A Changing Climate: Statistical Evidence of the Intellectual Property Landscape of Clean Energy Technologies

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Abstract

The intellectual property (IP) system plays an important role in the development and diffusion of technologies by determining the institutional context in which transactions occur. This article reviews the recent EPO report 'Patents and Clean Energy Technologies: Bridging the Gap between Evidence and Policy'[i] and offers further insights into the interplay between patents, innovation in climate change mitigating technologies and access to technology. Empirical evidence and analysis of patent trends forms the basis for understanding the spectrum of policy choices available to combat climate change. In an effort to bridge the gap between policy and evidence, the EPO report provides ample statistical analysis of existing patenting trends, fleshes out the current patent landscape and assesses licensing trends in emerging technologies relating to climate change. This review evaluates these statistical insights and discusses the implications for both the developed and developing world. It aims to deepen understanding of how intellectual property influences the development of markets for green technologies.

Introduction

As the threat of climate change looms, the intellectual property (IP) system will strongly impact the development of Climate Change Mitigating Technologies (CCMTs) and the spectrum of possible policy responses. The diffusion of clean energy technologies is essential to reduce global carbon emissions. While public support for climate change policies in developing countries is attributed lower significance than other economic priorities[ii], developing countries nonetheless have an important role in combating climate change. Dependence on the ecosystem, rain-fed agriculture and low adaptive capacity makes them particularly vulnerable.[iii] Furthermore, their pursuit of rapid industrialization will shift the global balance in carbon emissions, making developing countries necessary partners for curbing climate change.[iv] The developing world also has unique opportunities to leverage CCMTs to avoid being locked into a fossil fuel and nuclear energy infrastructure. However, corporations in OECD nations own the majority of CCMT patents. The IP system, by conditioning exchange relations and technology transfer, has a powerful influence over climate change policies. Technology transfer is a subject of extensive study[v] and the UNFCCC has recognized its importance in building a framework for low-carbon growth.[vi] Unfortunately, knowledge on patenting activities in CCMTs is limited. An accurate picture of the global patent and licensing landscape in CCMTs is needed to determine how IP influences the capacity of developing nations to combat climate change.

Assessing the role of patents in the development of CCMTs provides empirical evidence on which to base public policies regarding climate change. Pledging 'to support innovation, competitiveness and economic growth for the benefit of the

citizens of Europe' (www.epo.org), the European Patent Office (EPO) partnered with the United Nations Environment Program (UNEP) and the International Centre for Trade and Sustainable Development (ICTSD) to publish data about patents in CCMTs in September 2010.[vii] In an effort to bridge the gap between policy and evidence, the report provides statistical analysis of existing patenting trends, fleshes out the patent landscape and assesses licensing trends in technologies relating to climate change. Reviewing the findings is important for two reasons: 1) it increases understanding of the relationship between IP and technological development in a field of particular significance to policymakers; 2) it demonstrates how EPO's new patent information resources can be used. The effort to supply accurate and up-to-date patent information through centralized, easily searchable databases at the EPO is an important development. Analysis of patent trends yields valuable insights for both policymakers and firms. For example, a recent issue of the Economist describes the emergence and impact of Samsung as a leading player in CCMTs.[viii] Yet, anyone who had reviewed Samsung's patenting trends using EPO databases would have noticed this strategic shift a long time ago. Patents paint a picture of the innovation system, where it is heading and how it might change. It is time for an awareness shift among policy makers to recognize patent data as a strategic means to inform policy in areas of critical importance.

