KALKI Energy

Technology Competitive Intelligence Report
Solar Energy and Power Generation
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Solar Energy and Power Generation - Technology Competitive Intelligence Search Report

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Introduction and Summary:

A competitive intelligence landscape analysis was conducted to identify key owners behind issued patents and published patent applications (hereinafter, patent publications) in the field of solar energy; specifically pertaining to power generation by harnessing solar energy.

The last five years have witnessed a growth in developing, improving, and utilizing power derived from renewable energy sources. This is evident from the fact that the number of patent filings related to solar energy has almost doubled in this period in various jurisdictions; specifically in the United States (US) and European (EP) jurisdictions. US continues to be a top player though it faces tough competition from its European counterparts; particularly from countries like Germany and Netherlands that boast world-class research institutions dedicated to renewable energy research. The significant players identified in the landscape analysis belong to a diverse background, including private/public and small/large companies. Approximately, five top assignees are from the US, followed by two from Japan; companies from the Asian mainland, such as China, Taiwan, Korea, and Japan, are also worthy of consideration.

At a time when the world economy is going through a significant change, more and more organizations are looking forward to and are likely to invest in the 'energy for the future.' Therefore, it is likely that the companies mentioned above may play a pivotal role in changing market conditions and the competitive landscape in the world's most inhabited zones. The analysis also reveals an inclination of innovation towards integrated assemblies, installation solutions, and concentrators in general. As a result, an opportunity seems to exist for emerging players to focus innovation on specialized aspects such as fabrication methods and materials that may lead to a decrease in cost and installation time. It is expected that the key drivers for innovation in the near future may be cost and time saving factors.

In addition, small yet innovation driven start-ups and individual inventors may own important and strong solar energy patents or even complete portfolios and give the bigger companies a run for their money.

Geographically, while the current landscape seems to be limited to the upper part of the globe, more markets may soon emerge, specifically in the South American and African regions, owing to increased awareness and need. Consequently, current and the future innovators will have to direct their inventions or channelize efforts to ensure that their innovations allow them the requirec freedom-to-operate with regard to majority of regions. In other words, the number of jurisdictions in which protection is claimed may prove to be significant.

In sum, the entire landscape appears to be promising with plenty of space for new technologies and innovations focused on various technological aspects related to solar energy.

IPE Methodology:

The methodology adopted for this search involved the following set of activities:
1. A keyword based search was conducted on selected patent databases to obtain sets of results relevant to the chosen subject of study.
2. A taxonomy was created to categorize the above identified results into various technology levels. The taxonomy and the definitions corresponding to each of the levels have been summarized in the sheet titled 'Taxonomy'.
3. The categorized results were further used to generate trends and graphs that enhance competitive intelligence in this domain.

Project Assumptions:

1. All patent searches were conducted using the 'Delphion' patent database.
2. The total number of patent publications included the total number of published patent applications as well as issued/granted patents.
3. Scope of the search was limited to the following jurisdictions: United States Patent and Trademark Office (USPTO), European Patent Office (EPO), World Intellectual Property Office (WIPO), Germany (DE), and Japanese Patent Office (JPO) only.
4. Only 'English' language documents were analyzed.
6. The analysis of patent publications was based on their title, abstract, and claims.
7. All the search results correspond to the date of search; i.e., December 24, 2008.

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The taxonomy used for categorizing the results have been presented below for reference:		
S No.	**Taxonomy Levels**	**Definitions**
1	**Solar Cells**	*Any new or unique components or any new or unique design of the components of the 'Solar Cells', or any modification thereof, independent or in combination with the other components. For example, a new design of solar cells.*
2	**Concentrators**	*Any new, unique or improved additional components and/or features facilitating the storage or concentrating the 'Solar Energy'. For example, improvised mirrors, frensel lens, etc.*
3	**Manufacture**	*Systems and methods facilitating manufacture, improvement, and integration of solar cell components, modules, and/or assemblies.*
4	**Materials**	*Systems and methods disclosing manufacture or use of various materials (metals, dyes etc.) for solar cell applications.*
5	**Solar Plants**	*Any new or unique feature(s) that describe 'Commercial Solar Energy Farming' by installation of Solar Plants.*
6	**Solar Energy Applications**	*Systems and methods disclosing applications of solar energy, broadly 'electricity generation' and 'heating.'*

