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Technologic Information about Photovoltaic Applied in Urban Residences

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***Abstract*—**Among renewable energy sources, solar energy is the one that has stood out. Solar radiation can be used as a thermal energy source and can also be converted into electricity by means of effects on certain materials, such as thermoelectric and photovoltaic panels. These panels are often used to generate energy in homes, buildings, arenas, etc., and have low pollution emissions. Thus, a technological prospecting was performed to find patents related to the use of photovoltaic plates in urban residences. The patent search was based on ESPACENET, associating the keywords photovoltaic and home, where we found 136 patent documents in the period of 1994-2015 in the fields title and abstract. Note that the years 2009, 2010, 2011, 2012, 2013 and 2014 had the highest number of applicants, with respectively, 11, 13, 23, 29, 15 and 21. Regarding the country that deposited about this technology, it is clear that China leads with 67 patent deposits, followed by Japan with 38 patents applications. It is important to note that most depositors, 50% are companies, 44% are individual inventors and only 6% are universities. On the International Patent classification (IPC) codes, we noted that the most present classification in results was H02J3/38, which represents provisions in parallel to feed a single network by two or more generators, converters or transformers. Among all categories, there is the H session, which means Electricity, with 70% of the patents.

***Keywords*—**Prospecting, technology forecasting, photovoltaic, urban residences.

I. Introduction

TECHNOLOGY forecasting has been a very important tool, not only in the business context, but also in academia. The study of science technology and innovation (ST & I) systems, are considered fundamental to promote the creation of the ability to organize innovation systems to respond to the interests of society. From planned interventions in innovation systems, prospecting means identifying the opportunities and needs. It can be defined as a methodological alternative to the mapping of future technological and scientific developments, identifying possible directions as well as impacts in organizations, cities, regions or even countries, in order to assist in defining strategies for achieving a certain goal [1]. Thus, the great aim of technological forecasting is to understand the future with past data, and guide present actions that may benefit tomorrow, assessing the science, technology, economy and society in order to provide future economic and social benefits based on decision-making and planning that do not cause future crises [2].

The widespread use of fossil fuels, with the stored carbon being used to generate power, draws attention to the new challenge to reverse or stop this cycle of re-carbon, which, according to a brief report of the National Academy of Sciences, will increase the global average temperature leading to changes in climate [3], [4]. These factors encourage new researches on environmentally-friendly alternatives to generate power using renewable sources including the conversion of solar energy into electricity, and solar photovoltaics (PV) energy; today, one of the cleanest and efficient energy available in nature, produced in large proportions [3].

To complement conventional energy, an energy source with several particular characteristics is necessary: clean, not scarce, distributive and can be used in homes, industries and commercial establishments. The one that features all these traits is photovoltaic energy [5].

According to [6], photovoltaic energy is not relatively new, since the first solar cell device began to be produced by Bell Labs in the early 1950s and was aimed primarily for space research, but is a relatively new energy source for large energy deployment ratios in an electricity generation scenario by major carriers to a large population.

According to [3], as there is to be expected, whenever there are new technologies, there are new political and economic barriers to be overcome, which are "normal" when it comes to competing with an already established market. Currently, we are reaching a production cost that can rival conventional energy sources and advantages to have a clean and decentralized energy. Despite these adversities photovoltaic solar energy has made stunning progress since the beginning of its history, and is currently the fastest growing power generation technology worldwide, both in technology and economic solutions, such as the concept of similarity or the equivalence of costs of electricity supplied by utilities, currently in the distribution of conventional energy by centralized generation [7].

Several countries have adopted financing programs to support the technology of photovoltaic solar energy over the last 30 years, making the cost of photovoltaic modules reduce dramatically, contributing to a more effective participation in the economic market [8].

According to [3], we can enumerate some factors that may be responsible for this progress:

1) Global warming, which leads government and researchers to rethink the excessive use of fossil fuels to produce electricity.
2) The political and financial, national and international support for the implementation of clean ways of

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producing electricity with reduced CO2 generation [9], [10].

