Recent trends in the PV industry: lessons from the patent application filing figures

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This paper first appeared in the fifth print edition of *Photovoltaics International* journal.

ABSTRACT

This article will look at what trends can be gleaned from patent application publication figures of the past decade in the sector of PV technology. The study looks at the number of patent applications in PV technology published worldwide between 1999 and 2008. The data will show in which regions and countries patent protection is being sought. The figures are taken from patent documentation databases developed by the European Patent Office (EPO) and Japan Patent Office or databases used worldwide and available at the EPO, and they are retrieved mostly using patent classification schemes. The article also provides a brief overview of the role of the EPO and what companies, researchers and individual inventors should keep in mind when applying for a European patent.

Introduction

Patenting activity in the photovoltaic sector has grown rapidly during the past decade, with the number of PV patent applications published by the world's major patent offices more than tripling in the past 10 years (see Fig. 1). This is partly due to the generally growing trend of seeking intellectual property protection all over the world, as more and more individual inventors, companies and research institutions realise the importance and economic impact of patenting their inventions. Growth in the number of PV patent applications has outpaced other sectors, reflecting the growing interest in renewable energy sources in general and recent advances in PV technology in particular.

This paper presents results for some of the most technically and economically relevant PV technologies, such as crystalline and polycrystalline silicon cells, thin film cells, III-V solar cells, dye-sensitized cells, organic solar cells, architectural integration of solar modules and PV concentrators.

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Looking at patent filing figures is useful because it can shed light on the success of scientific research and development efforts in a given sector. The number of patent applications is widely regarded as an indicator of the level of innovation in a specific technical field. At the same time

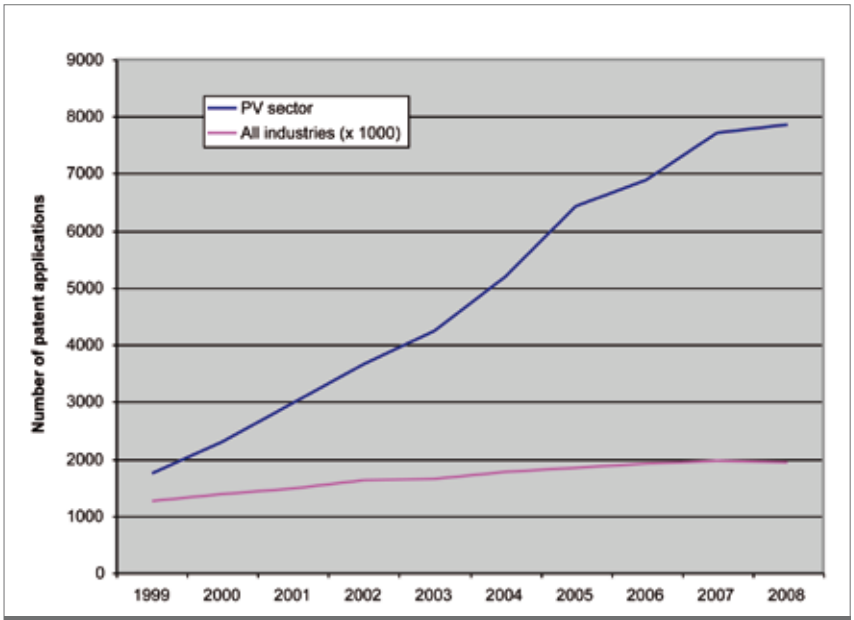

Figure 1. Global PV applications versus all industry applications.

