.87
TR	0.49	0.53	0.27	0.00	0.53	0.00	0.09	0.00	0.00	1.72	1.44
TH	2.17	1.98	1.58	0.00	0.00	0.00	0.00	0.00	0.00	3.75	1.38
CZ	0.08	0.11	0.06	0.06	0.17	0.11	0.00	0.00	0.00	0.48	3.51
PL	0.01	0.22	0.17	0.00	0.26	0.00	0.00	0.00	0.00	0.58	2.31
MX	0.10	0.10	0.00	0.00	0.30	0.03	0.10	0.00	0.00	0.53	1.50

Source: OECD/EPO

Annex 7

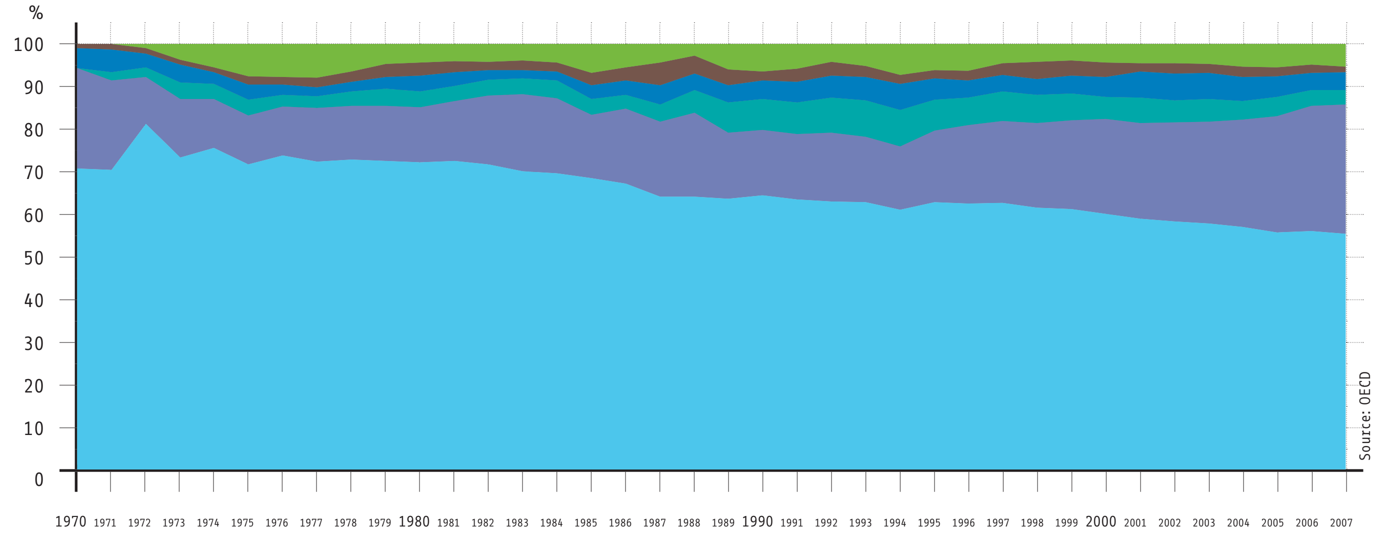
Patenting activity in solar PV technologies (1970-2007)*



- Microcrystalline silicon PV cells
- Polycrystalline silicon PV cells
- Dye-sensitised solar cells
- CuInSe2 material PV cells
- Roof systems for PVC cells
- Amorphous silicon PV cells
- PV systems with concentrators
- Solar cells from Group III-V materials
- Solar cells from Group II-VI materials

* Percentage share relative to all PV-related patents; 3-year moving average

Patenting activity in solar thermal technologies (1970-2007)*



- Heat exchange systems
- Mountings and tracking
- Tower
- Dish
- Fresnel
- Trough

* Percentage share relative to all solar-thermal-related patents; 3-year moving average

Annex 8

Patenting across countries for all examined CETs (1998-2007)

From / to	US	EP	JP	DE	AU	CN	CA	KR	AT	ES	UK	TW	BR	NO	FR	DK	MX
US		2 188	1 798	1 146	1 312	1 136	946	569	165	162	142	344	235	91	48	90	163
JP	4 633	1 533		1 161	561	1 338	213	883	65	59	72	536	36	42	65	28	14
DE	1 252	2 501	751	850	610	471	344	186	406	310	35	49	192	136	62	160	75
UK	463	485	263	260	334	142	149	60	78	65	742	20	39	43	7	32	19
FR	393	521	255	314	188	116	175	27	94	100	13	10	37	35	414	26	21
KR	1 008	140	484	95	37	348	9	168	2	3	22	41	2	4	8	1	2
EP	327		157	243	129	146	73	47	137	75	6	5	17	18	2	66	8
SE	84	106	47	82	103	28	42	10	31	24		6	13	23	1	16	3
NL	77	167	53	110	121	28	33	7	37	34	4	2	15	13	1	25	6
AU	105	86	52	25	346	46	39	9	10	10	3	2	15	5		2	11
NO	74	98	41	53	104	41	53	14	30	20	7		11	179		14	1
IT	88	207	32	78	46	32	28	6	27	23	1	6	13	9	1	8	2
DK	80	114	27	74	93	65	52		35	23	1		6	16		107	6
ES	60	115	18	47	47	37	16	1	24	179	2		11	4	2	8	10
AT	38	102	24	54	38	21	28	11	91	19			14	12	1	5	8
FI	46	71	29	49	51	16	31	4	20	12	1		7	10	1	9	1
CA	97	45	24	30	53	17	104	5	9	7	5		8	6	2	2	7
CN	60	35	11	8	46	158	8	5	2	1			2		2	1	1
IL	48	32	13	23	47	10	7	3	9	9	3		9	2		4	4