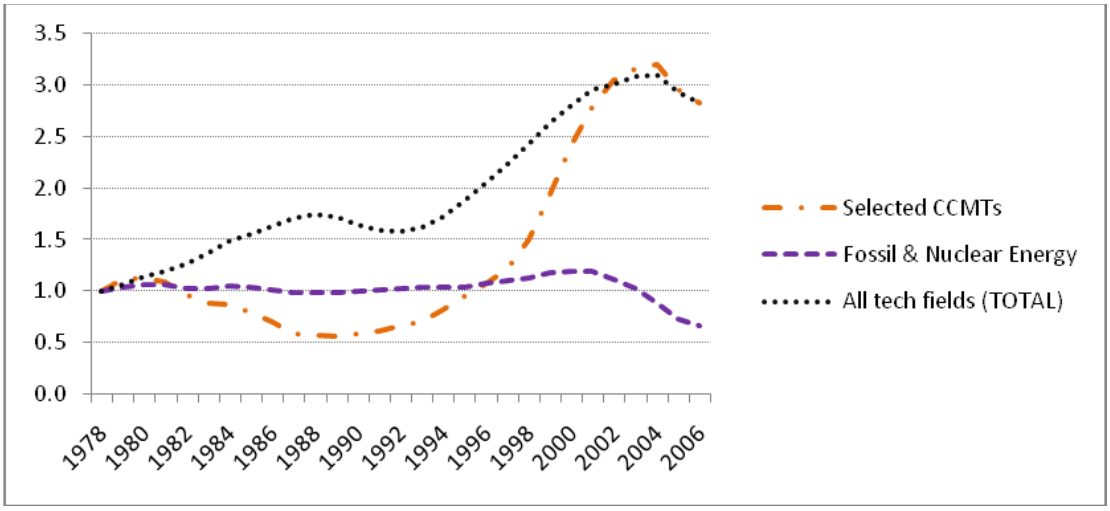
This review summarizes and elaborates on these statistical insights in order to define current trends and how they relate to innovation and IP policy in the context of climate change. It promotes a differentiated understanding of patents and identifies how the global IP landscape in green technologies is evolving. First, the key findings of EPO's patent analysis of CCMTs are discussed. Despite rapid growth rates and the emergence of Brazil, China and India as key players, CCMT patents remain highly concentrated in developed countries. The second section reviews the results of EPO's licensing survey. Particular attention is paid to the relationship between developing and developed nations in order to underline the interplay between the patent system and equitable access to innovation.

The patent landscape – key findings of the patent analysis

Patents for Climate Change Mitigating Technologies are growing rapidly

Patenting in CCMTs has grown at a phenomenal pace since the 1990s. The fact that the number of CCMT-related patents has tripled in the post Kyoto era suggests a strong relationship between markets and governance structures. The Kyoto Protocol provided additional incentives to invest in research and development (R&D) in this sector, resulting in the rapid growth of patenting activity. The minor decline in 2007 is likely to be related to the economic downturn. Nonetheless, growth rates for patents in CCMTs are impressive and clearly indicate that the market perceives this sector to be of significant value.

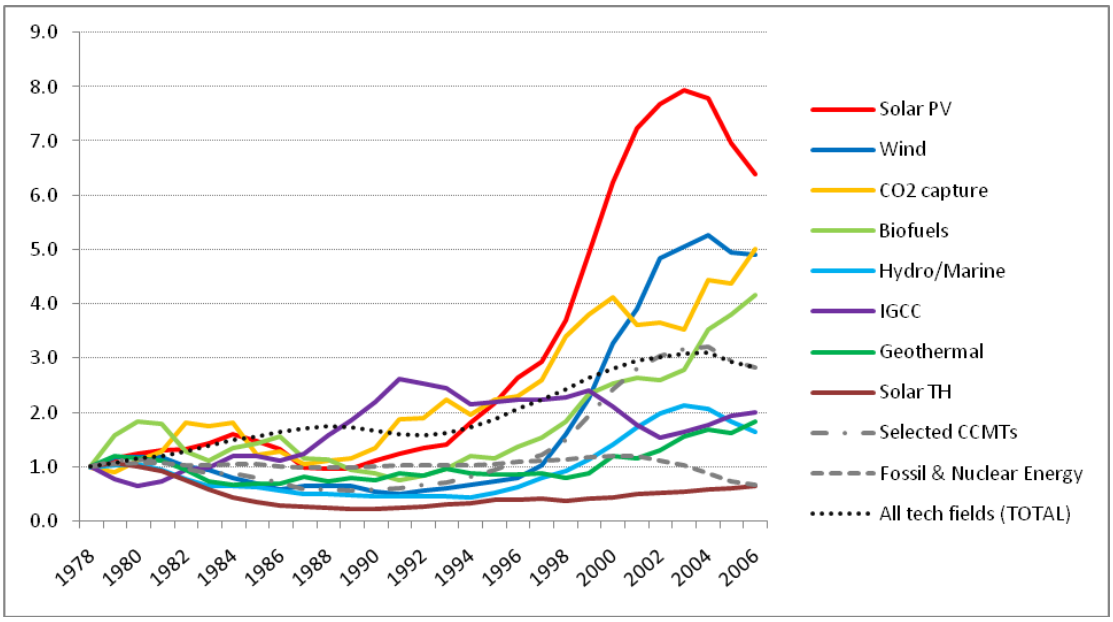
Figure 1. Aggregated Growth Rates of CCMT Claimed Priorities Patenting