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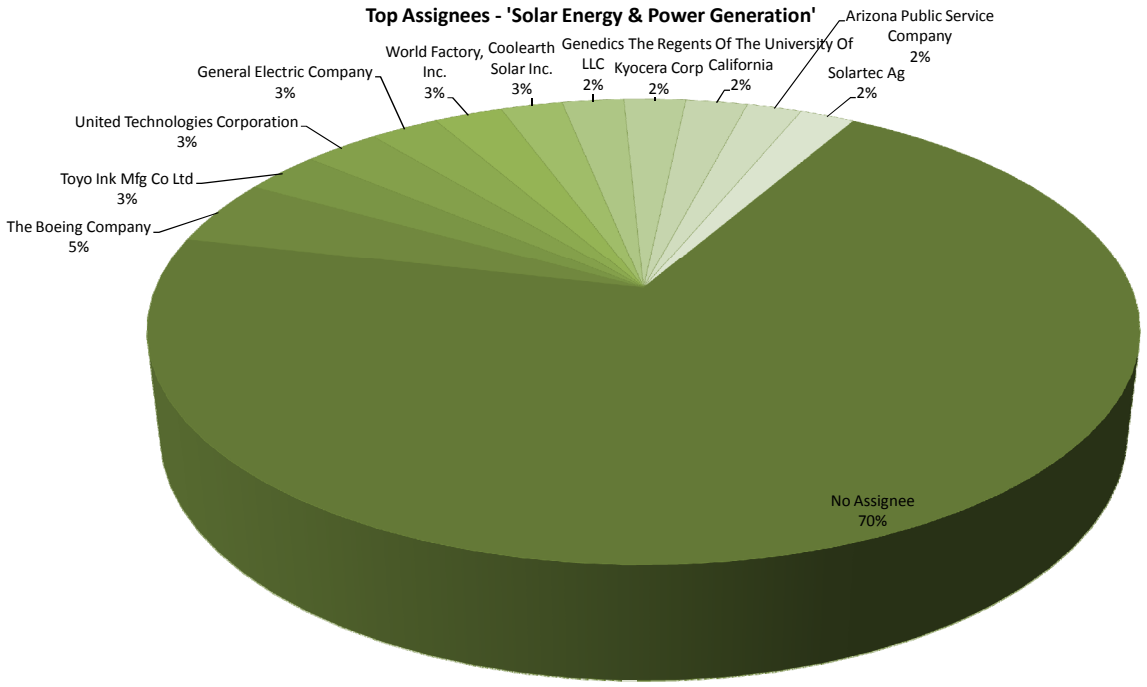
Competitive Landscape

The initial analysis of the last five year patent data reveals the following key players active in the field of 'Solar Energy'. These key players are identified based on the following factors:
a) players owning patents and published applications in the last five years.
b) players owning patents and published applications relevant to the chosen technology levels.
The initial analysis of the last five year patent data reveals the following key players active in the field of 'Solar Energy.

The Boeing Company	Toyo Ink Mfg Co. Ltd.	United Technologies	General Electric	World Factory Inc.	Cool Earth Solar Inc.	Kyocera Corp.	The Regents of the University of California	Arizona Public Service Company	Solartec Ag	Genedics LLC



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Competitive Landscape

Observations pertaining to Competitive Landscape

An initial investigation of the identified relevant patent data discloses that private and public, and large and small firms are equally active in populating their patent portfolios. Among the larger players, The Boeing Company, General Electric, and United Technologies Corporation feature in the list of active players. Interestingly, two of the above, Boeing and United Technologies are in the 'Aerospace & Defense' industry.

A close look at the patents of Boeing reveals that its inventions encompass the role of clean energy, and primarily solar energy, in advancement of materials, structures, and electronics to improvements in aircraft assembly, performance, operations, maintenance and flight simulation, innovative satellite and space vehicle capabilities, advancements in information technology, and civilian and military network-centric communications. The patents owned by Boeing describe improvements pertaining to solar simulators, concentrators, detectors, reflector coatings, insulator layers, and filters (e.g., notch filter for triple junction solar cells). Clearly, the attention is more towards materials and processes of fabrication of the above and similar devices.

Among the other companies, United Technologies ranks second and overall third in the list with 11 patents in the chosen field of study with a total of 687 issued US patents and 167 pending US patent applications. Most of the patents are directed to solar cell assemblies and integrated systems. The prominent companies with their various product lines include Carrier for air conditioning; Hamilton Sundstrand for advanced aerospace and industrial products; Otis for manufacture, installation and maintenance of elevators, escalators and moving walkways; Pratt & Whitney for design, manufacture, and support of aircraft engines, industrial gas turbines, and space propulsion systems; Sikorsky for helicopter design, manufacture, and service; UTC fire & security for managing century fire and security challenges; and UTC Power for environmentally beneficial advanced power solutions. UTC Power is also the proud recipient of the DOE Fuel Cell Technology Awards.