Source: OECD/EPO

Annexes

Annex 9

Patenting across countries for solar PV technologies (1988-2007)

From / to	CN	KR	TW	BR	SG	MX	IL	HK	ZA	AR	ID	IN	MA
JP	1 067	788	503	7	13	3	1	9	1		3	1	
US	663	409	318	47	74	46	46	20	11	15	1	2	
DE	185	104	46	19	3	14	10	11	9			1	
UK	57	41	17	6		4	4	6	8			2	
FR	35	10	3	8	1	7	5		7				2
AU	18	5	1	3		3	3		5		3		1
NL	10	3	2	4	1	2	1	1	1				
SE	6	3	3					1					
IT	5	1	2				1	2					
NO	9			2			4						
ES	5					3							
AT	7	3								1			
CH	4	1	1										

Source: OECD/EPO

Annex 10

Patenting across countries for solar thermal technologies (1988-2007)

From / to	CN	IL	BR	MX	KR	ZA	HK	MA	AR	EG	DZ	TW	ID	SG	IN
DE	46	28	16	11	8	11	2	4	1	3	1			1	3
US	58	33	23	25	18	7	8	1	4	1		3	1	1	
JP	49	1	3	5	16		1					2	1	1	
FR	8	7	6	7	1	4		2			1				
AU	19	2	7	4	3	8	1	1		1	1		1		1
UK	9	1	1	3		4									
NL	7	3	4	4	2	1	2	2							
AT	4	2	3	2	2	1	1	1			1			1	
ES	9	3	4	2		1		1	1						
IT	4	2	1	1	2	1	2		2						
SE	6				1										
NO	2														
CA	3	1	1	3	1	1	1	1							
HU	3	1	5	1	1	1							1		
CH	3			1											
GR	3					1									

Source: OECD/EPO

Annex 11
Survey of licensing activities in selected fields of environmentally sound technologies (ESTs)[1]

Cover letter issued in July 2009

The United Nations Environment Programme (UNEP) the European Patent Office (EPO) and the International Centre for Trade and Sustainable Development (ICTSD) are collaborating in the production of a study that aims to enhance the understanding of the role that intellectual property plays in relation to the transfer, access and deployment of environmentally sound technologies (ESTs), starting with the energy generation sector.

As part of this study, the project partners are working with [Supporting Organisation] to conduct a survey that focuses on licensing practices in ESTs. We believe this analysis will provide useful input into the ongoing technology transfer discussions taking place in the context of the UN Framework Convention on Climate Change (UNFCCC) negotiations.

For the purpose of this survey the term ESTs refers to those technologies that protect the environment; are less polluting; use resources in a more sustainable manner; recycle more of their wastes and products; or handle residual wastes in a more acceptable manner than the technologies they substitute.[2]

While representing only one piece of a wider set of conditions and components that determine the rate, composition and magnitude of technology transfer, intellectual property rights (IPRs) are of fundamental importance. Moreover, we have chosen in part to focus on licensing activities given that they represent a "real-life" manifestation of technology transfer activities.

We would like to emphasise that the results of this survey are not intended for any type of commercial use. Moreover, the responses collected in this survey will be kept confidential, and the identity and answers provided by any individual respondent will not be disclosed. Rather, all the results collected and analysed in this survey will be presented at an aggregated level.

For the purpose of this study we have asked Dr Meir Perez Pugatch, of the University of Haifa and Research Director of the Stockholm Network think-tank, to coordinate this survey and to analyze its results. Should the need arise, and with your permission, Dr Pugatch may contact you directly via electronic mail or telephone to discuss survey inputs.

For your convenience the survey is provided in the attached file.

You may choose to fill in the survey using the attached Word document (just click in the appropriate boxes and save the document). In this case please send the survey to the following e-mail address: meirp@pugatch.co.il.

Alternatively, you may choose to fill in the survey on a hard copy and fax it to the following number +972-3-6204395.