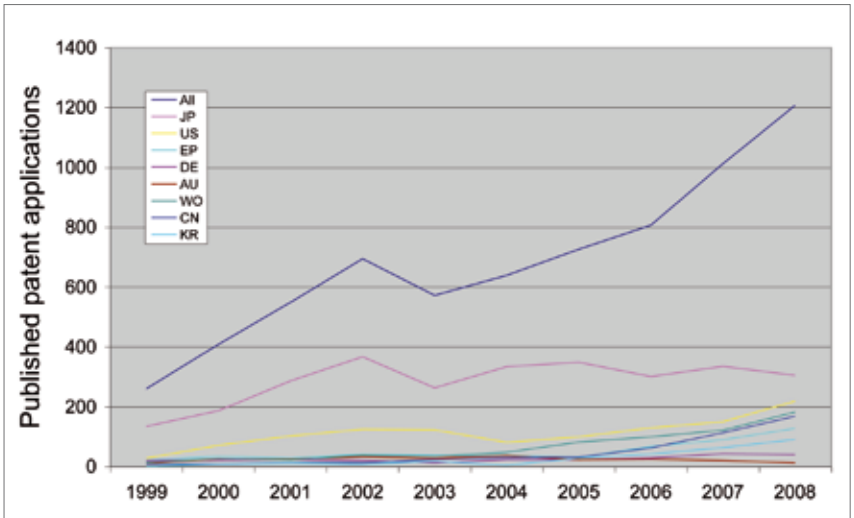

Figure 2. Published patent applications – crystalline and polycrystalline Si devices.

it can also give an indication of technology trends that are considered potentially successful.

Legend:

All – patent applications filed at the main patent offices around the world (including, but not exclusively, the below)

JP – patent applications filed with the Japan Patent Office

US – patent applications filed with the US Patent and Trademark Office

EP – regional patent applications filed with the European Patent Office

DE – patent applications filed at the German Patent and Trademark Office

AU – patent applications filed at IP Australia

WO – international patent applications filed at the World Intellectual Property Organization under the Patent Cooperation Treaty, for which the EPO and a select number of major national offices serve as 'international searching authority' and 'international preliminary examining authority'.

CN – patent applications filed at the State Office for Intellectual Property of the People's Republic of China

KR – patent applications filed at the Korean Intellectual Property Office.

The growth in PV patent applications seen in the past 10 years reflects the strong interest of the market and thus a growing demand for patent protection in the field. Analysis of the yearly patenting activity in specific sectors of PV technology and its distribution in different countries allows a detailed study of the trends in targeted markets and the differentiation of growing markets from those that are stable or falling.

Given the multidisciplinary nature of PV technology, which requires experts to have a thorough knowledge of material science and of several specific production technologies for a large spectrum of semiconductor materials both in the laboratory and in industry, it is difficult to provide a comprehensive picture of patent applications relating to all sectors and sub-sectors of PV technology. Therefore, results in this study are given for some of the technically and economically most relevant PV technologies, namely:

Crystalline and polycrystalline silicon cells: this includes all applications related to manufacturing methods for the production of crystalline and polycrystalline silicon solar cells (including multi-step methods) and to the structure of the cells (see Fig. 2).

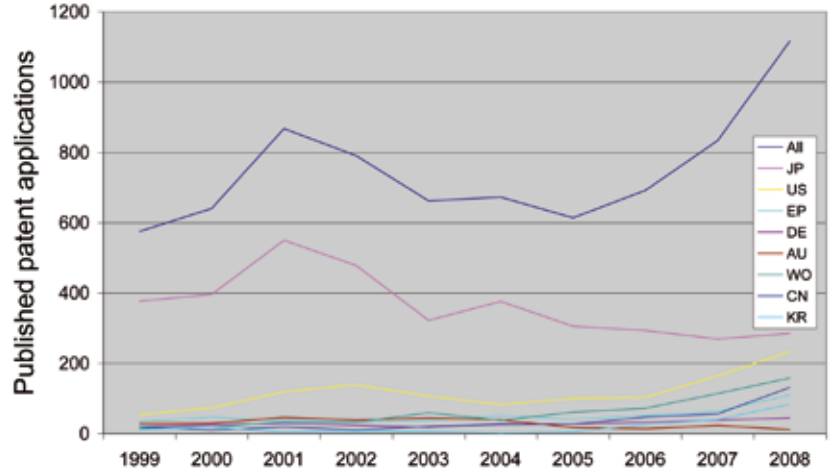

Figure 3. Published patent applications – thin film solar cells.