There are 10 relevant patents identified for General Electric (GE) relating to solar panels (including panel installation systems), concentrators, energy converters, and grid control solutions. It is well known that GE is actively pursuing clean energy patents, and specifically patents focused on wind energy. It appears all the solar energy patents pursued are an effort to build the portfolio of 'GE- Energy,' a very research and innovation driven subsidiary of GE Global and constantly churning out energy efficient solutions for residential, commercial, and industrial applications.

Toyo Ink Mfg. Co. (11 patents), a company founded in 1896 and based in Japan, has emerged as a leader in patent filings in the last five years, following Boeing. The company mainly manufactures printing inks, newspaper inks, uv-curing inks, gravure inks, graphic arts materials, graphic arts equipments, can coating finishes, resins, adhesives, waxes, laminating adhesives, coating & painting materials, pigments, processed pigments, plastic colorants, media materials, and natural products. The patenting activity for this company is primarily concerned with photo/optically functional active materials for solar cells such as sensitizing dyes and pigments.

Other players worthy of mention in the list of top assignees include World factory Inc., Coolearth Solar Inc., Genedics LLC, Kyocera Corp., The Regents of the University of California, Arizona Public Service Company, and Solartec Ag.
World Factory Inc. is the specialist in International Procurement Services. This Chinese company believes in a mix several different products from different factories into one container/platform (Container Builder™). In sync with this ideology, the patents identified for this company were mostly solar energy based consumer products such as solar wind chimes, solar powered spotlight, and decorative windmill with solar panels, solar operated bird feeder, and umbrella running on solar cells.

Similarly, Coolearth Solar Inc. is a small start-up which revels in a patented technology namely, 'Concentrator Photovoltaic Utility' (CPV), that is used in installation of solar plants. The interesting feature of this patented technology is the innovative design of the solar concentrators; i.e., concentrators made of thin plastic film that can be inflated with air to form a concentrator shape focusing maximum sunlight onto a PV cell placed at the focal point; in addition, an architectural system holds this design in place. According to the company, this patented technology reduces expensive material requirements and plant deployment costs, uses a minimum amount of material, has a small footprint, and causes the least disruption to the natural environment of any solar power plant.

Genedic LLC is an invention incubator start-up by Gene Fein and Ed Merritt; and patents range to across a variety of applications; e.g., use of solar energy in desalination plant, alternative energy pumping billing system, and infrastructure distribution platform for alternative energies.

Patents of Kyocera Corp. are focused on prepackaging and integration of solar and conventional electric systems. They own many trademarked solar products pertaining to trackers, controllers, module mounting systems, inverters, and batteries.
Arizona Public Service (APS) Company, a proud recipient of the 2008-Edison Award for excellence in electric industry, is actively pursuing components and materials for supporting solar energy collection and conversion modules.

Solartec Ag is a German firm focusing on concentrator technology, thin film technology, and manufacture of crystalline silicon. The various patented assets of this firm talk about the photovoltaic devices with various features like positioning aid, holographic structures, RFID safety devices, mountable laterally on optical elements, and comprising ultra-thin optical elements.

However, there are a considerable number of results that currently do not have assignee information (70 %). Probably, once the assignment of these results is disclosed, there may be a significant change in the present competitive scenario and companies that are down the list but actively engaged in research and innovation activities in this domain may climb-up the assignee ladder. Other companies to watch out for are Sanyo Electric, Sharp Solar, Q Cells, First Solar, Matsushita, Energy Conversion Devices, Raytheon, Applied materials Inc., Solel, and Solaria, to name a few.

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Technology Overview

The initial analysis of the last five year patent data reveals the following insights regarding the active technology classes/categories; categories or technology focus areas most prominent among the key players active in the field of 'Solar Energy'. The following is illustrated:

a) Top IPC classes recognized in the identified relevant patents.

b) IPC classes featuring in the patents owned by the top key players.

c) Taxonomy levels of high/busy patenting/claiming activity.