Should you encounter any problems, please feel free to contact Dr Pugatch at the e-mail address indicated above or at telephone number +972-3-6299294.

As a leader in technology innovation and patenting in this field your response to this survey is invaluable. We are very grateful for your time and willingness to assist us in this important project.

With kind regards,

On behalf of the Project Partners　　　　On behalf of the Supporting Organisation

Hussein Abaza
Chief, Economics and Trade Branch, UNEP

1 Although the project is focused on clean energy technologies, which is a sub-sector of ESTs, the survey was formulated in broader terms to enable participation of companies engaged also in other sectors of climate change mitigation technologies (chemical industry, IT, transportation, etc.)
2 The above definition is based on Chapter 34 of Agenda 21 of the UN Program on Sustainable Development.

Questionnaire

Unless stated otherwise, the term licensing refers to both the in-licensing and out-licensing of patented inventions, and any type of additional trade secrets, know-how etc. that is part of the subject-matter of the licence.

Part A – General questions

Question 1

What is the estimated proportion of EST-related patents in your overall patent portfolio?

☐ Negligible (<2%)　☐ Low (2-15%)　☐ Significant (15-50%)　☐ Substantial (>50%)

Question 2

How important are licensing activities to your organisation (as far as the commercialisation and/or exploitation and/or development of proprietary assets are concerned)?

2(a) Importance of EST out-licensing activities

☐ Negligible　☐ Moderately important　☐ Very important　☐ Fundamental

2(b) Importance of EST in-licensing activities

☐ Negligible　☐ Moderately important　☐ Very important　☐ Fundamental

Question 3

Has there been a shift in your organisation's business strategy towards licensing of ESTs in the past three years?

☐ Less supportive of licensing　☐ No change　☐ More supportive of licensing　☐ EST licensing is not a part of my business strategy

Question 4

4(a) To what extent is your organisation active in collaborative mechanisms for intellectual property rights, such as patent pools, cross-licensing, etc.?

☐ Never　☐ Rarely　☐ Occasionally　☐ Frequently

4(b) To what extent does your organisation engage in co-operative research and development agreements or joint venture agreements with other companies or organisations to develop or improve ESTs?

☐ Never　☐ Rarely　☐ Occasionally　☐ Frequently

Question 5

Please rank your organisation's intellectual property activities related to EST patents and technology (including know-how) in the following areas:

1 2 3 4 (Rank on a scale of 1 to 4 with 1 = low intensity, 4 = high intensity)

- ☐ ☐ ☐ ☐ Patent out-licensing
- ☐ ☐ ☐ ☐ Patent in-licensing
- ☐ ☐ ☐ ☐ Technology out-licensing
- ☐ ☐ ☐ ☐ Technology in-licensing
- ☐ ☐ ☐ ☐ Joint ventures or alliances
- ☐ ☐ ☐ ☐ Spinouts / start-ups
- ☐ ☐ ☐ ☐ Collaborative research and development
- ☐ ☐ ☐ ☐ Consulting / services
- ☐ ☐ ☐ ☐ Other (please specify) ______

Part B – Questions focusing on developing countries

One of the objectives of the study, which is outlined in the introductory letter, is to obtain some further insights into the transfer, access and deployment of ESTs in developing counties, inter alia by also looking at licensing activities (and more specifically at out-licensing activities).
For the purpose of this survey the term developing countries may refer to countries that are not members of the OECD.
It is, of course, well understood that the concept is very broad and that developing countries cannot be grouped into a single entity.
Therefore, this survey by no means implies that the flow of ESTs is going in one direction. In particular, if your company is also based in a developing country, then the following questions refer to actions towards other developing countries.

Question 1

To what extent has your organisation entered into licensing agreements that involve licensees (which are not majority-controlled subsidiaries) based in developing countries in the last three years?

☐ Never (no deals) ☐ Rarely (< 5% of deals) ☐ Occasionally (5% - 25% of deals) ☐ Frequently (> 25% of deals)

Question 2

With which countries has your organisation been most involved in licensing or other commercialisation activities of intellectual property in the field of ESTs? Please name up to six countries.

☐ Country A ☐ Country B ☐ Country C
☐ Country D ☐ Country E ☐ Country F

Question 3

When your organisation is making a decision whether or not to enter into a licensing or co-operative development agreement with a party in a developing country, to what extent would the following factors positively affect your assessment? (Please rank from 1-4 based on the categories below).