(Source: EPO 2010)

The exponential growth of CCMT patents contrasts strongly with patents granted in traditional energy sectors, such as fossil and nuclear energy, which has seen systematic decline since 2000. Even though patent grants in all technology fields show steady growth, CCMT patents exhibit a far steeper development curve. This suggests firms increasingly focus attention on proprietary innovation in CCMTs and are slowly phasing out technologies in traditional energy sectors. For policy makers, these trends demonstrate that CCMTs are a rapidly growing market of significant economic and social value that may require new governance structures. Patent Offices, for example, could support this process by introducing accelerated procedures for granting CCMT patents in an effort to spur innovation in an area of critical importance.

Figure 2.Growth Rate of Claimed Priorities for Selected CCMTs



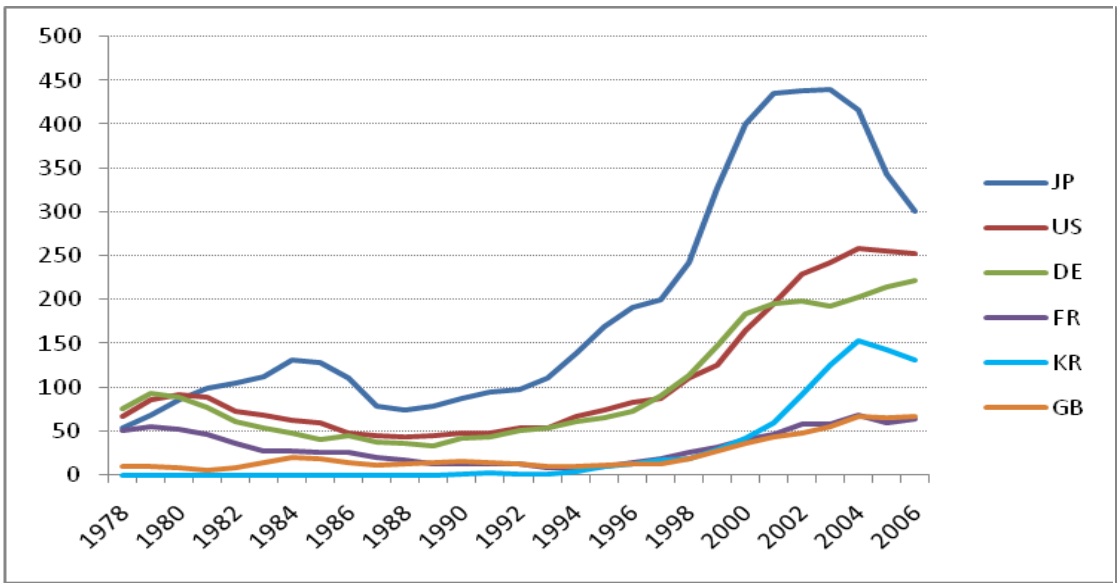
(Source: EPO 2010)

Disaggregating CCMT patenting trends makes growth rates even more impressive. Using an aggregated indicator of patenting in all technology fields as a benchmark enables analysis of the global trends in different technologies fields. Adopting the aggregated benchmark, we find that growth rates in areas such as *solar PV*, *wind* or *CO2 capture* outperform the benchmark by a factor of 2.6. The CCMT group *Solar TH* is the exception; patenting in this sector is significantly below the aggregated average for all technology fields. Unfortunately, the data does not permit evaluation of the direct market impact of these technologies, the de facto use of patents filed in certain sectors, or the commercialization of patented technology. This is a highly complex relationship. However, the data does illustrate the high growth rate of CCMT patenting. This implies increased R&D expenditure in these fields and indicates that firms believe CCMTs may ultimately offer new and lucrative market opportunities.

