

Renewable Energy Patent Filings go East



Climate change is one of the biggest challenges of our time. A global adoption of climate change mitigation and adaptation technology that support the effective transfer of technologies is crucial. Biofuels, solar thermal, solar photovoltaics (PV) and wind power are renewable energy technologies that may thus be referred to as Climate Change and Mitigation Technologies (CCMTs).

As stated by the International Renewable Energy Agency (IRENA) in a working paper¹ from 2013 on the role of patents in renewable energy technology innovation it appears clear that:

- the role of patents in Renewable Energy Technologies (RETs) is not well understood by many policy makers;
- making patent information more accessible may help accelerate innovation;
- patents are an important instrument to assess patterns in RET innovation.

Analysis of patent data relating to a specific technology can indeed reveal important information about the origins of the technology and its development.

Data on patent holdings by type of institution (public or private) and the evolution of patent filing activities in a particular technological area provide useful information about industry structures and value and supply chains.

Identification of technology owners and the emerging technological advances from the patent literature can highlight areas of industrial investment and innovation. Similarly, patent based institutional profiles on technology owners can identify shifts in R&D focus, highlight collaborations and demonstrate market strategy. Shifts in corporate strategy concerning various technology aspects can also be identified.

Not surprisingly, the World Intellectual Property Organization (WIPO) has thus commissioned a study to Cambridge IP which was released in June 2014 showing interesting patent trends in CCMTs².

The highlights of these studies related to solar energy conversion combined with further studies³ on the temporal trends in energy patents are collected in this article.

Global patent application trends for selected CCMTs: 1975-2011

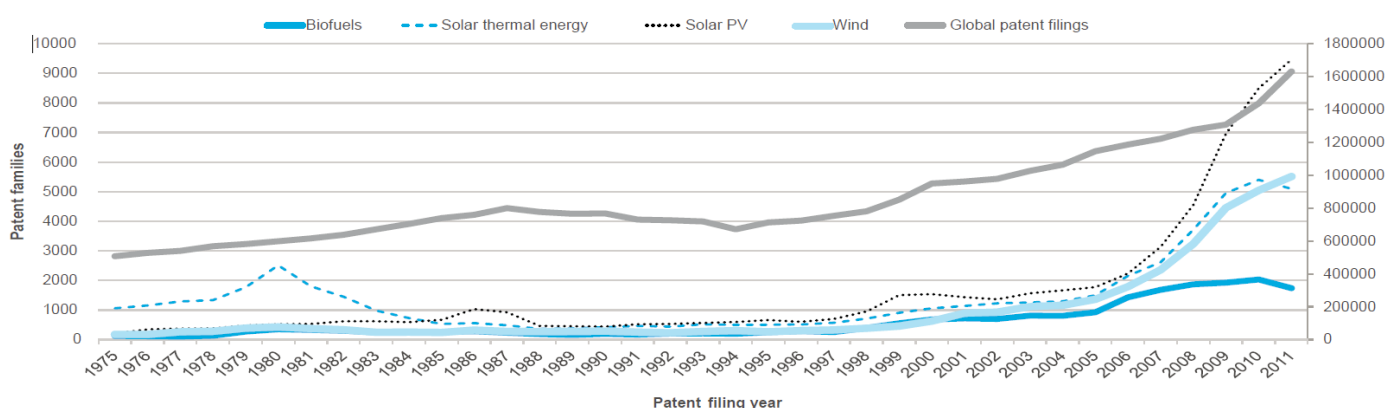


Figure 1²

¹ https://www.irena.org/DocumentDownloads/Publications/Intellectual_Property_Rights.pdf

² http://www.wipo.int/pressroom/en/stories/green_tech.html

³ Bettencourt et al. Plus One, 2013, 8, 10

PATENT TRENDS

The volume of patents filed in these Climate Change Mitigation Technologies (CCMTs) during the last five to six years for which comprehensive data is available (2006–2011) exceeds the volume of patents filed in these areas in the previous 30 years.