☐ Not a factor ☐ A basic precondition for doing business, but not a driving factor ☐ Significantly attractive condition: would encourage negotiation ☐ Compelling reason toward an agreement

1 2 3 4 Extent of influence

Protection of intellectual property rights

- ☐ ☐ ☐ ☐ 1. Existence of an established legal patent framework in that country, membership in international IP treaties, such as Patent Cooperation Treaty (PCT)
- ☐ ☐ ☐ ☐ 2. Ability to enforce the licence and relevant patent rights in the country, including effective civil and criminal penalties
- ☐ ☐ ☐ ☐ 3. Ability to gain access to know-how, patents or other assets owned by the other party in the developing country

Scientific capabilities, infrastructure and human capital

- ☐ ☐ ☐ ☐ 1. Existence of scientific and research capabilities (in universities, national laboratories, private sector etc.)
- ☐ ☐ ☐ ☐ 2. Availability of R&D infrastructure (including well-equipped laboratories, testing facilities, etc.)
- ☐ ☐ ☐ ☐ 3. Access to well-trained human capital in that country or region

Favourable market conditions

- ☐ ☐ ☐ ☐ 1. Size of potential national or regional market (providing opportunity for market expansion)
- ☐ ☐ ☐ ☐ 2. Sufficient purchasing power of the national or regional population
- ☐ ☐ ☐ ☐ 3. Existence of established distribution channels in the country or region

Favourable investment climate

- ☐ ☐ ☐ ☐ 1. Existing measures aimed at encouraging foreign direct investment (financial incentives, administrative procedures that are not burdensome for doing business in the country, effective and timely government response)
- ☐ ☐ ☐ ☐ 2. Demonstrated commitment of the national government to address climate change and/or to EST deployment
- ☐ ☐ ☐ ☐ 3. Governance (rule of law, transparency, non-discrimination)
- ☐ ☐ ☐ ☐ Other factors (please specify): ______

Comment (optional)

Question 4

When entering into an out-licensing agreement with parties that are based in developing countries, to what extent do the monetary terms of your licence reflect your willingness to introduce greater lenience due to differences in the purchasing power of the parties?

- [ ] No difference in licensing terms
- [ ] Licensing terms are more flexible
- [ ] Licensing terms are much more accommodating
- [ ] Licensing terms are substantially more accommodating

Comment (optional)

Part C – General questions regarding your organisation

1. Is your organisation

- [ ] Private company
- [ ] Academic institution
- [ ] Research institute
- [ ] Governmental body
- [ ] National research institute or laboratory
- [ ] Non-profit organisation
- [ ] Consortium
- [ ] Other (open text)

2. Size of your organisation

- [ ] Multinational (over 5000 employees)
- [ ] Multinational (between 1000 to 5000 employees)
- [ ] Large (more than 250 employees) but mostly focused on domestic markets
- [ ] SME (up to 250 employees)
- [ ] Very small (fewer than 10 employees)

3. In which country is your HQ based?

Please enter name of country:

4. Innovation development activities of your organisation

The current study has a particular focus on selected ESTs for the energy generation sector. Please indicate which of the categories below describe the innovation development activities of your organisation. Indicate all that apply, and list others as appropriate.

- [ ] Wind
- [ ] Solar thermal
- [ ] Solar PV
- [ ] Geothermal
- [ ] Biomass / Biofuels
- [ ] Ocean / Wave
- [ ] Hydro
- [ ] Waste-to-Energy
- [ ] Other

5. Please estimate the level of investment in R&D in your organisation

If possible, please provide an estimate of investment in research and development (in USD)

- [ ] Low
  the organisation's business model is not based on significant internal research and development
- [ ] Limited
  the organisation primarily engages in research and development activities aimed at improving existing technologies
- [ ] Significant
  the organisation engages in the early and middle phases of research and development
- [ ] Research-based
  the organisation is based on full-scale research and development activities

Annex 12
Overview of new CET classification scheme[1]

The EPO has established a new classification scheme for technical attributes of technologies that can be loosely referred to as clean energy technologies - a specific sub-sector of climate change mitigation technologies.

The new categories were defined with the help of experts in the field, both from within the EPO and from the Intergovernmental Panel on Climate Change (IPCC).

The Y02 subclasses already available to the public relate to clean energy technologies, namely Y02C (greenhouse gases - capture and storage/sequestration or disposal) and Y02E (greenhouse gases - emissions reduction technologies related to energy generation, transmission or distribution).

The Y02E subclass, for example, looks like this:

Y02E Greenhouse gases (GHG), reduction of emissions related to energy generation, transmission or distribution

ECLA code	Description
10/00	Energy generation through renewable energy sources (Geothermal, hydro, oceanic, solar (PV and thermal), wind)
20/00	Combustion technologies with mitigation potential (CHP, CCPP, IGCC, synair, cold flame, etc.)
30/00	Energy generation of nuclear origin (Fusion and fission)
40/00	Technologies for efficient electrical power generation, transmission or distribution (Reactive power compensation, efficient operation of power networks, etc.)
50/00	Technologies for the production of fuel of non-fossil origin (Biofuels, from waste)
60/00	Technologies with potential or indirect contribution to GHG emissions mitigation (Energy storage (batteries, ultracapacitors, flywheels...), hydrogen technology, fuel cells, etc.)
70/00	Other energy conversion or management systems reducing GHG emissions (Synergies among renewable energies, fuel cells and energy storage)

[1] Preliminary list; for the final one, see Y02 Class in classification search menu of *esp@cenet*
http://v3.espacenet.com/eclasrch?classification=ecla&locale=en_EP.