Thin-film cells: this important sector specifically includes amorphous silicon cells, CIS (and related compounds) cells and II-VI (CdS/CdTe) cells, comprising the methods of materials growth, the structure of the cells and the monolithic integration of series-connected cells to form thin-film modules (see Fig. 3).

III-V solar cells: this comprises III-V material cells, from monojunction GaAs or InP cells to multijunction cells including ternary and quaternary materials. Included also are methods of production of the cells. These cells have recently reached the highest levels of efficiency and are important for use in space and under high light concentration (see Fig. 4).

Dye-sensitized cells: this sector is dedicated to all technical aspects of so-called DSSC (dye-sensitized solar cells) comprising the structure of the cells and modules, their components and their method of fabrication. Although relatively new, this technology has already shown strong growth in numbers of patent applications (see Fig. 5).

Organic solar cells: this sector includes all developments related to solar cells comprising organic materials, and to their methods of fabrication. Also included are patent applications concerning specific organic materials used in organic solar cells (see Fig. 6).

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Architectural integration: this refers to the combination of solar cells and modules in buildings and urban landscapes. An important part of this sector is dedicated to roof systems, roof modules and their specific mounting technology. Important recent market developments in this sector are stimulated by national laws providing a guaranteed tariff for the electricity produced by small PV plants installed by private persons on the roof of their homes (see Fig. 7).

PV concentrators: this sector is dedicated to all aspects of solar light concentration to increase considerably the intensity of light coming on the cells. With the use of concentrators, small solar cells can produce more energy than a much bigger solar cell without concentration. There has been a major increase in patent applications in recent years, surely due to the solar-grade silicon shortage that has opened the way to new PV developments

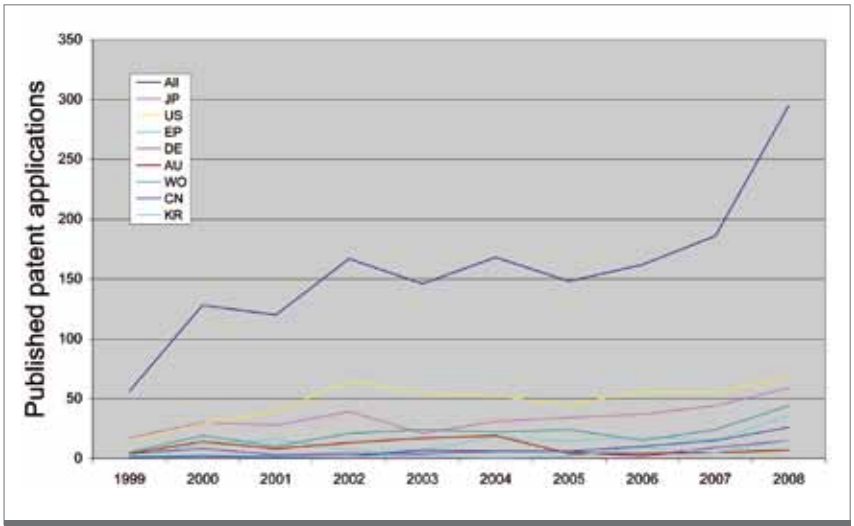

Figure 4. Published patent applications – III-V solar cells.