3) Government decisions to buy renewable electricity at attractive prices during most part of a life cycle of photovoltaic systems, after some adjustment schemes with a fixed or scalable value, combined with investment subsidies and friendly loans [11], [12].
4) The technological improvements in production scale, which show the learning curves, allowed substantial reduction in production costs throughout the chain value [13].

A great solution so future generations also can enjoy what the environment can still offer would promote sustainability in all forms of acquisition of natural and derived resources and promote sustainability in urban homes, schools, industries, and commerce in all places. [14].

Building sustainable social housing is based not only on environmental reasons, but also for social reasons. A proposal for ecologically sustainable homes essentially seeks the use of natural resources paying attention to environmental preservation, but also through these resources, provides a better quality of life, such as through increased environmental, thermal and acoustic comfort [15]. Thus, the study aims at carrying out a mapping based on a patent search and with that provide an overview of the technologies related to photovoltaics applied in urban homes.

II. Methodology

In the present study was conducted a survey on the ESPACENET database that offers free access to over 90 million patent documents worldwide, containing information on technical inventions and developments. For the search of patents in these sources, we used the keywords: photovoltaic and home, where it was found 136 patent documents from 1994 to 2015. We performed the survey during the month of September 2015.

The selected and tabulated data were extracted to Microsoft Excel and selected according to the year of filing of patents, profile depositors, deposit countries, inventors, according the amount of protection orders, and quantities of patents according to IPC among others.

The Classification, being a means for obtaining an international standard classification of patent documents, has as initial objective of establishing an efficient search tool for retrieval of patent documents by the Intellectual Property Office and other users in order to establish the novelty and evaluate the inventive step or non-obviousness (including the assessment of technical advance and useful results or utility) of technical disclosures in patent applications. [16]

The Classification represents the whole body of knowledge which may be regarded as proper to the field of patents, divided into eight sections. Sections are the highest level of the classification hierarchy [16].

Table I shows the meaning of each of the eight areas (Sections) of the technological expertise of the IPC.

TABLE I
IPC

Sections	Sections Means
Section A	Human necessities
Section B	Performing Operations; Transporting
Section C	Chemistry; Metallurgy
Section D	Textiles; Paper
Section E	Fixed Constructions
Section F	Mechanical engineering; lighting; heating; weapons; blasting engines or pumps
Section G	Physics
Section H	Electricity

Source: Data obtained in INPI/Brazil [16].

III. Results

Fig. 1 shows the annual evolution of patent deposits, demonstrating that the first deposit occurred in 1994. In the following years, less than two patent deposits per year were protected, having three deposits in 2005, thus demonstrating little incentive to search for implementation and improvement of this technology. It is also observed that from 2005 there was a significant amount of patent applications on this technology and the year 2012 presented the highest number of deposits in relation to other years, with 29 patents, and in 2015 so far presented a single deposit.

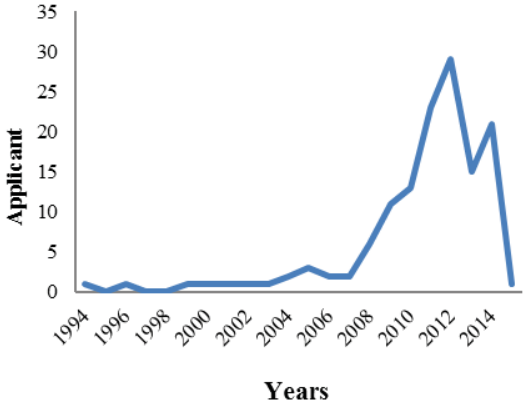

Fig. 1 Annual patent applications evolution between the years 1994-2015

Among the depositories countries ESPACENET database, we noted that China is the largest patent holder, having 67 patents followed by Japan 38 patents (Fig. 2).

In the countries mentioned below, it may be noted that China is the country which holds 42% of the patents involved in photovoltaics panels.

The Chinese are concerned about energy sources that can help fight heavy pollution; the Chinese gave great impetus to a cutting-edge technology: solar energy, which is growing increasingly in the country [17].

We have also analyzed the data according to the IPC, which aims at organizing patent documents in order to facilitate access to the technological and legal information contained in these documents [4].