Rates of patent filings in the sectors of bio-fuels, solar thermal, solar PV and wind energy began to rise in the late 1990s (figure 1). Since 2006, this increase has been particularly striking across all four CCMT focus areas, especially solar photovoltaics (PV). Patent filings around CCMTs are growing at an even faster rate than the global average, indicating the high pace of commercial innovation in CCMTs.

Combined, this average growth rate in the period 2006–2011 stands at 24%, while the global average for all technologies is 6%.

The growth in patenting rates in the respective technology fields is most likely a response to

market conditions including increased levels of R&D investment, shifts in policy incentives such as feed-in-tariffs, and technological advances, such as cost reductions in manufacturing.

This conclusion is supported by a further study on temporal trends in energy patents during the period 1974–2009³, which shows rapid growth over the last decade, with the greatest increases for patents, related to renewable energy. Public funding for energy R&D increased dramatically in the 70s and, 80s but then remained relatively constant. A similar trend is seen when aggregating globally (figure 2B).

It can be concluded that there has been a boom in energy innovation, as measured by patents, which is dominated by solar and wind conversion technology. These trends over time cannot be explained by public funding alone, but, can be accounted for by combined effects of public investments in R&D and a fast rate of growth in markets for these technologies (figure 2).

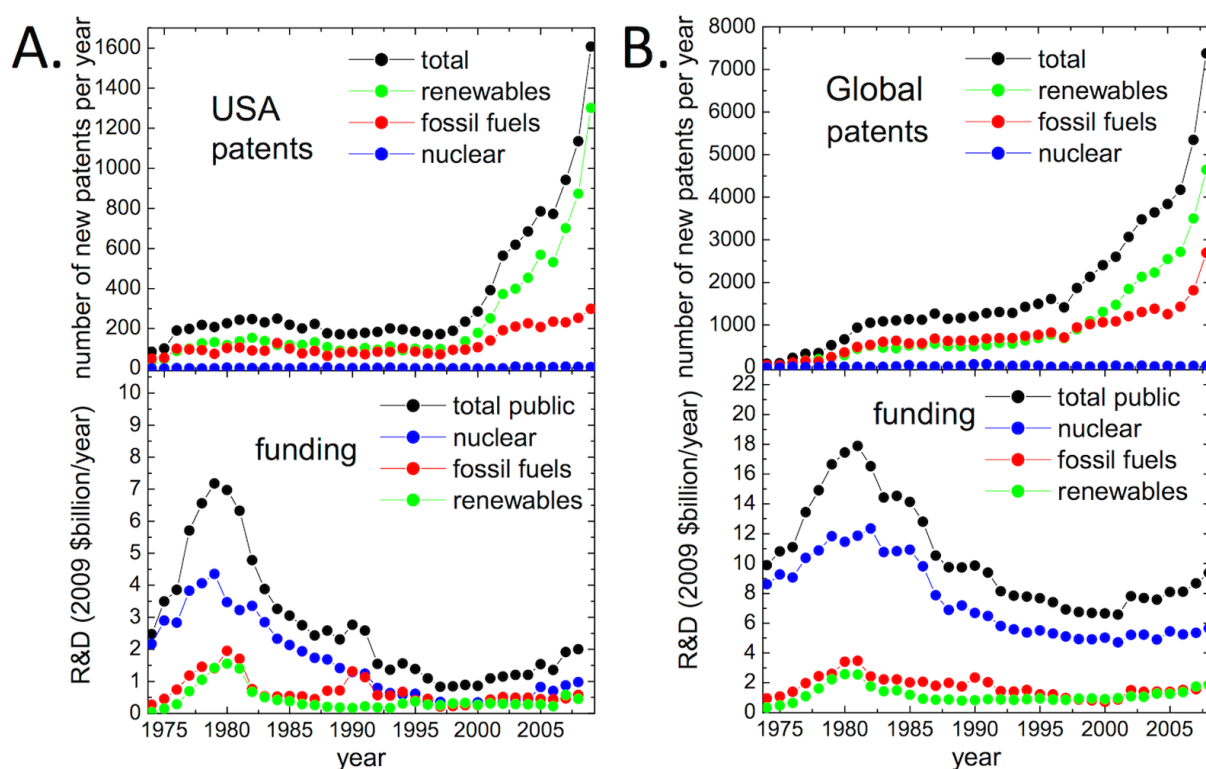


Figure 2³

When analyzing the combined ranking of key technology owners based on patent family filings from the individual technical fields of each of the four CCMTs it can be noticed that solar PV accounts for a majority of the technology owners listed with a number of patent families ranging from 1108 for LG to 185 for Suzlon Energy.

RANKING OF THE TOP 20 TECHNOLOGY OWNERS ACROSS THE FOUR CCMTS

Rank 2006-2011	Technology Owners	Country/Region of Company HQ	Technology Area
1	LG	Republic of Korea	SolarPV
2	Mitsubishi	Japan	SolarPV
3	General Electric	USA	Wind
4	Sharp KK	Japan	SolarPV
5	Panasonic	Japan	SolarPV
6	Samsung	Republic of Korea	SolarPV
7	Siemens AG	Germany	Wind
8	Mitsubishi	Japan	Wind
9	Kyocera Corp	Japan	SolarPV
10	Konica Minolta	Japan	SolarPV
11	Fujifilm Corp	Japan	SolarPV
12	Hitachi	Japan	SolarPV
13	Vestas Wind Sys As	Denmark	Wind
14	Hyundai	Republic of Korea	SolarPV
15	Sumitomo	Japan	SolarPV
16	Toyota	Japan	SolarPV
17	Industrial Technology Research Institute	China	SolarPV
18	Sony Corp	Japan	SolarPV
19	Dainippon Printing Co Ltd	Japan	SolarPV
20	Suzlon Energy (REpower Systems)	India (Germany)	Wind

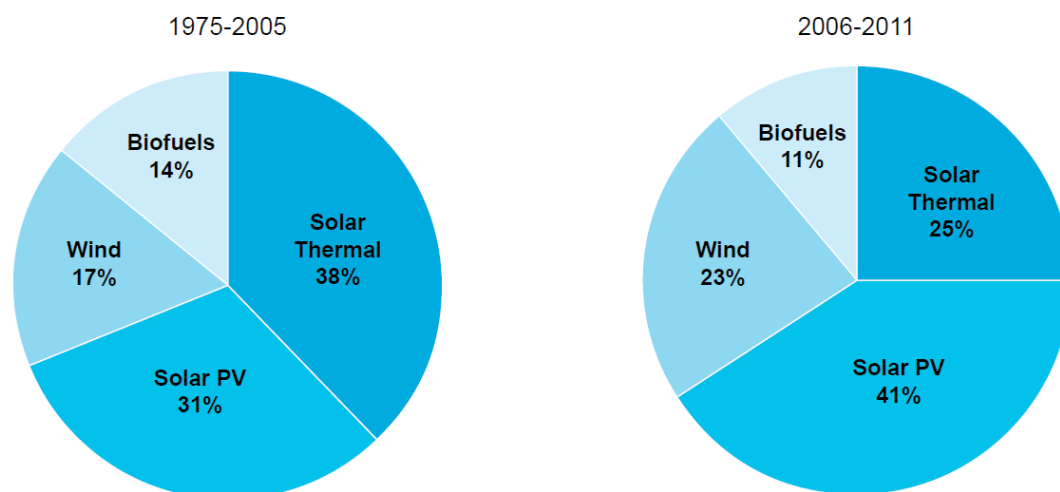
Table 1²

When comparing the number of patent families filed in the four CCMT technical fields (figure 3) it can be noticed that Solar thermal energy saw the highest number of inventions filed in proportion to the three other areas from 1975-2005, while both solar PV and wind energy saw an increase in their share of the proportion of CCMTs filed from 2006-2011.