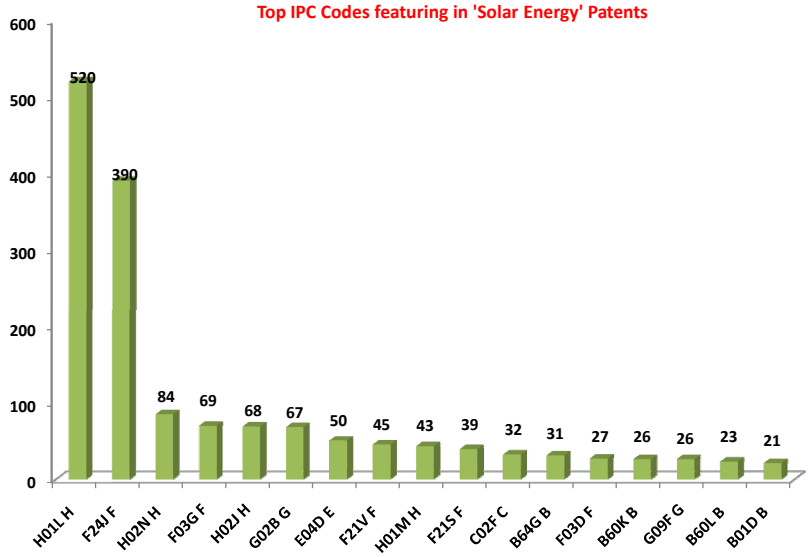

Fig. 1A

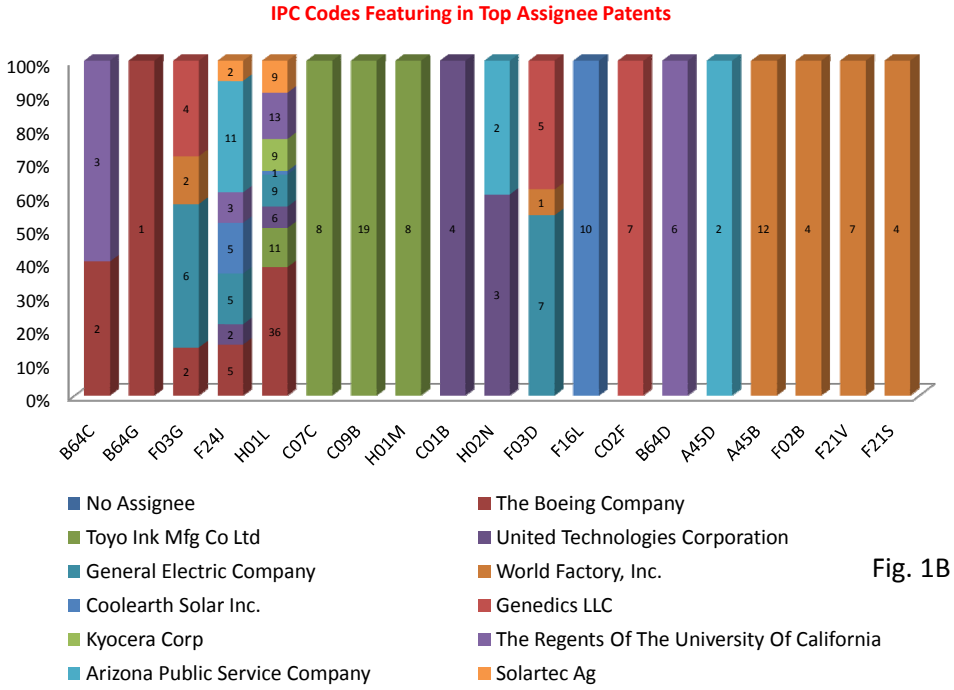

Fig. 1B

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International Patent Classification Codes & Definition :

A45B	*Walking sticks; umbrellas; ladies' or like fans*	***F02B***	*Internal-combustion piston engines; combustion engines in general*
A45D	*Hairdressing or shaving equipment; manicuring or other cosmetic treatment*	***F03D***	*Wind motors*
B01D	*Separation (physical or chemical)*	***F03G***	*Spring, weight, inertia, or like motors; mechanical-power-producing devices or mechanisms, not otherwise provided for or using energy sources not otherwise provided for*
B60K	*Arrangement or mounting of propulsion units or of transmissions in vehicles; arrangement or mounting of plural diverse prime-movers; auxiliary drives; instrumentation or dashboards for vehicles; conjoint control of drive units; arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicles*	***F16L***	*Pipes; joints or fittings for pipes; supports for pipes, cables or protective tubing; means for thermal insulation in general*
B60L	*Electric equipment or propulsion of electrically-propelled vehicles; magnetic suspension or levitation for vehicles; electrodynamic brake systems for vehicles,*	***F21S***	*Non-portable lighting devices or systems thereof*
B64C	*Aeroplanes; helicopters*	***F21V***	*Functional features or details of lighting devices or systems thereof; structural combinations of lighting devices with other articles, not*
B64D	*Equipment for fitting in or to aircraft; flying suits; parachutes; arrangements or mounting of power plants or propulsion transmissions*	***F24J***	*Production or use of heat not otherwise provided for*
B64G	*Cosmonautics; vehicles or equipment therefor*	***G02B***	*Optical elements, systems, or apparatus*
C01B	*Non-metallic elements; compounds thereof*	***G09F***	*Displaying; advertising; signs; labels or name-plates; seals*
C02F	*Treatment of water, waste water, sewage, or sludge*	***H01L***	*Semiconductor devices; electric solid state devices not otherwise provided for*
C07C	*Acyclic or carbocyclic compounds*	***H01M***	*Processes or means, e.g. Batteries, for the direct conversion of chemical energy into electrical energy*
C09B	*Organic dyes or closely-related compounds for producing dyes; mordants; lakes*	***H02J***	*Circuit arrangements or systems for supplying or distributing electric power; systems for storing electric energy*
E04D	*Roof coverings; sky-lights; gutters; roof-working tools*	**H02N**	*Electric machines not otherwise provided for*