And here is the breakdown for the groups and subgroups related to solar energy:

Y02E10 Energy generation through renewable energy sources

ECLA code	Description
...	
10/40	Solar thermal energy
10/41	**Tower concentrators**
10/42	**Dish collectors**
10/43	**Fresnel lenses**
10/44	**Heat exchange systems**
10/45	**Trough concentrators**
10/46	**Solar-thermal plants for electricity generation, e.g. Rankine, Stirling solar-thermal generators**
10/47	**Mountings or tracking**
10/48	**Mechanical power, e.g. thermal updraft**
10/50	Photovoltaic (PV) energy
10/52	**PV systems with concentrators**
10/54	**Material technologies**
10/54B	CuInSe2 material PV cells
10/54D	Dye-sensitised solar cells
10/54F	Solar cells from Group II-VI materials
10/54H	Solar cells from Group III-V materials
10/54J	Microcrystalline silicon PV cells
10/54L	Polycrystalline silicon PV cells
10/54N	Amorphous silicon PV cells
10/56	**Power conversion electrical/electronic aspects**
10/56B	for grid-connected applications
10/56D	concerning power management inside the plant, e.g. battery charging/discharging, economical operation, hybridisation with other energy sources
10/58	**MPPT systems (maximum power point tracking)**
10/60	TPV hybrids
...	

Annex 13
Comparison of new classification scheme with previous situation

As indicated in Chapter 2, most studies on patenting of climate change mitigation technologies have made use of the IPC classification coding of patent documents, which is the standard tool for patent offices worldwide, in order to retrieve pertinent documents. In the following, an example for the sector of carbon capture and storage (CCS) will be used to demonstrate the added value, both in precision and scope, that the Y02 scheme brings to patent data analysis in certain technology areas.

The current closest category to CCS in the IPC system is presented below.

IPC structure for removing carbon oxides from waste gases
Section B Performing operations; transporting

Subdivisions to Section B	Separating; mixing; shaping; printing; transporting
Classes	e.g. B01 Physical or chemical processes or apparatus in general; B08 Cleaning
Subclasses	e.g. B01D Separation
Groups	e.g. B01D53/00 Separation of gases or vapours; Recovering vapours of volatile solvents from gases; Chemical or biological purification of waste gases, e.g. engine exhaust gases, smoke, fumes, flue gases or aerosols
Subgroups	e.g. B01D53/62 Chemical or biological purification of waste gases – carbon oxides

As also described in Chapter 5.2, the European Classification system (ECLA) developed by the EPO builds on the IPC, whereby EPO examiners systematically attribute ECLA codes to documents of which at least one family member is published in an official language or as a PCT application. When an ECLA classification is given to a document, the classification is automatically allocated to all family members (documents having exactly the same priorities) of the document which was first classified in ECLA. Internally, the EPO examiners also use 'ico-codes' (used for cross-classification aspects in certain technical areas) and 'controlled keywords' (used for re-classification purposes).

In some cases relating to climate change mitigation technologies, for example in wind motors, the IPC classification is quite extensive and well-contained. Improvements vis-à-vis the IPC classification mainly manifest themselves in extra possibilities to extract specific cross-classification details which are technically relevant such as, for example, a split between off-shore towers and on-shore towers for wind motors.

In other technology sectors, such as carbon capture or carbon storage, advantages of additional classification efforts beyond IPC level can be very substantial. As shown, the only IPC entry relating explicity to carbon capture and/or storage (CCS) is the subgroup B01D53/62. This is also the IPC category used by studies such as those of Dechezleprete et al. (see Chapter 3) as a basis for extracting CCS data. Other classification entries under IPC Group B01D53/00 are not specific to the gas removed, but rather describe general techniques used for many different purposes.

However, one cannot analyse the CSS market relying solely on the patent documents retrieved with the B01D53/62 IPC code. One reason is that not all relevant documents would be retrieved, as this category relates only to chemical and biological purification of waste gases and does not include industrially very common techniques such as adsorption (IPC subgroups B01D53/02 to B01D53/12) or absorption (IPC subgroups B01D53/14 and B01D53/18).

Another important reason is that this code relates to any carbon oxides and thus also includes patent documents relating to the removal of minute quantities of carbon monoxide, which is an extremely poisonous gas and therefore has been the subject of a lot of patenting activity. In addition, this category relates only to certain aspects of purification (other pertinent subgroups in entirely different IPC sections are e.g. C01B31/20 or F25J3/02) and not to sequestration or storage of the gas (to be found inter alia under B65G5/00, E21B41/00 or 43/16, E21F17/16).