Each patent family may be regarded as an indication of innovation, making solar PV the most commercially innovative area of technology as measured by volume of patented innovations.

Importantly, China accounts for the highest percentage of patent filings in three of the four CCMT patent areas for the period 2006-2011 (biofuels, solar thermal and solar PV). The contribution from China is particularly strong in solar thermal, with China accounting for around 55% of Office of First Filing applications in that period.

TECHNOLOGY LANDSCAPE COMPARISON: PATENT FAMILIES FILED FROM 1975-2011



CAMBRIDGE *IP*

Figure 3²

INTELLECTUAL PROPERTY CONCENTRATIONS ARE SHIFTING

IP concentrations assess the concentration of patent ownership in a technical field. In figure 4, IP concentration is assessed by the proportion of patents held in each technical field by the 20 most patent active companies (by number of patent family filings).

Concentration levels can be indicative of a range of features within technology markets. Figure 4 illustrates the differences in the level of IP concentration between the technical fields of the four CCMTs in periods 1975-2005 (first period) and 2006-2011 (second period). From the first to the second period, IP concentration decreased across all except one technical fields, i.e. with the exception of wind.

The wind energy area has the most consistent IP concentration among the four focus areas across the two periods. This is likely indicative of the relative maturity of wind technologies compared to technologies in the other spaces. Market players in the wind energy field have remained relatively consistent. On the contrary, the relatively low IP concentration in biofuels is evident.

A low IP concentration can be indicative of a fragmented industry, or one in which there is still a substantial amount of basic research and development required, or a relatively high level of technology system customization required.

INTELLECTUAL PROPERTY CONCENTRATIONS OF THE TOP 20 COMPANIES FROM 1975-2011

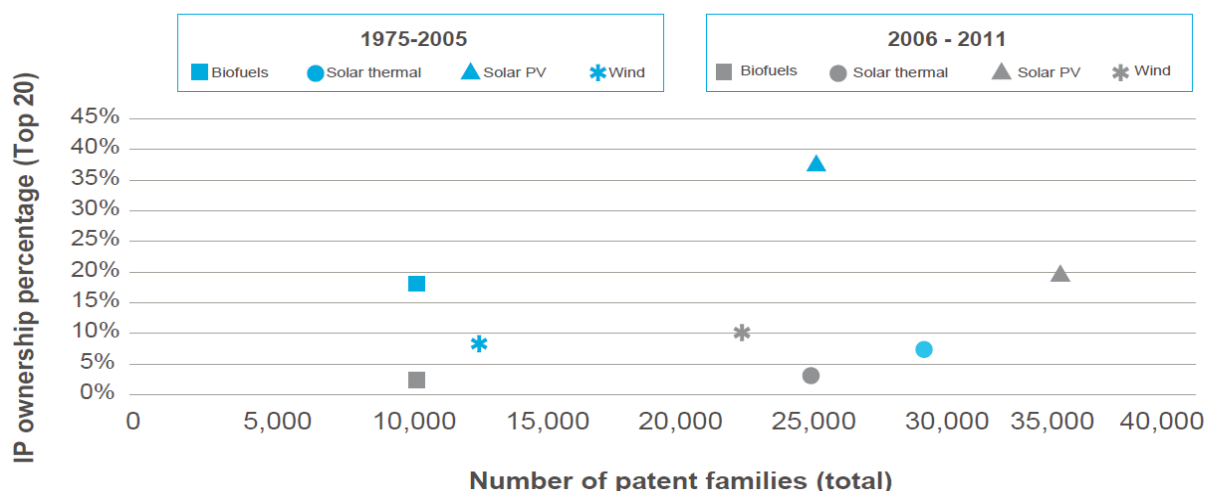


Figure 4²

The majority of the growth in patent filings of solar thermal has been within heat exchange systems and mounting/tracking systems. Together, they account for over 80% of the technology classifications applied to solar thermal patent filings in that period. Importantly, 16 of the top 20 technology owners are new entrants and half of these new entrants are from China when comparing the second period to the first period.