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Technology Overview

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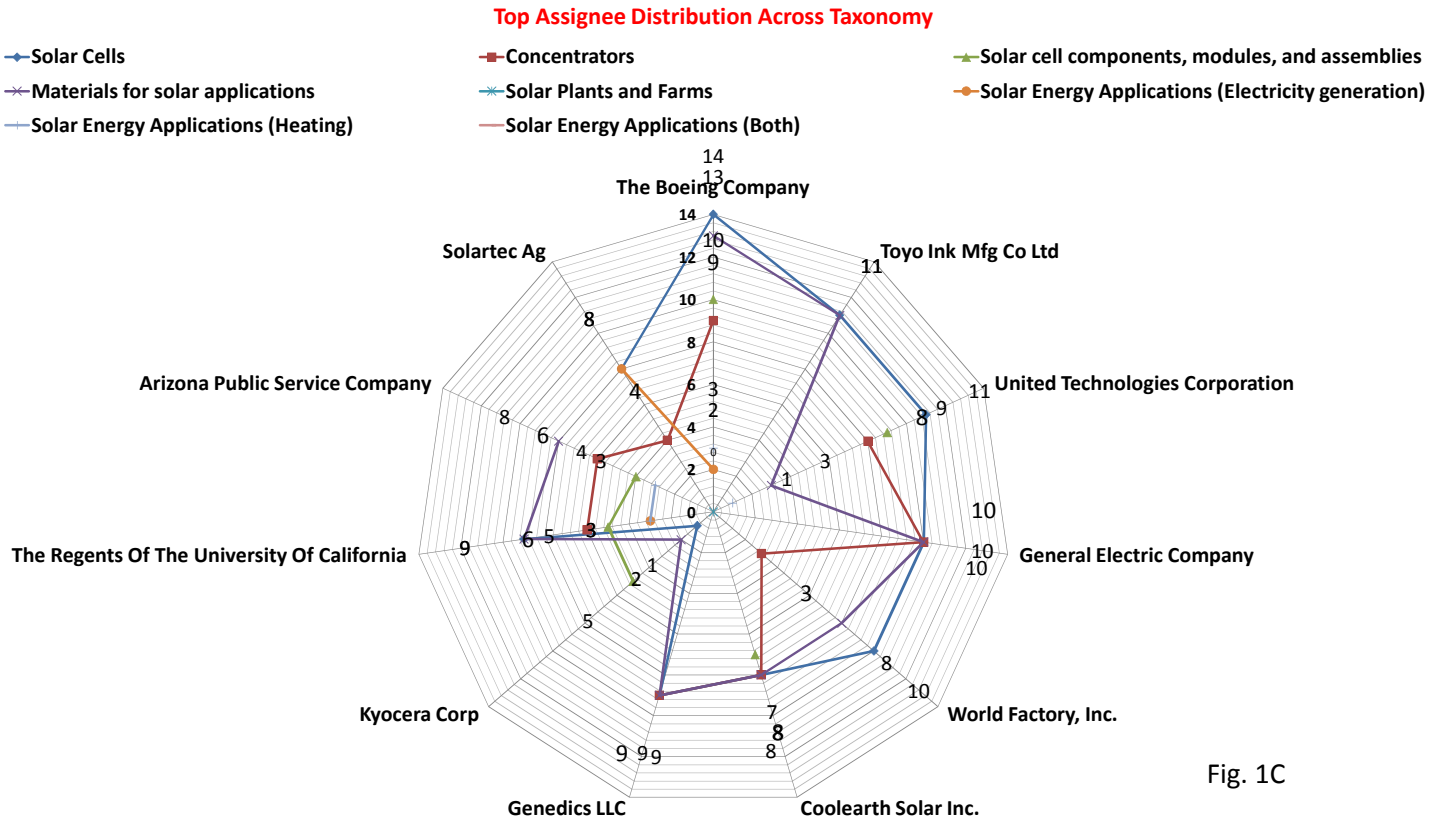

Fig. 1C

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Technology Overview	
The initial analysis of the last five year patent data reveals the following insights regarding the active technology classes/categories; categories or technology focus areas most prominent among the key players active in the field of 'Solar Energy'. The following is illustrated: a) Top IPC classes recognized in the identified relevant patents. b) IPC classes featuring in the patents owned by the top key players. c) Taxonomy levels of high/busy patenting/claiming activity.	