Patents for Climate Change Mitigating Technologies are highly concentrated in developed economies

CCMT patents are not equally distributed internationally. So which nations are driving these phenomenal growth rates?

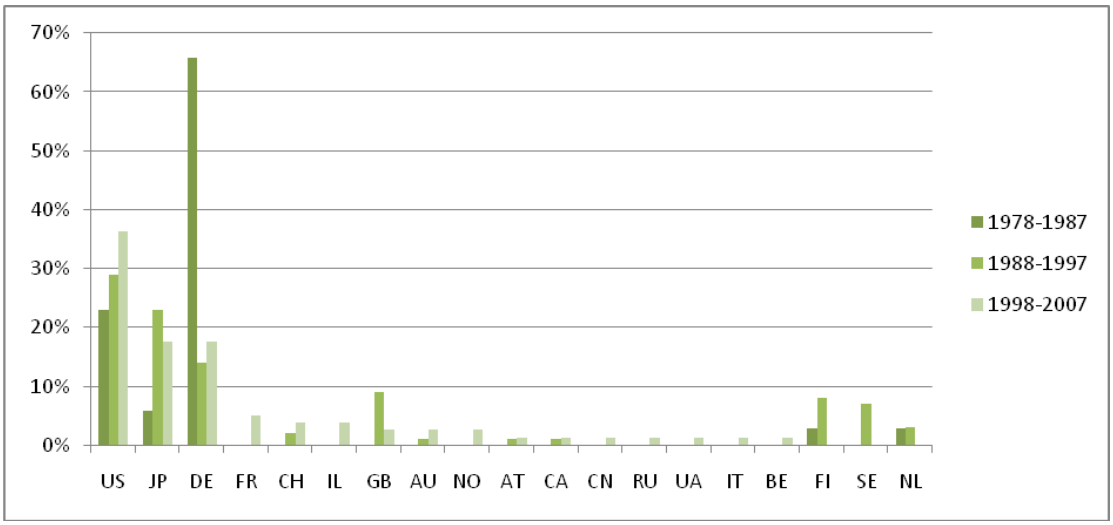
Figure 3. Countries leading patenting activity in CCMTs



(Source: EPO 2010)

Splitting the data by country of origin of patent owners shows that research activity occurs primarily in six countries; Japan, the United States of America, Germany, France, Korea and Great Britain. These results are not particularly surprising. Innovation in CCMTs is highly concentrated in developed economies with an average gross domestic product per capita (GDP/capita) of 35,000 Euro. Further disaggregating the data according to selected CCMT categories reveals a similar degree of concentration.

Figure 4. Share of world patenting in IGCC by country, based on claimed priorities worldwide



(Source: EPO 2010)

Some CCMT fields - such Integrated Gasification Combined Cycles (IGCC) technologies – have experienced significant market fluctuations. Germany lost most of its 65% market share in IGCC patents in the past twenty years. This most likely benefited the US, which enjoyed an increase from 20% to 35% in IGCC global market share during this period. However, market fluctuations have not impacted the overall concentration of patent ownership. Little evidence suggests new players have entered the CCMT market. The international distribution of CCMT patents remains highly concentrated within developed economies. Not a single developing country igures among the leaders.[ix]

Ownership concentration is also evident in individual CCMT fields such as *CO2 capture*, *CO2 storage* and IGCC. *CO2 storage* patents, despite experiencing ownership diffusion over the past twenty years, still remain highly concentrated.