This demonstrates a clear relative shift in investment towards China. Similar to other CCMTs, annual solar thermal patent filings increased significantly at an average annual rate of 24% from 2006 to 2011.

Solar thermal is unique in the comparative volume of patents filed during the 2006-2011 and 1975-2005 periods. Despite a marked increase over the past 6 years, it is the only technology of the four considered in this report where fewer patents were filed in the 2006-2011 period than the 1975-2005 period. This is likely due to the early stage technology developments in the late 1970s that yielded significant advances, particularly around power generation.

Solar thermal is an industry, however, in which the top technology owners will not necessarily

reflect the top operators of solar thermal power generation plants. This is due to the large-scale investment and resource capacity necessary to own and operate a solar thermal plant. Often operators will be aggregators of technologies and specialize in large-scale projects.

China, with its capability for large-scale projects and abundance of land, appears to be well-suited as a potential developer and user of solar thermal. Not surprisingly, therefore, patent filings in China have increased steadily and now account for around 40% of all filings globally. A similar increase is seen when analyzing the office of first filings. China leads with a 57% share whereas Japan dominated in the period 1975-2005 with 37% of all filings. Across the four CCMTs of this report, solar thermal shows the highest percentage of Chinese patent filings from 2006-2011.

The Republic of Korea shows an increased share of global filings from 1% to 6%; Japan decreased its share from 37% to 15%; and Germany decreased from 14% to 9%. Germany is still the second most popular office of first filings in recent years. This together with the fact that five of the top 20 patent owners are headquartered in Germany demonstrates that the country is still a major player in this technical field.

Japanese companies continue to play a prominent role in the solar PV technical field. Fourteen of the top 20 technology owners in the solar PV technical field are Japanese companies, and of those, a majority appear in the top 20 list in period 1975–2005.

Major new entrants in the top 20 technology owners in the solar PV technical field are from China and particularly the Republic of Korea as evidenced by the rise of number of patents held by LG and Samsung. Solar PV is the only CCMT technology area where all of the top 20 patent holders are based in Asia.

Solar PV has the highest volume of patent filings of the four CCMTs presented in the report from WIPO², with 34,849 patent families filed and 80,781 patent applications filed in the 2006–2011 period. Solar PV also sees the highest annual average increase in patent filings with a rate of 33%. The period with the highest rate of increase was between 2008 and 2009, when patent filing rates increased by nearly 50%.

Materials innovation accounts for 58% of innovation in the solar PV technology landscape for 2006–2011; the most patent intensive materials focus was in organic silicon PV cells and dye sensitized solar cells.

Japanese companies continue to play a prominent role in the solar PV technical field. Seven out of the top ten technology owners are Japan-based companies, and of those, a majority appear in the top 10 patent ownership table for the period between 1975 and 2005. Of the four CCMTs reviewed in this report, solar PV retains the highest proportion of ranked technology owners of the two periods. Major new entrants are from China and particularly the Republic of Korea as evidenced by the rise in number of patents held by LG and Samsung.

In strong contrast to the biomass landscape, there is only one research institute among solar PV innovators, with 95% being private entities.

In terms of patent filing locations there is a fairly even distribution between China, Japan, and the US, each accounting for approximately 20% in the period of 2006–2011. Filings in the Republic of Korea accounted for 13% of the solar PV technology landscape in 2006–2011. This is a significantly higher percentage than in any other CCMT. The trend is not surprising considering the presence of three Korean companies in the top ten patent owners.



<http://www.seia.org/sites/default/files/PV-panels-sun-flare.jpg>

Japan is the most common office of first filing for solar PV, which is to be expected considering the prevalence of Japanese companies as top technology owners. However, there has been a considerable reduction in the dominance of Japan as an office of first filing, with China and the Republic of Korea accounting for much higher proportions.