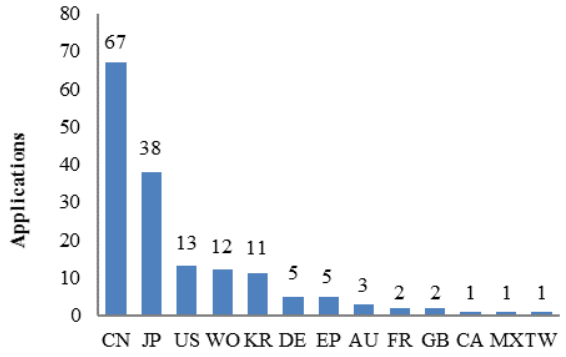

Fig. 2 Distribution of deposits by country of origin, Legend: CN (China), JP (Japan), US (United States), WO (World Intellectual Property Organization), KR (South Korea), DE (Germany), EP (European Patents Organizations), AU (Australia), FR (France), GB (Great Britain), CA (Canada), MX (Mexico) and TW (Taiwan)
Source: Authors (2015)

Fig. 3 shows the codes of the IPC, where the top 10 ratings that presented a higher number of documents are presented.

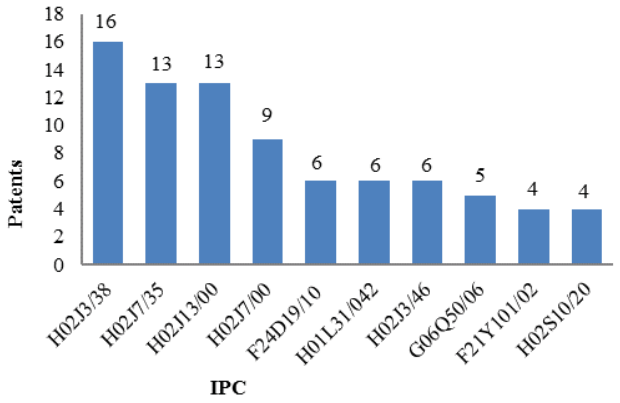

Fig. 3 Patent by IPC, Source: Authors (2015)

The most present rankings in results were: H02J3/38, H02J7/35, H02J13/00, H02J7/00, F24D19/10, H01L31/042, H02J3/46, G06Q50/06, F21Y101/02 and H02S10/20; where deposits are most present in the classification H02J3/38 with 16 patents. The H (Electricity) section had the highest number of patents (70%), followed by section F (mechanical engineering, lighting, heating, weapons and blast) with 20% of patents and G (Physics) with 10 %, as shown in Fig. 4.

Table II shows the meanings of each IPC. It is noted in Table III that the meaning of sections of classifications that had the highest result on this technology, they are: Section H (Electricity), Section F (mechanical engineering, lighting, heating, weapons and explosion) and Section G (Physics).

The profile of depositors, shown in the figure below, points out that 50% of patent applications come from companies, 44% from individual inventors and only 6% from Universities (Fig. 4).

Based on the data studied it is clear that companies and individual inventors demonstrated more attention on such technology than universities, which by being means of research should make greater investments in technological innovation.

TABLE II
IPC, BRAZIL - 2015

ICP	Meaning Classifications
H02J3/38	Arrangements for parallely feeding a single network by two or more generators, converters or transformers.
H02J7/35	With light sensitive cells.
H02J13/00	Circuit arrangements for providing remote indication of network conditions, e.g. an instantaneous record of the open or closed condition of each circuit-breaker in the network; Circuit arrangements for providing remote control of switching means in a power distribution network, e.g. switching in and out of current consumers by using a pulse code signal carried by the network (circuits for indication of single switches H01H9/167; circuits specially adapted for remote switching of lighting via the power line H05B37/0263).
H02J7/00	Circuit arrangements for charging or depolarizing batteries or for supplying loads from batteries.
F24D19/10	Arrangement or mounting of control or safety devices (control valves F16K; only the heater being controlled F24H9/20) including control or safety methods
H01L31/042	PV modules or arrays of single PV cells (supporting structures for PV modules H02S20/00).
H02J3/46	Controlling of the sharing of output between the generators, converters, or transformers.
G06Q50/06	Electricity, gas or water supply.
F21Y101/02	Miniature, e.g. Photometers diodes (LED).
H02S10/20	Systems characterized by their energy storage means (H02S40/38 takes precedence).