Thus, the information about CCS is scattered across at least 4 different IPC sections and in a way that even combining the results will still not deliver satisfactory results (e.g. because of the presence of a lot of CO-related data).

For this reason, EPO examiners have added a special code in their internal classification scheme to single out carbon dioxide as removed gas, as a cross-classification aspect at the higher level of the B01D53 group, i.e. including other separation technologies. A further ECLA code has been introduced to deal with CO_2 sequestration by injection into a subterranean formation (E21B41/00M2C). The introduction of these two additional classification categories provided a significant improvement in both coverage and specificity for CCS, as many other documents are now included, but documents only relating to carbon monoxide removal are excluded. As a result, the EPO is able to provide a comprehensive scheme on carbon capture and storage, which includes details on specific technologies used.

These developments were used to develop the structure of the new scheme in the Y section, dealing with these technologies. An overview is shown below.

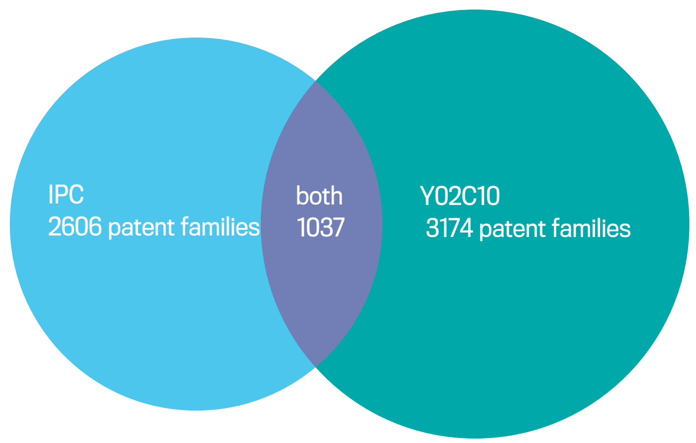
Scheme for capture, storage or sequestration of carbon dioxide within Section Y (general tagging of new technological developments)

ECLA code	Description
Y02	Technologies or applications for mitigation or adaptation against climate change
Y02C	Capture, storage, sequestration or disposal of greenhouse gasses (GHG)
Y02C10/00	CO_2 capture or storage
Y02C10/02	Capture by biological separation
Y02C10/04	Capture by chemical separation
Y02C10/06	Capture by absorption
Y02C10/08	Capture by adsorption
Y02C10/10	Capture by membranes or diffusion
Y02C10/12	Capture by rectification or condensation
Y02C10/14	Subterranean or submarine CO_2 storage

The diagram below shows a schematic comparison of the patent documents retrieved via the B01D53/62 code on the one hand and using the Y02C10/02 to 14 codes on the other.

It is clear from this figure that the Y02C10 dataset contains more priority documents than the dataset from B01D53/62. In addition, the overlap between the two datasets is not very large. A closer look at the documents in B01D53/62 which do not overlap with Y02C10 reveals, as expected, that a large number of documents relating to carbon monoxide removal is indeed also present there.

Comparison of datasets retrieved through the IPC (B01D53/62) and the new EPO classification scheme (Y02C10 codes)



April 2010

Source: OECD

Annexes

In the penultimate graph, the development over time of the applications in B01D53/62 and Y02C10 is compared. It can be seen that the growth in Y02C10 is significantly larger than that in B01D53/62 from 2005 onwards. Given the fact that B01D53/62 also contains carbon monoxide data, this would indicate that the relative growth of CO_2-related applications is high with respect to other carbon oxides. This is an indication of increased research activities in CCS.

Further, the number of applications in CCS, as reflected in Y02C10, shows a marked peak in the year 2002. This peak is completely absent in the curve formed by the B01D53/62 data. A closer look at the data in 2002 reveals that this peak can be almost completely ascribed to a very large number of applications involving carbon dioxide sequestration made by one company (Shell Oil) in that year. Since sequestration is not included in B01D53/62, the reason for the deviation is clear.