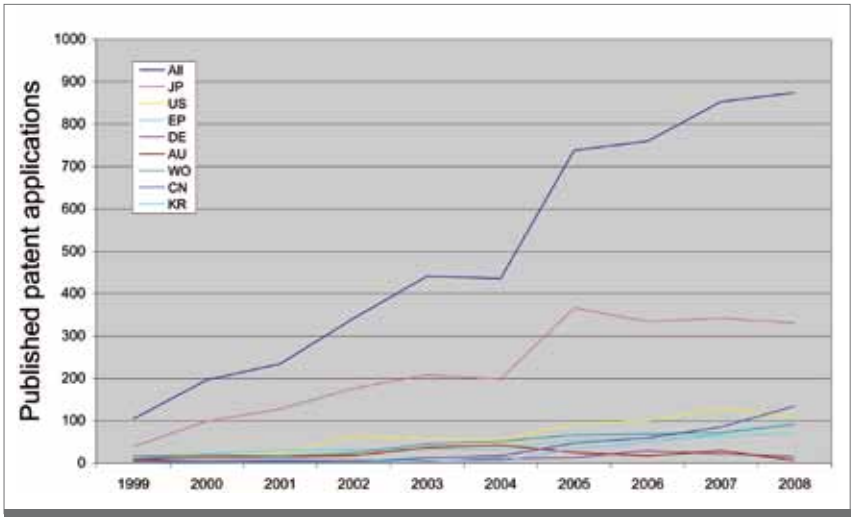

Figure 5. Published patent applications – dye sensitized cells.

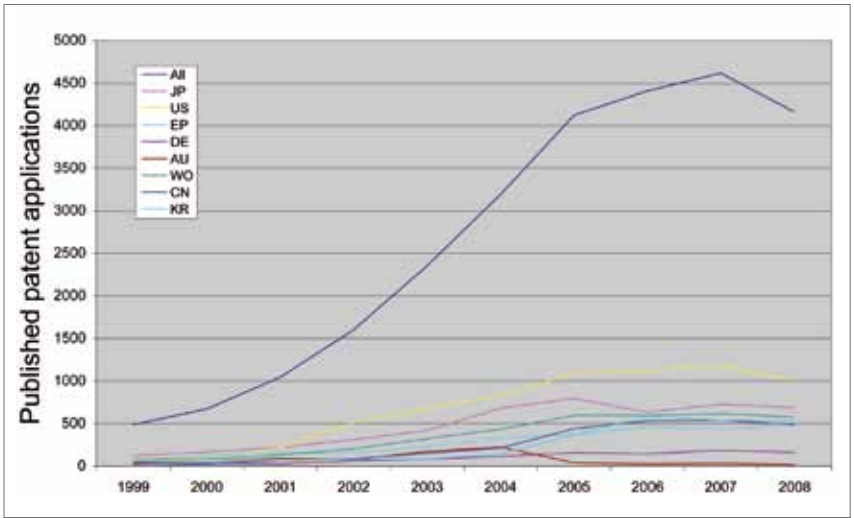

Figure 6. Published patent applications – organic cells.

in alternative sectors, consequently leading to a growing demand for patent protection (see Fig. 8).

For each of these technologies, the annual total number of patent applications published around the world for the past 10 years was extracted from patent databases and provides an overview of the development of patent filing activity over time in each individual sector.

The figures also show the main geographical areas in which patent protection was sought, thus giving an indication of the market importance of those countries/regions for the patent applicants. However, this particular

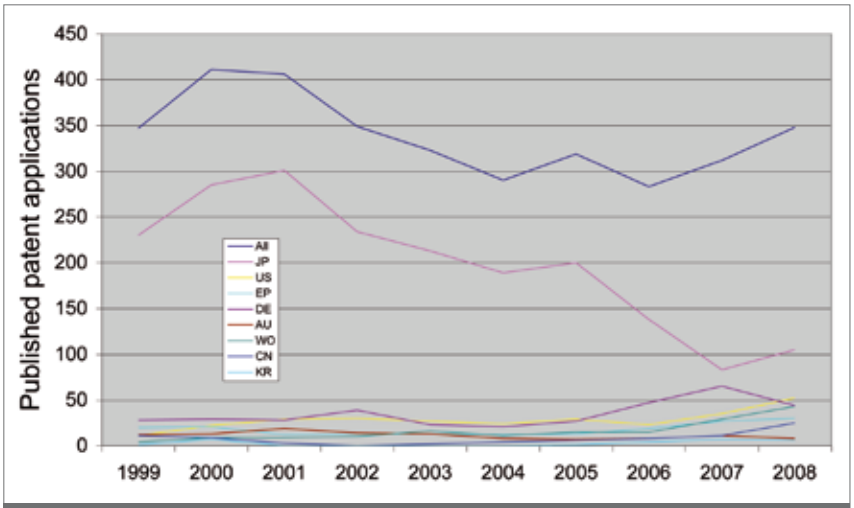

Figure 7. Published patent applications – architectural integration.