Observations pertaining to 'Technology Overview'

An overview of the most prominent IPC classes in Fig. 1A indicates that most of the solar energy patents and applications are filed under 'H01' IPC class (semiconductor devices; electric solid state devices not otherwise provided for; electrochemical processes or apparatus in general; semiconductor or other solid state devices for converting light or heat into electrical energy), followed by F24J (materials thereof; engines or other mechanisms for producing mechanical power from heat, for using natural heat.)

The same trend can be seen in the IPC codes for the top assignees (Fig. 1B.) The multiple numbers of stacks corresponding to an IPC code indicate the multiple numbers of top assignees whose patents are classified under this IPC code. However, there are certain classes which are specific to a given assignee. For example, classes A45B, F02B, F21V, and F21S are featured only for World Factory Inc., suggesting that these patents relate to a combination of consumer articles (hand or travelling articles), combustion engines, and lighting sources (lighting devices or systems with functional features, combination with other devices, and portability .)

Similarly, patents belonging to Toyo Ink fall under C07 and C09 classes that disclose dyes, paints, and pigments. These classes in combination with class H01 have been prominently featured in these patents.

The Boeing and United Technologies companies' patents cover multiple classes, ranging from B64, F03, F24, and H01. This is primarily due to the fact that some of the Boeing solar energy patents may be strategically important from the view of aerospace and military applications.

Genedics LLC, an invention incubator company, run and managed by Gene Fein, who is also the primary inventor in all these applications, follows a similar trend (though on a smaller scale) to that of Boeing and UTC.

Coolearth Solar Inc's focus has been more on the CPV technology; therefore it holds the major share of the IPC class F16L (concerned with fittings and thermal installations) in combination with F24J and H01.

It should be noted that a claims focused analysis of the patents (illustrated in Fig. 1 C) disclosed that the patenting activity is most visible for the categories – Solar Cells; Concentrators; Solar cell components, modules, and assemblies (improvements and integration); and Materials for solar applications and lesser for Solar Plants /Farms (commercial solar energy farming); Solar Energy Applications (Electricity generation); and Solar Energy Applications (Heating).

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Geographical Spread

Based on the initial analysis of the last five year patent data the following observations are made regarding the geographical spread of the 'Solar Energy & Power Generation':

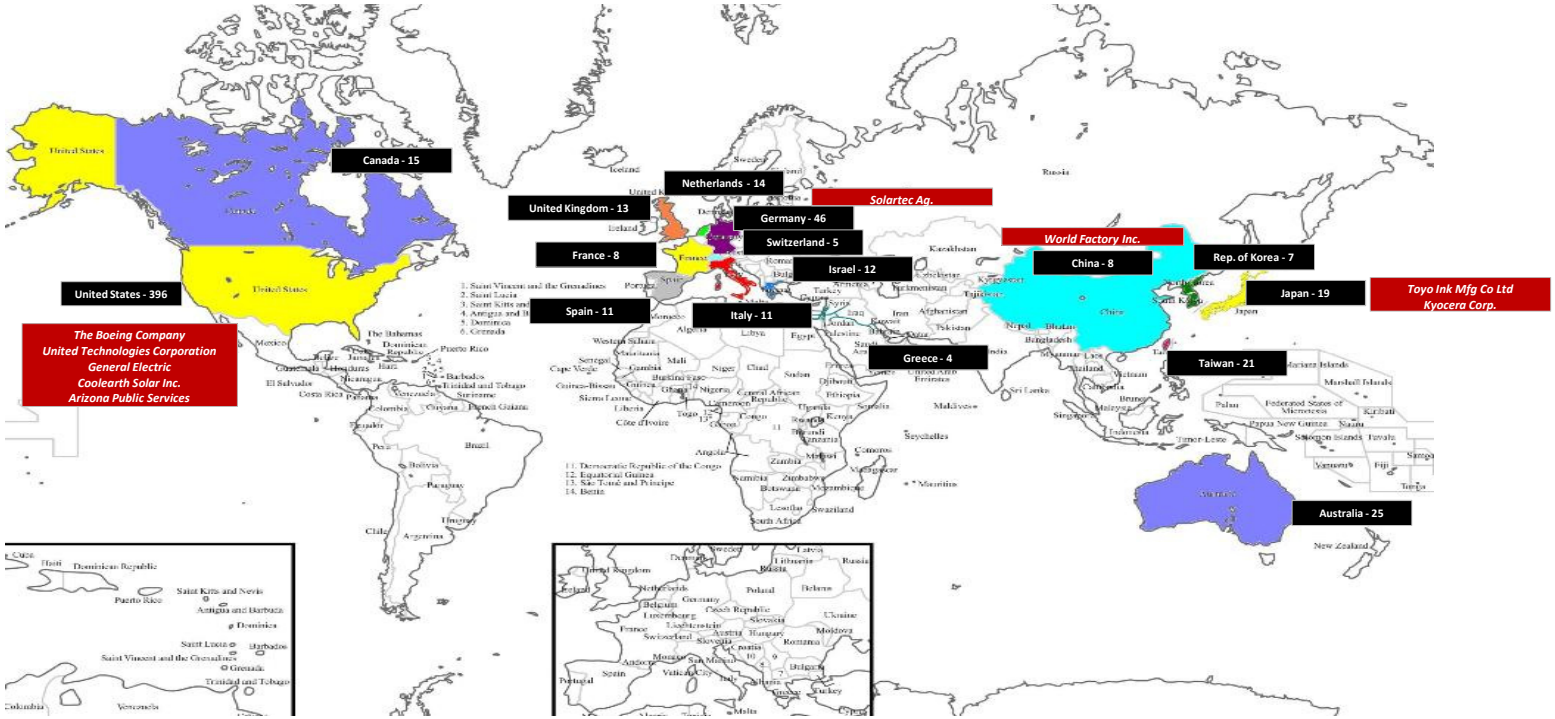
a) top assignee nations figuring in the total number of patents and published applications of last five years;