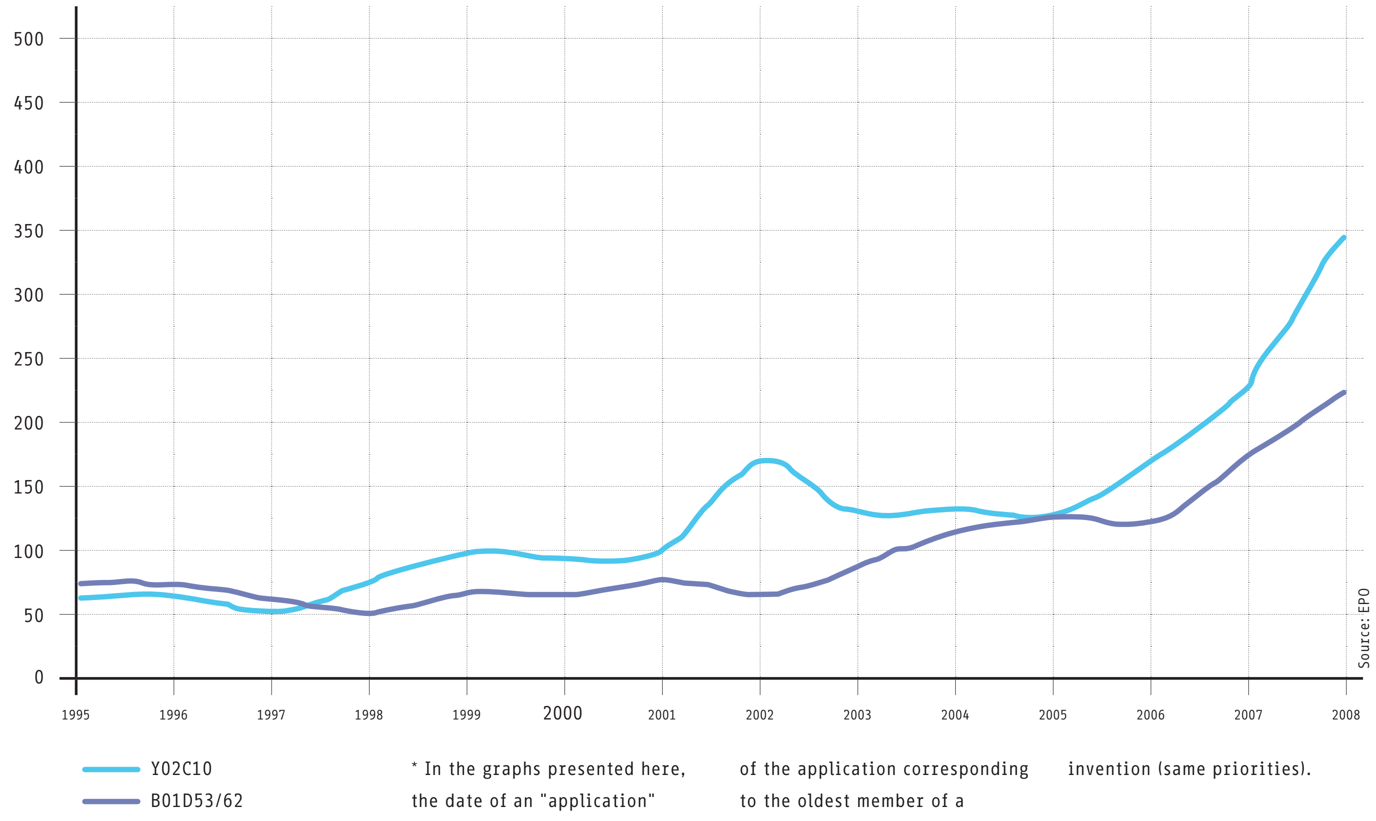
To further illustrate the influence of carbon dioxide sequestration on total CCS figures, the development of applications in Y02C10/14 with time is shown in the last graph, where the sudden increase in applications in 2002 can be very clearly seen.

Reliability and quality of data

EPO examiners have identified all patent documents worldwide fitting into the newly defined categories according to Annex 12, using all documentation and search means available to the EPO and also their expertise in the field. The data retrieved has been checked internally for inclusiveness (no essential patents missing) and accuracy (few or no documents that do not relate to the envisaged category). Further, the search strategies applied by the examiners to retrieve data for each of the 200 new categories are published internally so that they undergo continuous peer review.