As mentioned, Solar PV exhibits particularly high volumes and rates of patenting activity when compared with the other CCMTs. Although nearly one third of all patent filings are currently made in China, representing a major increase since 2006, the proportion of Chinese first filings in solar PV is smaller in this patent

landscape than in the wind, biofuels or solar thermal patent landscapes. In addition, solar PV is the only area in which a Chinese company does not feature within the top ten technology owners.

In the early 2000s, solar PV panels were primarily manufactured in the US, Germany and Japan. By 2010, however, China manufactured over half the world's annual panel supply. China's National initiatives supplied R&D and installation support for solar PV. Additionally, by 2011, China's only confirmed solar feed-in tariff applied to photovoltaic plants alone.

The fall in solar panel manufacturing prices means that installation is now the largest cost component of solar PV systems. Improvement of solar-to-electric power conversion efficiency, reducing the number of panels that need to be installed, is now increasingly important for further reductions in the overall cost of solar PV. The drive toward conversion efficiency has, in turn, encouraged innovation and R&D, elements which are now listed as basic principles within China's Five-Year Plan for the Solar Photovoltaic Industry. Chinese solar PV manufacturers thus appear to have begun shifting their focus from manufacturing to innovation.



<http://media.gottraffic.net/images/iHBY.QJLuxqg/v14/640x-1.jpg>

Historically, Chinese players in the solar PV space have focused on the conventional manufacture of silicon-based panels. However, more recently China has used its experience in scaling-up conventional panel production to inno-

vate in the solar PV market. China has pioneered methods for translating unconventional technologies, with non-domestic origins, into mass production.

One example of Chinese innovation, Yingli Green Energy (China), collaborating with the Energy Research Centre of the Netherlands (ECN), announced in 2010 their capacity for the large scale production of solar panels with a conversion efficiency of 17.6% (significantly above the industry average of just over 14%). The partnership involved Yingli scaling up production of technology originally developed by ECN.



<http://www.yinglisolar.com/en/>

There is also evidence of western companies moving R&D to China. In 2009, Applied Materials Inc. (ranked 22nd based on patent family filings with 131 patents filed between 2006 and 2011) opened the world's largest, self-declared 'most advanced' commercial solar R&D facility in Xi'an, China. Applied Materials, Inc is a US-based global provider of equipment services and software for the manufacture of solar PV products that first entered into the solar PV patenting in 2002. Recent patents from Applied Materials demonstrate innovation in the manufacturing and layering design of solar PV cells. Their commercial R&D 'Solar Technology Center' houses facilities for R&D engineering, as well as product demonstration and testing for crystalline silicon and thin film solar manufacturing equipment. It also serves as hub for research collaborations with over 40 universities.

Applied Materials' activity may also portend a popular path for future solar PV innovation in China. The company's Chinese R&D facility is primarily concerned with testing, machine construction and acting as a location for customers to see demonstrations and work on equipment before installing it at their own facilities.

The Solar Technology Center is not a production facility; rather it provides a new approach to research and design of entire solar PV assembly lines, and is focused on innovative production scale-up. Given the role of China in the solar PV space to-date, it seems likely that the country will play an increasingly important role in the solar PV patent landscape.

Conclusion

- Patenting activity has increased in all four technology sectors analyzed (biofuels, solar thermal, solar PV and wind).
- Innovation and patent filing rates in these technology sectors grew by 24% annually between 2006 and 2011 and outpaced the 6% global average increase in patent filings.
- China and the Republic of Korea have contributed most in recent years across all four technology areas.
- Patent concentrations have decreased across three of the four technical fields (wind being the exception), reflecting greater globalization as well as higher competition between players from more countries.
- The highest rate of technology investment is in the solar PV sector⁴.

***“Remember to find time for innovation ...
and to protect it with an appropriate
powerful tool.”***

⁴The data herein contained are based on the information provided by the WIPO Global Challenges Report² and other articles³. The information has been presented at the WREC in 2014 and will be presented at EUPVSEC 2015 by the author of this article.