Table 1. Major applicants in CCS and IGCC technologies (1988-2007)
(n =number of filings; % = percentage share)

CO_2 Capture

1988-1997	n	%	1998-2007	n	%
BOC GROUP	157	9.7%	PRAXAIR	206	6.3%
MITSUBISHI	138	8.6%	AIR LIQUID	162	5.0%
AIR PRODUCTS AND CHEMICALS	93	5.8%	AIR PRODUCTS AND CHEMICALS	141	4.3%
KANSAI	78	4.8%	BOC GROUP	113	3.5%
AIR LIQUID	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 CORP.	28	1.7%	INSTITUT FRANCAIS DU PETROLE	57	1.8%

			44%			33%

CO_2 Storage

1988-1997		n	%	1998-2007	n	%
MITSUBISHI		18	38%	SHELL	98	21%
AGRICULTURAL GAS CO		9	19%	INSTITUT FRANCAIS DU PETROLE	43	9.3%
NKK CORP		5	10%	TERRALOG	23	5.0%
SEEC INC		4.5	9.4%	EXXON	20	4.2%
ELECTRIC POWER RESEARCH INST		2.5	5.2%	SCHLUMBERGER	18	3.9%
BAL AB		2	4.2%	CDX GAS	17	3.7%
UNION OIL CO. OF CALIFORNIA		2	4.2%	AIR PRODUCTS AND CHEMICALS	15	3.2%
DANIEL STEWART ROBERTSON		1	2.1%	DIAMOND QC TECHNOLOGIES	14	3.0%
HEINZ SEBASTIAN, LEIPZIG DE		1	2.1%	DROPSCONE	11	2.4%
NAUCHNO-TEKHNICHESKIJ PODZEMGAZPROM	TSENTR	1	2.1%	BHP BILLITON INNOVATION	8.5	1.8%
			96%			57%

IGCC

1988-1997	n	%	1998-2007	n	%
MITSUBISHI	90	9.3%	MITSUBISHI	57	7.8%
AIR PRODUCTS AND CHEMICALS	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%
IMATRAN VOIMA	32	3.3%	ISHIKAWAJIMA HARIMA	22	3.0%
ISHIKAWAJIMA HARIMA	32	3.3%	NORSK HYDRO	21	2.9%
SIEMENS	32	3.3%	ALSTOM	19	2.7%
AHLSTROM	25	2.6%	ORMAT	19	2.6%
		53%			49%

(Source: EPO 2010)

The top ten applicants for *CO2 storage* patents between 1988 and 1997 controlled 96% of the global distribution. This decreased to 57% between 1998 and 2007. Yet, almost 60% of *CO2 capture* patents remain concentrated within ten corporations. Concentration rates for *CO2 capture* and IGCC sectors have remained more or less constant at 45% since the late 1980s. Again, a few corporations control nearly half the patents. It is worth noting how the leading patent owners between 1988 and 1997 are often different from those for 1998 to 2007. However, all of them are multinational corporations headquartered in the developed world.

Considering the market dominance of ten corporations within six countries, an important question arises. Are there opportunities for developing countries to secure patent ownership and actively engage in innovation? Is it possible to shift from an innovation follower to the innovation leader of tomorrow? Or, on the contrary, are developing nations restricted to relying on CCMTs developed elsewhere in their efforts to combat climate change?

China, India and Brazil are important new players

The EPO data reveals that, while most developing countries remain marginalized in the international patent system, India, China and Brazil are increasingly asserting ownership over patents. Instead of passively relying on proprietary innovation developed elsewhere, these nations are innovating themselves. This is an important

milestone in their development. India features among the five leaders of *solar PV* patents, one of the fastest growing CCMT categories. Brazil is the leader for *hydro- and marine-based* patents and ranks second for global *biofuel* patents. There is clearly an important degree of innovation happening in these countries.

Since 1998, China emerged as a top patentee in the fields of *geothermal*, *solar PV*, *wind*, *CO2 capture* and IGCC. China's *geothermal* patents are growing at nearly the same rate as those of the UK, Sweden and Italy. If it maintains current growth rates, China will upset the global patent ownership distribution in these sectors. However, forecasts based on the EPO data must be cautious. Patent data can be misleading due to the role of foreign multinational corporations in emerging markets. Overall, developing countries' activities in CCMTs tends to focus on the production and dissemination of existing technology, rather than on genuine innovation. Moreover, the emergence of three important CCMT innovators like China, India, and Brazil should not be misread as a fundamental shift in the international patent system. There is no evidence of a diffuse ascension of developing countries in global innovation. For example, no evidence suggests that smaller economies in Africa and central Asia are consolidating patent ownership.