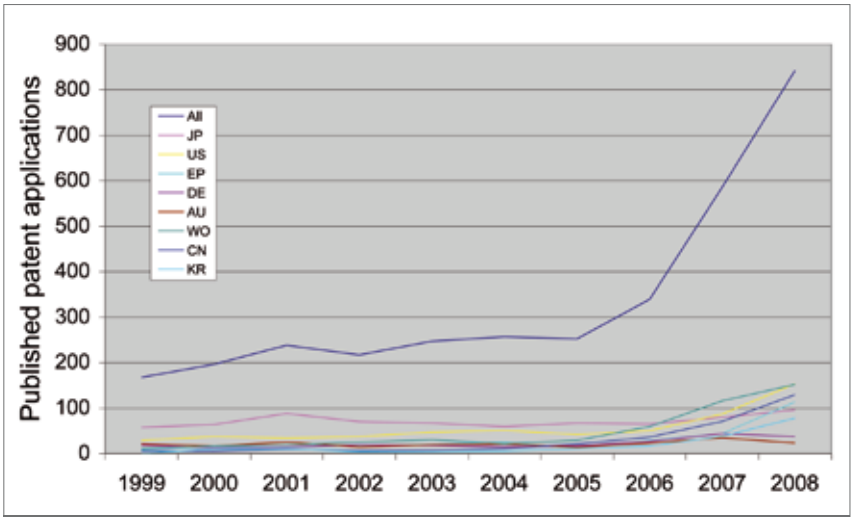

Figure 8. Published patent applications – PV concentrators.

study does not attempt to provide information about the countries of origin of the inventions or the nationality of the inventors or patent applicants.

It is also important to keep in mind that the number of patent applications is not the same as the number of inventions, as globally acting entrepreneurs tend to seek protection in several countries for the same invention and therefore apply for patent protection in each targeted country. A significant number of applications filed would relate to one and the same invention, resulting in a 'family' of patent applications originating from that invention. With the methodology adopted for this study, the overall number of patent applications in a given sector and year are listed, irrespective of the number of applications belonging to the same family.

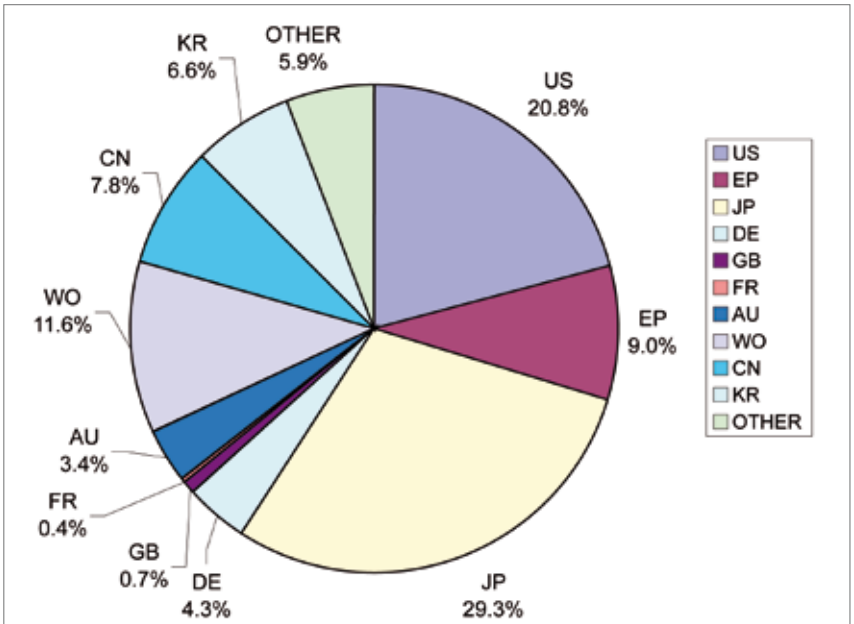

Figure 9. Global patent distribution 1999-2008.