b) top assignee nations figuring in the patents and published applications relevant to the study scope identified for last five years;

c) patent jurisdictions figuring in the patents and published applications for the top assignees (similar to b).

The complete geographical spread of the technology is represented below:

Top Patent Filing Assignee Countries - Solar Energy & Power Generation



Source: Blank maps available through http://english.freemap.jp/

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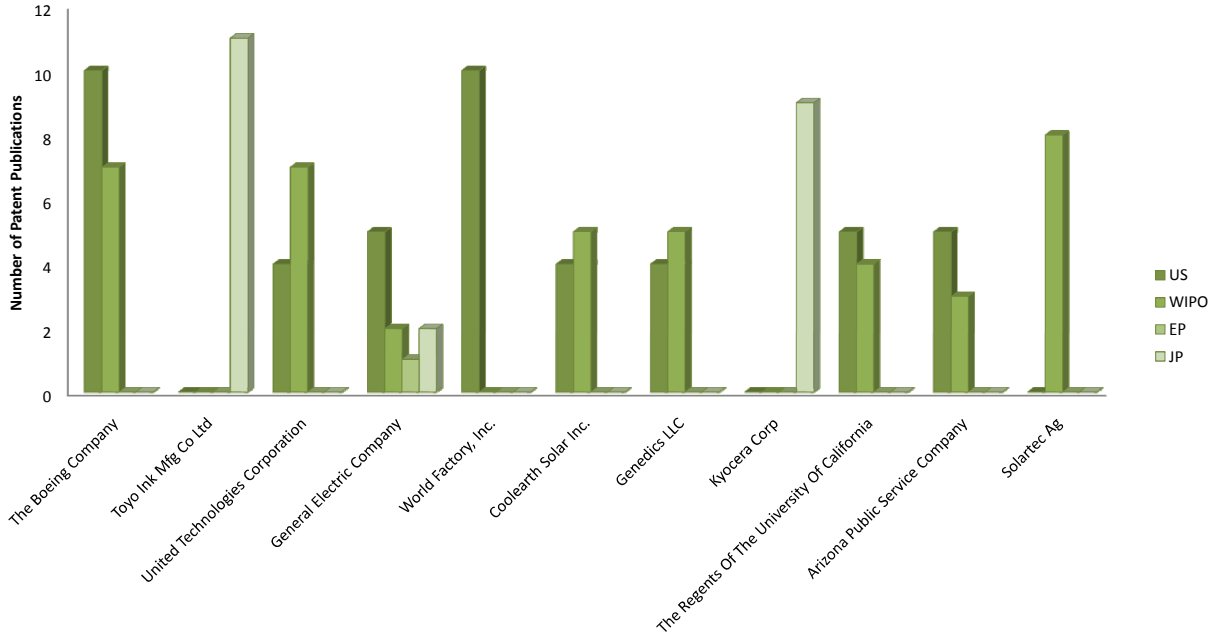
Geographical Spread

Patent Jurisdiction Distribution for Top Assignees



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Geographical Spread

Observations pertaining to 'Geographical Spread'

US, Japan, and Germany emerge as the most significant country markets for solar energy. They are also the representatives of the industrialized markets in the segment of solar energy. There have been many national market incentive programs launched in both Japan and Germany that resulted in a further surge. The products and processes in these countries have been mostly grid-tied applications (i.e., applications focused on providing residential roof mounted systems and building integrated PV to be used with conventional systems.)