Whether or not developing nations actively engage in domestic innovation, a functioning international patent system should support technology transfer and improve access conditions. The EPO data suggests that, in the developing world, the improvement of access conditions and the implementation of technology transfer agreements related to CCMTs are also concentrated in China and Brazil. Both are large and important markets for green technologies. The patent filing levels of multinational corporations in different technology fields help evaluate the value ascribed to particular sectors and markets. The filing activities of foreign corporations in developing countries are also a proxy indicator of technology transfer and spill over. As the leading filing destination for foreign corporations, China may experience important spill over effects, though the scope of these effects are uncertain.[x] The largest number of priority patent filings in China come from Japan and the USA. The USA and Germany have the highest levels of priority patent filings in Brazil. India, however, does not receive the same degree of attention from innovation leaders.

The licensing landscape – key findings of the licensing survey

Greater scope for proactive patent management

The licensing survey supplements the findings from the patent landscape by providing a more dynamic picture of how patent owners manage IP. In particular, the survey identifies the varying emphasis that institutions place on out- and in-licensing in relation to business strategy, the scope of collaborative patent management, and the general licensing activities of patent owners in developing nations. Important stakeholders were identified by the patent landscape data and in consultation with multinational corporations (MNCs), small to medium-sized enterprises (SMEs), and industry associations. The survey produced a response rate of roughly 30% (160 out 500 patent owners responded). 71% of respondents were businesses (the ratio of MNCs to SMEs being 47:24) and 16% were public research institutions. While

respondents were relatively evenly distributed among CCMT fields, the *biomass/biofuels* sector had a higher than average response rate (overall 63%).

Out-licensing is when the underlying technology for specific products is made available voluntarily for a given period of time in a specific market in exchange for a monetary return. 40% of respondents considered out-licensing *very important* or *fundamental* to their business. 60% thought that out-licensing was *moderately important* or *negligible*. Compared to the overall benchmark, firms investing heavily in CCMTs focused more on out-licensing than others: 53% rated out-licensing *very important* or *fundamental* and only 47% considered out licensing *moderately important* or *negligible*.

Table 2. Importance of out-licensing: CCMT-intensive organisations compared to all respondents

Importance of *out-licensing* activities	**% of all respondents**	**% of *CET-intensive***
Negligible	27%	16%
Moderately important	33%	31%
Very important	31%	43%
Fundamental	9%	10%

(Source: EPO 2010)

This data suggests CCMT-intensive organisations use out-licensing more than the average across all technology fields. On the other hand, that 47% considered out-licensing *moderately important* or *negligible* reveals there is greater scope for pro-active patent management. In fact, 60% of respondents reported that neither out- nor in-licensing of CCMTs impacted their business practice.

Table 3. Importance of out-licensing activities according to type of organisation

Importance of *out-licensing* activities	**% of private companies**	**% of academic institutes**	**% of public bodies**
Negligible	35%	14%	4%
Moderately important	28%	41%	46%
Very important	30%	26%	42%
Fundamental	5%	19%	8%

(Source: EPO 2010)

Academic institutions and public agencies placed stronger emphasis on out-licensing than the business sector. 45% of academic institutions and 50% of public bodies considered out-licensing *very important* or *fundamental* in comparison to only 35% of

private sector respondents. The data also reveals that MNCs focus more on out-licensing than SMEs. This could be due to a lack of adequate legal resources and insufficient awareness of patent management among small firms.

Table 4. Importance of in-licensing activities according to type of organisation

***Importance of in-licensing* activities**	**% of private companies**	**% of academic institutes**	**% of public bodies**
Negligible	33%	74%	71%
Moderately important	41%	11%	21%
Very important	22%	15%	4%
Fundamental	4%	0%	4%

(Source: EPO 2010)

In-licensing is used to promote innovation among actors who collaborate on projects with shared objectives and resources. In-licensing was considered by all respondents as less important than out-licensing. Only 26% of firms rated in-licensing *very important* or *fundamental*. Not a single academic institution considered in-licensing *fundamental* and less than 8% of public bodies stated in-licensing was *very important* or *fundamental* to their activities.