Source: Authors (2015).

TABLE III
SECTIONS MEANS

Section	Means
F	Mechanical Engineering, Lighting, Heating, Weapons and Explosion
G	Phycsics
H	Electricity

Source: Authors (2015).

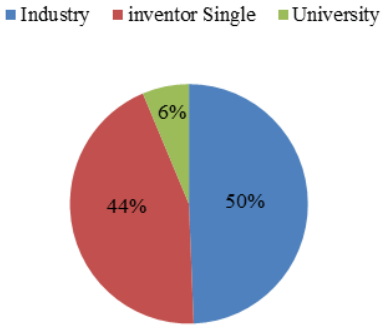

Fig. 4 Distribution of the patent documents listed by type of depositor, Source: Authors (2015)

With respect to the inventors relating to more than one patent deposit, we found out that the inventor Jianliang Chen obtained six patent deposits. The other inventors, each with two deposits (Fig. 5).

The analysis also showed that the inventor Jianliang Chen is a Software Engineer from San Jose, California, his education was at the University of Southern California.

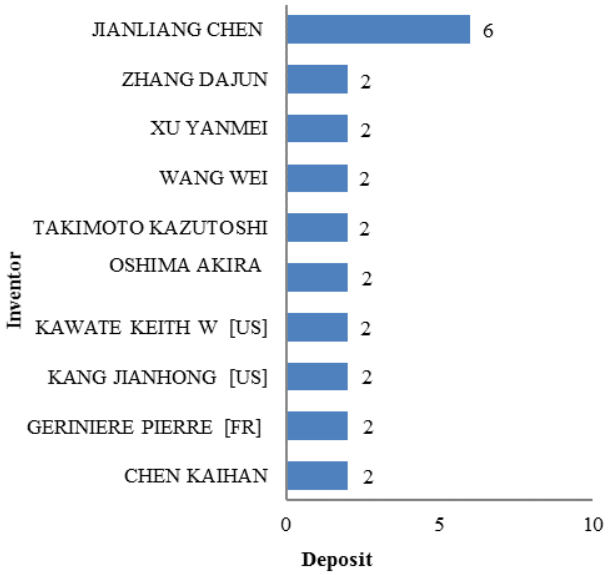

Fig. 5 Deposits of patents for inventor, Source: Authors (2015)

IV. Conclusion

In this study we performed a technology prospection in the ESPACENET patent base, where it was possible to acquire information on patent applications referring to photovoltaics plates applied to urban residences. Several scientific and technological studies are being conducted worldwide in the solar energy sector, considering the use of photovoltaic plates in order to allow this renewable and clean energy to be present in urban residences in countries that have a highly productive energy potential (sunlight) to distribute this clean and low cost energy and reduce greenhouse gas emissions to the environment.

Regarding the annual evolution of deposits on this technology, we note that the first patent was filed in 1994, and starting in the year 2005 there was a significant amount of deposits and for the year 2012 we see the highest number of deposits compared to other years, 29 patents, and in 2015 presented one deposit.

Among the deposited documents, it was observed that China leads the per country patent ranking with 67 patents, followed by Japan with 38, and then United States, the World Intellectual Property Organization, South Korea, Germany, the European Patent Organization, Australia, France, Britain, Canada, Mexico and Taiwan.

We also found in this study the H02J3/38 classification, which is directed to provisions to feed in parallel a single network by two or more generators, converters or transformers and the H section is electricity, was the most used for this technology when compared to other classifications.

In the distributions of the patent documents listed by type of depositor, we note that 50% of them were made by companies, followed by individual inventors (44%) what demonstrates more interest in this field of study than universities that showed only 5% of patent deposits, which being source of knowledge, should make greater investment in this research field.

The study identified that there is still a gap in academia. This area requires more research in order to make the technology of photovoltaic panels accessible to everyone, and thus, improve society's quality of life.

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