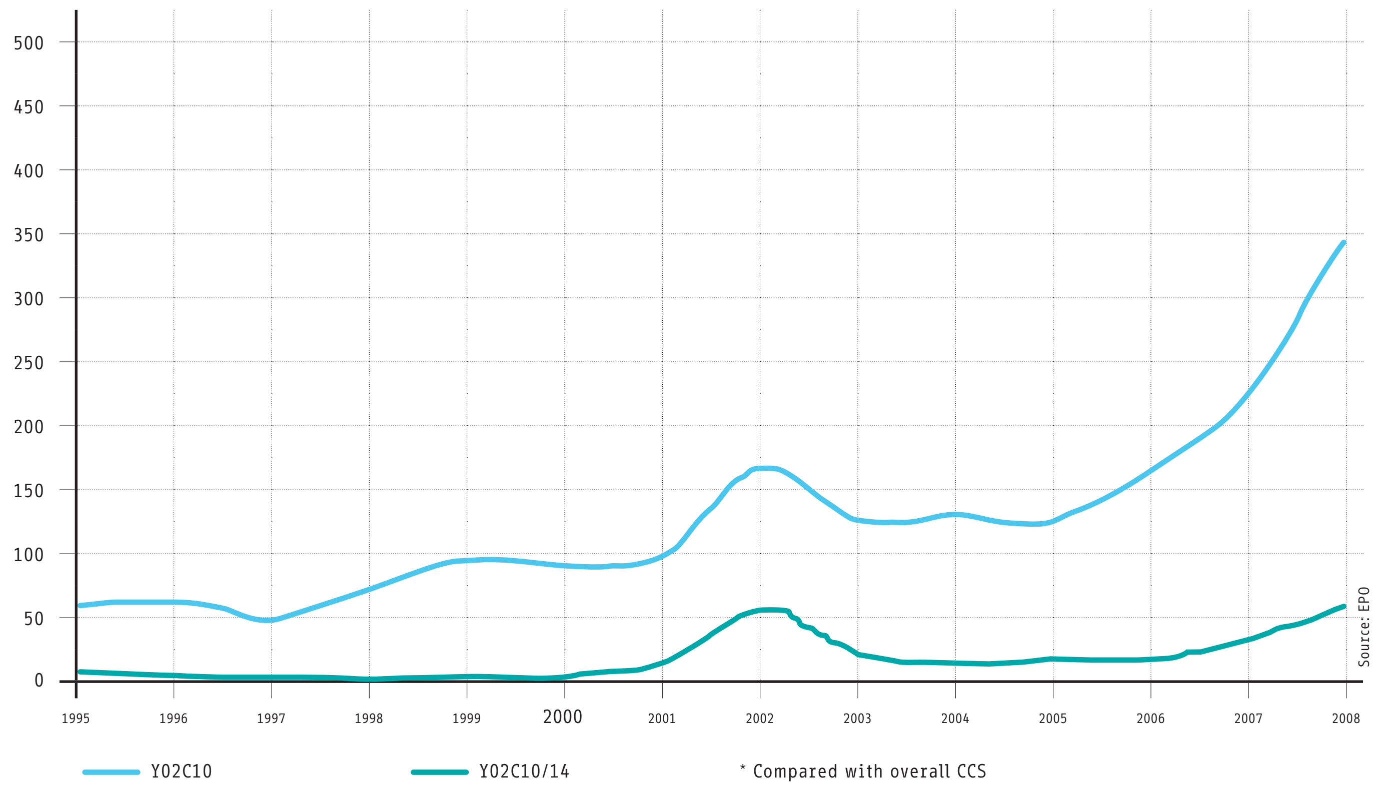
Wherever possible, external checks have been carried out. This was feasible, e.g. when a third party had independently of the EPO tried to identify patent data in certain CET sectors, using its own means and expertise. In this way, the OECD Environment Directorate thoroughly checked all data relating to renewable energy sources, biofuels, IGCC and CCS. Experts from LESI checked the data relating to CCS. Moreover, as classification is not cast in stone, it is relatively easy to amend the scheme by correcting existing search strategies to make it more precise and inclusive. Given the groundbreaking character of this development and the vast amount of information that has been re-organised, the EPO may offer a possibility to the public to give feedback on certain aspects of the scheme (e.g. if an essential patent known to the user is not retrieved when using the new code).

Applications* (patent families) in Y02C10 and B01D53/62



* In the graphs presented here, the date of an "application" denotes the date of publication of the application corresponding to the oldest member of a patent family representing the invention (same priorities).

Applications relating to carbon dioxide sequestration*



* Compared with overall CCS

ABBREVIATIONS AND ACRONYMS

General	
CDM	Clean development mechanism
CETs	Clean energy technologies
CCS	Carbon capture and storage
COP	Conference of the Parties
CSP	Concentrated solar power
ECLA	European patent classification system
ECN	Energy Research Centre of the Netherlands
EGTT	Expert Group on Technology Transfer
EPO	European Patent Office
EU	European Union
FDI	Foreign direct investment
ICTSD	International Centre for Trade and Sustainable Development
IGCC	Integrated gasification combined cycle
IPC	International Patent Classification
IPCC	Intergovernmental Panel on Climate Change
IP	Intellectual property
IPRs	Intellectual property rights
LDCs	Least developed countries
MNEs	Multinational enterprises
NGOs	Non-governmental organisations
ODS	Ozone-depleting substances
OECD	Organisation for Economic Co-operation and Development
PATSTAT	Worldwide Patent Statistics Database
PCT	Patent Cooperation Treaty
PV	Photovoltaic
R&D	Research and development
SMEs	Small and medium-sized enterprises
Solar PV	Solar photovoltaic
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

Country	
AT	Austria
AU	Australia
BE	Belgium
BR	Brazil
CA	Canada
CH	Switzerland
CN	China
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GR	Greece
HK	Hong Kong
HU	Hungary
IE	Ireland
IL	Israel
IN	India
IT	Italy
JP	Japan
KR	Republic of (South) Korea
MX	Mexico
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RU	Russian Federation
SE	Sweden
SG	Singapore
TH	Thailand
TR	Turkey
TW	Taiwan
UA	Ukraine
UK	United Kingdom
US	United States of America
ZA	South Africa

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