Though licensing is fundamental to proactive IP management strategy, it is not the only tool available. The licensing survey thus also documented the extent to which other forms of IP management, like patent pools or strategic partnerships, influenced the strategies of various actors.

Table 5. Share of responding organisations reporting a high intensity in their use of different IP-based activities relating to CCMT patents and technology

Type of IP-based activity	**% of all responding organisations**	**% of responding *CCMT intensive* organisations**
Collaborative R&D	68%	76%
Joint ventures or alliances	33%	42%
Consulting / services	33%	29%
Spin-outs / start-ups	21%	26%

(Source: EPO 2010)

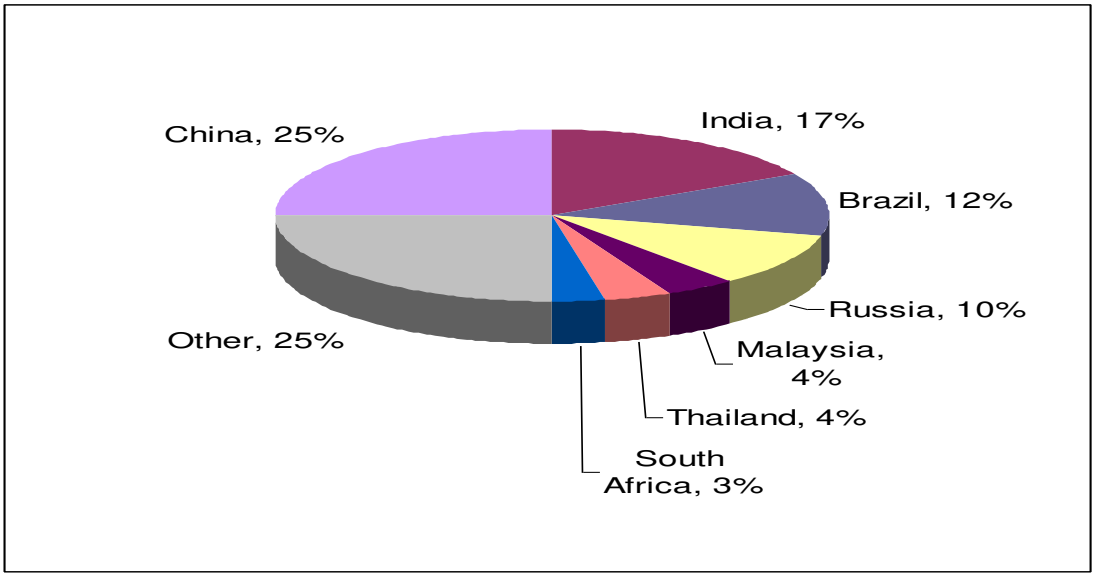
The survey again shows that the CCMT field is more progressive than the benchmark. 76% of respondents reported highly intensive use of collaborative R&D in CCMTs, whereas only 68% did so in other sectors. Joint ventures or alliances were also more important for CCMT-intensive organizations than the average technology firm (42%

vs. 33%). Again, MNCs are consistently more engaged in collaborative R&D enterprises than SMEs.

License agreements in developing countries

Like priority patent filings, licensing agreements in emerging markets are also highly concentrated. Nearly 60% of correspondents indicated they had not entered into a licensing agreement with a partner based in a developing country in the past three years. Only 17% stated they frequently (5%) or occasionally (12%) did so. China, Brazil and India emerge once again as leaders of the developing world.

Figure 5. Developing countries with which responding organisations have been most involved with regard to licensing agreements or other IP-based commercialization activities involving ESTs



(Source: EPO 2010)

Of all global licensing activity with a developing country partner, 54% of cases involved a partner in China, India or Brazil. This licensing concentration suggests that, while important new innovation players are emerging, the majority of developing countries are left out.

The EPO data contradicts conventional wisdom in two ways. First, patent protection is not the only important factor in determining whether a multinational firm enters into licensing arrangements with partners in the developing world. Inadequate IP protection is often identified as the primary obstacle to technology transfer in developing nations.[xi] However, supportive institutions and other socio-economic factors, which condition the context of knowledge exchange, are also critical in determining the extent of collaboration. 85% to 87% of respondents stated that scientific capabilities, infrastructure and human capital, favourable market conditions and investment climate were considered slightly more important than the extent of IP protection in a country. Patent protection is only one element in a mix of factors that determine the scope, direction and intensity of licensing arrangements in the

developing world. The second insight is that the majority of surveyed organisations would license patents to developing countries under more favourable conditions.