Results and analysis

A look at the number of PV patent applications published worldwide between 1999 and 2008 reveals some interesting trends. Comparing the global filing figures for PV patent applications published in the past decade to the global figures for all patent applications published in all other technical fields (see Fig. 1), it is clear that the PV sector has grown much faster. The number of PV patent applications has more than tripled in the past decade (multiplied by 3.5, compared to 1.5 for all other applications). This demonstrates the increasing importance of patent protection in PV technology.

The distribution according to countries where patent protection is sought (see Fig. 9) is also interesting: most patent applications are filed in the countries/regions where PV technology is largely developed and used. Japan continues to receive the highest number of patent applications in the field, followed by the U.S. Also significant is the number of applications filed using the centralised procedures at the European Patent Office (EPO) and World Intellectual Property Office (international applications filed under the Patent Cooperation Treaty (WIPO (or WO) applications)). Taken together, they almost add up to the number of U.S. applications, showing that both systems, although relatively recent (the EPO has been in existence for just over 30 years), are widely recognised and used.

Also of interest is the strong showing of China and South Korea (CN and KR in Fig. 9). Hardly relevant for PV only a few years ago, both Asian countries, China in particular, are becoming increasingly important markets, with China now one the biggest producers of solar cells in the world. It is worth noting that the Chinese Patent Office (SIPO) was only opened in 1985, and has received during the decade examined in this study about the same number of PV applications as the EPO.

From the technical sectors perspective, while the figures do not show a clear trend in some areas (see the data for architectural integration in Fig. 7), a rapid pace of growth has been seen in other sectors, especially since 2005. A particularly large increase in the number of patent applications is apparent in PV concentrators technology (see Fig. 8), where the numbers grow by 404% between

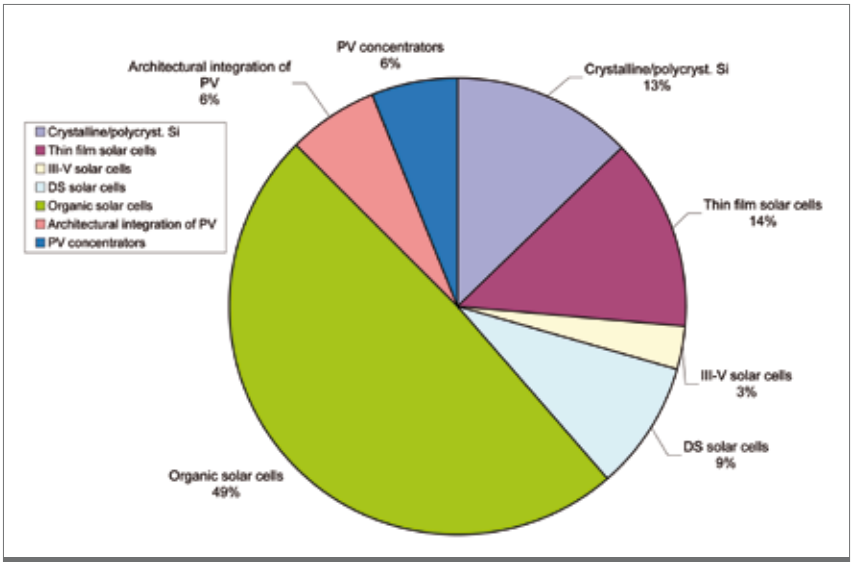

Figure 10. Distribution of main PV technologies 1999-2008.