US leads the pack (approximately 396 patent publications in the last five years). In the current scenario, it may seem that the world economic crisis would have stopped the solar energy technology growth in its tracks. However, this may not be true, since many of the corporate companies and firms are trying to mobilize the growth by becoming energy independent with clean energy. The newly appointed US energy secretary, Steven Chu has already hinted at some serious measures regarding enforcement of the green energy policy. The US Department of Energy's 'Solar Energy Technologies Program' also focuses on developing cost-effective solar-energy technologies. Another initiative includes bringing 25 cities across the US on to a common platform to achieve the target of making every city in US a 'Solar America City.' California is the most active state and Georgia has been identified as the most promising state with regard to solar energy. There are many dedicated solar research organizations working in the US such as Florida Solar Energy Center, Institute of Energy Conversion, National Renewable Energy Laboratory (NREL), Renewable and Appropriate Energy Laboratory (RAEL), Sandia National Laboratories Photovoltaic Program, and Schatz Energy Research Center (SERC).

According to Solar Industries Association (SEIA), the amount of usable solar resources in the US is much greater than Germany, yet the latter poses a tough competition in the market of installed solar energy due to a comparatively greater policy support. For example, the "Feed-in Law" in Germany permits customers to receive preferential tariffs for solar generated electricity depending on the nature and size of the installation. In another example, some German states have subsidy programs for PV installations that can be used in combination with the national "Feed-in Law." There were 46 patent publications that belonged to German assignees. Bavaria has been identified as the most promising 'solar state market' of Germany based on the fact that the world's largest PV installation is in Hemau in Bavaria consisting of 32,740 solar modules with a combined peak power output of 4 Megawatts. An interesting fact regarding the city of Freiburg in southwest Germany is that it has embraced solar energy since 1986. Also, Germany is home to some of the best solar energy research centers, Institut für Thermodynamik und Wärmetechnik, Fraunhofer Institute for Solar Energy Systems ISE, and Institut für Solarenergieforschung GmbH.

Australia and various European countries also exhibit significant activity in the field of photovoltaic systems. Following Germany's footsteps, Netherland, Greece, Italy, France, Spain, Belgium, Portugal, and Switzerland have already joined the solar energy race. Research organizations active in European countries include Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H in Austria, Ekomation Solar Energy Consultancy & Netherlands Energy Research Foundation (ECN) in Netherland, and Institut für Solartechnik SPF (Solar Energy Lab) in Switzerland. In Australia, a recent $6 million Brumby Government Grant has paved the way for advancement in solar energy research, and more than 50 solar energy research and commissioning projects are ongoing. Companies such as Solar Systems and BP Solar lead the way with production and manufacturing facilities located in AU. A Solar Cities program was also initiated and Adelaide, Alice Springs, Blacktown, Central Victoria and Townsville have been nominated as the first Solar Cities of Australia.

New Energy and Industrial Technology Development Organization (NEDO) has been significantly active in Japan that boasts of manufacturers like Kaneka, Matsushita Battery, Sanyo, Sharp, and Showa Shell Sekiyu. Recently, it was reported that 'Kyocera Corporation' has developed a residential solar power system with a conversion rating of 15.7%, the highest rating in the world for a residential system.

For all the above top assignee nations, the common yet prominent factors driving the above observations are:
1. Support by national or state governments in the form of directives and subsidies
2. Solar conditions
3. Sound delivery infrastructure including abundant local suppliers and qualified installers
4. Green energy awareness

Developing nations like China and India still have a long way to go in the matter of solar energy systems; new technologies in these regions will have to focus on microfinance to improve the affordability of solar photovoltaic systems. The Chinese Academy of Sciences (CAS) has recently launched an initiative to boost the development of solar energy technology. The major companies active in manufacturing and research in Chinese region include Taiwan's Motech, Wuxi's Suntech Power, Yingli Green Energy, and Sunoasis. In India, solar energy has been identified as an 'R&D thrust area' by the Ministry of New and Renewable Energy (a Government of India initiative). Many governmental and non-profit organizations are currently engaged in R&D activities related to solar panels, thin film solar modules, materials for solar cells, storage systems, and concentrators. Prominent organizations active in this domain include Solar Energy Center, SSS-National Institute of Renewable Energy, and Indian Renewable Energy Development Agency. However, there is still scope for extensive research and emergence of new technologies in these raw markets.

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