Table 6. Willingness of ESTs patent owners to provide more flexible licensing terms (including monetary ones) to entities that are based in developing countries

Willingness to provide for 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%

(Source: EPO 2010)

The vast majority (70%) indicated they would willingly provide more flexible licensing terms in developing countries. The extent of flexibility differed: 5% stated they would willingly offer *substantially more accommodating* license terms while 15% were prepared to offer *much more accommodating* terms. Academic institutions were the most willing to provide more flexible licensing terms to developing country partners with limited financial capacity. Public bodies followed as the next most likely. SMEs were also more likely to offer flexible terms than MNCs. These results suggest there is considerable scope for proactive IP management in developing nations to combat climate change.

Conclusions

The EPO data advances our understanding of how patents influence CCMTs in several ways. Current trends show CCMTs enjoy substantial patenting growth rates in the post-Kyoto era. *Solar PV*, *wind*, *CO2 capture* and *CO2 storage* outperformed patent filing activity in conventional energy sectors by a factor of 2.6. Yet, CCMT patenting is highly concentrated in robust economies with an average GDP/capita of 35 000 Euro. Japan, the United States of America, Germany, France, Korea and the Great Britain are the leaders of proprietary innovation in this field. Among developing countries it is China, Brazil and India that are increasingly important. While the majority of the developing world may still be classified as technology followers, these three nations are important to the global development and diffusion of green technologies. Local R&D capacity in China, India and Brazil demonstrates that the developing world is not a homogeneous bloc as regards innovation. In CCMTs, a handful of large players are catching up to the world's leading economies.

Existing terminology frames debates on IP protection as a dichotomy between developed and developing nations. This distinction should be revised to promote a subtler understanding of innovation in climate change mitigating technologies.

Current dialogue on technology transfer, which implicitly casts developing nations in a passive role, does not adequately account for the rise of China, India and Brazil. However, most developing countries remain dependent on third party technology. It is essential for policymakers to understand the range of IP strategies that provide both incentives for private R&D and guarantees of equitable access to new technologies. The EPO data offers new perspectives on what institutional reforms could assure access to innovation is not rationed by ability to pay. If patent owners are willing to license their technology under more favorable conditions to partners in developing nations - as the data shows - there may be no immediate need for more aggressive measures to assure the public interest in climate change policies, such as compulsory licensing.

The data suggests that equitable access to proprietary innovation is not hampered by IP protection itself, but because corporations, public organizations and universities around the globe do not sufficiently leverage the range of options available to them. The spectrum of opportunities created by the IP system is limited by a lack of awareness on the proactive ways it can be used. This was shown, for example, by the fact that 47% of respondents considered out-licensing *moderately important* or *negligible* to their operations, only 26% rated in-licensing *very important* or *fundamental*, and 60% indicated they had not entered into a licensing agreement with a partner based in the developing world in the past three years. These trends imply that the majority of potential users are unaware of the enabling opportunities of the current IP framework. They also suggest that most patent owners deploy patents defensively rather than as a means to establish new revenue streams. It is in this respect that public policy can contribute. By raising awareness about the enabling opportunities of the patent system, policymakers can support markets for technology and stimulate an equitable IP framework. This will help align the patent system with the needs of users. It will also provide a mechanism with which to generate additional information on how adequately institutionalized market strategies can benefit the transfer and diffusion of important technologies. Essentially, the new data depicts a more differentiated patent landscape than conventional wisdom paints. Further study is needed to comprehend exactly how patents relate to commercial activities in critical research fields and what institutional frameworks need to be established to foster more equitable patterns of technology transfer.

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[vii] The full report, titled 'Patents and Clean Energy Technologies: Bridging the Gap between Evidence and Policy', is available at http://documents.epo.org/projects/babylon/eponet.nsf/0/cc5da4b168363477c12577ad00547289/$FILE/patents_clean_energy_study_en.pdf

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