1999 and 2008; in III-V cells (see Fig. 4), with an increase of 426%; in crystalline/polycrystalline Si cells (see Fig. 2) with an increase of 366%, and in thin-film cells (see Fig. 3), with an increase of 94%.

Even more impressive is the growth of applications in organic solar cell technology (see Fig. 6), with an increase of 754%, and in the field of dye-sensitized cells (see Fig. 5), which grew by 740%. It will be interesting to see if this trend continues at the same pace in the future.

A look at the distribution of technologies in terms of published patent applications in the past decade (see Fig. 10) is also interesting: the largest number of applications relate to organic cell technology (49%), followed by thin-film cells (14%) and crystalline/polycrystalline Si technology (13%). DSSC cells (9%), PV concentrators (6%) and architectural integration (6%) follow. III-V cell technology comes last with a contribution of 3%.

The evolution of this distribution over the years (see Fig. 11) is also telling: there is rapid growth in the number of patents related to new emerging sectors (organic and concentrator technology), while the more mature crystalline/polycrystalline Si technology still makes a strong showing, indicating a continuous effort in the further development of this successful technology.

The new DSSC cells are also undergoing important developments which result in a growing demand for patent protection, and PV concentrator technology with its recent large growth (see Fig. 8) will probably make up a larger proportion of applications in the near future. As for III-V solar cells, they showed a relatively stable number of applications in the decade till 2007 (see Fig. 4) and a clear growth in 2008, which will probably continue. Their position in the percentage distribution has remained quite stable. This technology is highly sophisticated and its use for specific applications (space, high concentration) without real alternatives speaks for its continued development in the future. But this technology will likely maintain the lowest position in the distribution, due to the high cost and complexity of the cells.

Notes on the methodology

The figures are taken from patent documentation databases developed by the European Patent Office (EPO) and the Japan Patent Office or databases used worldwide and available at the EPO. EPO patent examiners currently have access to 121 bibliographic databases (patent and non-patent literature), of which 23 are full text patent databases.

The figures were retrieved mainly using patent classification schemes. The systems used were those of the European Patent Office's scheme (ECLA), WIPO's International Patent Classification (IPC) scheme, the classification used by the Thomson Reuters World Patent Index (WPI), the Japanese classification schemes (FI and F-Term), and specific keywords. Each classification scheme has its own characteristics and the use of several allows one to retrieve documents in the most efficient and complete way.

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For each technical sector, specific ECLA groups, FI and F-Term indices and IPC classification associated with relevant keywords were used to retrieve a data set as complete and precise as possible.

Patent applications are published 18 months after they are first filed, so figures shown for 2008, for example, relate to patents filed in 2006-7. In all the figures and the trends presented in this kind of study, one must therefore take into account that a time delay of 18 months is always present and cannot be avoided.

In this respect it is worth noting that the impact of the financial crisis on patent filing figures is not visible in this study. Any decrease or abrupt change in filing numbers after June 2007 would not yet be captured by these figures (which only include publications till December 2008).

Figure 11. Evolution in the distribution of main PV technologies 1999-2008.

Patenting your invention

By filing a patent at the European Patent Office (EPO), it is possible to obtain patent protection in up to 39 European countries (and reach a market of about 570 million people) on the basis of a single application in one of the EPO's official languages (English, French or German). This makes it the largest transnational patent system in the world. Applicants select the countries in which they would like protection, and, if granted, the European patent has the same legal effects as a national patent in each country. Set up in 1977, the EPO has its headquarters in Munich with offices in The Hague, Berlin, Vienna and Brussels, and employs around 6,700 staff.

Under the European Patent Convention (EPC), patents are only granted for inventions that are new (not known to the public in any form prior to the date of filing or to the priority date), involve an inventive step (not obvious to a skilled person) and are industrially applicable (can be manufactured or used industrially).

There are several things to bear in mind before making a European patent application. Firstly, if an invention is made public in any way before an application is filed (e.g., during business negotiations, academic lecture, etc.), then it can no longer be considered new. Secondly, the fact that an invention is not commercially available does not always mean that it is new. Before filing a patent application, it can be useful to look at catalogues and trade journals to see what is already on the market; and, even more importantly, at the many published patent documents. The EPO's patent databases are the largest in the world: the Office's esp@cenet contains over 64 million patent documents from around the globe and is available via the internet free of charge. Information from patents can also be very useful in identifying business partners and sources of capital.

Patenting can be expensive. The fees for a European application depend very much on the number of designated states and the planned term of the patent. Fees are charged for filing, search, designation, examination, grant and printing, along with renewal fees and translation fees payable later. The overall costs usually also include fees for the services of a patent attorney. As with any investment, the risks and benefits need to be weighed up carefully. However, patenting is advisable in any country where an invention can be expected to yield significant economic benefits. As a general rule, it makes sense to file a European patent application rather than national applications when protection is sought in at least four European countries.

Benefits of a European patent

Patents provide inventors with an exclusive right to prevent third parties from commercially exploiting their inventions for up to 20 years from the date of filing. This enables them to recoup their development costs and gives them time to reap the rewards of their investment. But there are other reasons to file patents. Today, it is often important to have a large patent portfolio to be recognised as a serious business partner and raise capital. Patents have also become an important tool for measuring a company's performance, as well as a trading and bargaining device for cross-licensing and alliances.

In return for the protection bestowed by the patent, the holder has to disclose the details of the invention, which are published in the patent document. This contributes greatly to the dissemination of new technical knowledge. Over 80% of the world's technical knowledge can now be found in patent documents. This inspires further inventions and at the same time prevents the duplication of R&D work.

Quality patents for quality inventions

Every application for a European patent is subject to a thorough search by a patent examiner specialised in the field and a rigorous examination by a team of three patent examiners. This ensures that the application fulfils all the strict requirements of the EPC and only true inventions that deserve protection are patented. In addition, there are several legal mechanisms in place to enable the public to monitor the procedure and to allow decisions taken by the EPO to be challenged, one of which is inspection. European patent applications are published 18 months after the first filing and the file relating to it is open to inspection, meaning that any member of the public can view the communications between the EPO and the parties involved in the procedure free of charge [1].

The EPC also provides a means of centrally opposing European patents within nine months of grant. This legal procedure enables anyone to contest European patents. (Oppositions are filed against about 5% of the European patents granted each year.) In addition, any party to proceedings adversely affected by an EPO decision in grant and opposition proceedings can challenge this decision by an appeal to the EPO's judiciary, the Boards of Appeal.

Faced with a steady rise in the number of applications and a global backlog affecting all of the world's patent offices, the European Patent Office continues to work on making its procedures more efficient, while applying strictly the criteria for patentability and improving the standard of incoming applications.

The EPO also works closely with other patent offices in Europe and worldwide (especially the US, Japan, Korea and China) to make the patent system more effective by reducing duplication of efforts (by exploring work-sharing in everything from documentation and classification to search and substantive examination). As many companies operate globally, a large number of applications filed with the various offices relate to one and the same invention. Work-sharing is key to tackling the global backlog of applications.

Reference

[1] EPO Online Services [available online at http://www.epoline.org/portal/public/registerplus].

About the Author

Alberto Visentin earned a degree in physics from Rome University La Sapienza in 1977. From 1977 to 1979 he worked at the University of Cosenza (Italy) carrying out experiments on concentrating troughs for the exploitation of solar thermal energy. He joined the European Patent Office as a patent examiner in 1980 and has been working in the Berlin office of the EPO since 2003, dealing with the search, classification and examination of patent applications. He has worked in the field of semiconductor technology – in particular optoelectronic and photovoltaic (PV) devices for electricity generation – since 1985 and has presented statistical studies of PV patent applications at the European Photovoltaic Solar Energy Conference in 2004-07.

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