

Patenting in Renewable Energy Sector- An Analysis

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Renewable resources are a part of Earth's natural environment and the largest components of its ecosphere. Because of this very nature, development in the sector of renewable energy is a fast evolving technology area. The non-conventional energy sources consist of solar, thermal, wind, rain, tides, waves, geothermal, hydro/marine, and biofuels. Innovation in solar, wind and other renewable power sector has been growing worldwide. Analysing the patent activity in the area will help in studying the global patenting trends in the area of renewable energy. Hence, the paper aims to analyze the patenting trends in renewable energy sector. The paper further aims to analyze renewable energy policy of the selected countries. This trend illustrates that China is considered as one of the largest hub for renewable energy development. This could be due to the reason that most of the inventors/assignees find bigger market here along with policy support. Governments and policy makers across the world are introducing legislations and support mechanisms to accelerate the development of the renewable energy sector. Many countries have sector-wise laws and ordinances for compulsory purchase of renewable power, promotion of specific technologies like biomass, wind power, geothermal energy, etc. Based on the analysis, it is observed that China is having well-structured renewable energy policies that may be stimulating patenting activities in China.

Keywords: Kyoto Protocol, White space analysis, OECD countries, renewable energy, patent, policy, wind, solar, biofuels, clean development mechanism

Energy is a prerequisite requirement for driving all living forms on this planet. Non-conventional or renewable forms of energy are the most sought after forms of energy of all because of their naturally existing nature and replenishment. Renewable resources are a part of earth's natural environment and the largest components of its ecosphere. Because of this very nature, development in the sector of renewable energy is a fast evolving technology area. The non-conventional energy sources consist of solar, thermal, wind, rain, tides, waves, geothermal, hydro/marine, biofuels and carbon capture and storage (CCS).

Innovation in solar, wind and other renewable power is booming worldwide.¹ A number of Pacific Island countries (PICs) now have ambitious renewable energy programmes in place with some including the objective of electricity generated from "100% renewable energy" by 2020.² Market for renewable energy sector has been increasing. This leads to competition and collaboration among private players. Research and development in this sector is accelerating over the years. To promote research and

development, patent provides incentive to private players. Hence, patenting activity in clean energy initiatives has been increasing. Government body like American Federal Agency is also involved in patenting activity in renewable energy sector.³ Government policy measures can be an influencing factor to encourage investment in these sectors. Further, the market for providing carbon offsets under the clean development mechanism (CDM) under the Kyoto Protocol is driving the economy. Analysing the patenting activity in the area will help in studying the global patenting trends in the area of renewable energy, the patents having the features of interest, in identifying the potential applications of upcoming technologies in the area and in studying the competitor trends along with technology analysis based on the IPCs, in identifying potential licensing opportunities and collaboration partners, with a view to pursue further research and in identifying the white space for future research. Hence, the paper aims to analyze the patenting trends in renewable energy sector. Inventor or assignee files patent applications to get incentive in the form of profit out of the invention. Policy and regulatory framework creates supportive incentive structure to promote specific technology.

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Researchers have indicated that positive relationships exist between policy and patenting trends.^{4,5} The paper further aims to analyze policy framework of specific countries based on patenting trends and activities.

Patent Space Analysis

The geographical distribution of patents across the globe helps in finding out the regions that are favored by inventors and assignees for filing their applications. This also gives an indication of the size of market in different geographies. Carrying out analysis of concentration of patents in different geographies helps in forming an idea as to where major investors in the technology are located. Furthermore, the sections on technological space including Top IPC's favored by top assignees/players (strength); Most prolific inventors are included to identify potential patents for acquisition or licensing, or any other similar partnerships. This section discusses the geographical spread of patents/patent applications filed globally in the area of renewable energy which helps in identifying the geographies where major assignees/applicants have chosen to protect their technologies, thus, giving an indication as to where major assignees/applicants foresee the real market for their products.

The Fig. 1 shows the geographical distribution of patents/patent applications and indicates the extent of geographical protection sought by the applicants in different territories around the globe. It further illustrates that most of the assignees of patents/patent applications found relevant with respect to renewable energy technology broadly have filed the patents/patent applications in China with 120175 patent filings. This is followed by United States of America (83799), Japan (31584), World Intellectual

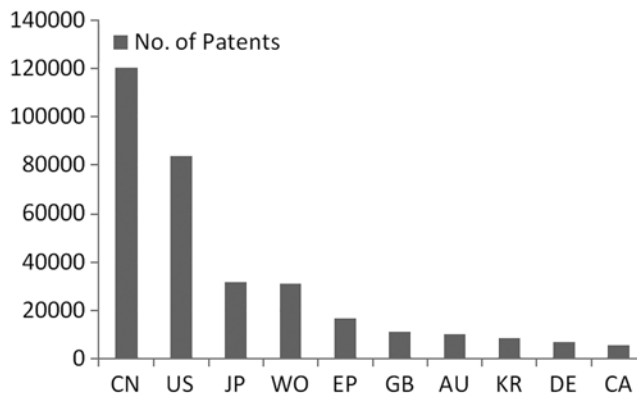


Fig. 1 — Geographical distribution of patents/patent applications

Property Organization (31192), European Patent Office (16775), United Kingdom (11061), Australia (10018), Korea (8627), Germany (6822) and Canada (5639) (Table 1).

The pattern of geographical distribution of patents indicates that most of the assignees/applicants have chosen to protect their technologies in China. This may be attributed to the following reasons:

- Bigger market, manufacturing support, and cost
- Patent prosecution and granting pathway
- Higher probability of infringement of their technologies in this jurisdiction and
- Policy support from the State.

The above distribution pattern also means that there is high probability of getting patents granted in the countries where the concentration of patents is relatively less, that is, the countries other than the top four countries. This also indicates the need for exercising extra caution for filing patents in the high concentration countries to avoid infringement claims and litigation in the future. However, since the bigger market is available in these countries, the option of filing patents there may be explored after careful analysis of the patent portfolios of assignees.

Distribution of Patents amongst Top 10 Applicants

This section identifies top corporations working in the technology area of renewable energy

Fig. 2 is a 3D pie chart showing distribution of patents amongst top 10 applicants. It reveals that General Electric, and Siemens AG are the leaders amongst the applicants having 2634 patents/patent applications and 1676 patents/patent applications respectively in their patent portfolio. These two corporations are followed by Hitachi Ltd., Matsushita Electric Ind. Ltd., Mitsubishi Heavy Ind. Ltd., Canon

Table 1 — Worldwide distribution of patents

Geographical location	Number of patents/patent applications
China (CN)	120175
USA (US)	83799
Japan (JP)	31584
World Intellectual Property Organization (WO)	31192
European Patent Office (EP)	16775
United Kingdom (GB)	11061
Australia (AU)	10018
Korea (KR)	8627
Germany (DE)	6822
Canada (CA)	5639

Source: <https://www.lens.org/>

KK having 1646, 1390, 1224 and 1164 patents/patent applications each in their respective patent portfolios (Table 2) .

Technology Trend Analysis

The distribution of patents / patent applications in the technological area of renewable energy across top 10 IPC gives an indication regarding the most favored technology subclasses amongst top applicants.

Fig. 3 is a bar diagram illustrating the spread of patenting activity across top 10 subclasses of technologies corresponding to IPC. This reveals that IPC F03D9/00 is the most favoured technological subclass having 8686 patent filings. This is followed by IPCs H01M8/04, H02J7/00, F24J2/46, H02N6/00, H01L31/042, F24J2/04 having 6698, 6682, 6404, 5190, 5042 and 4460 patent filings respectively (Table 3). The distribution pattern means that these

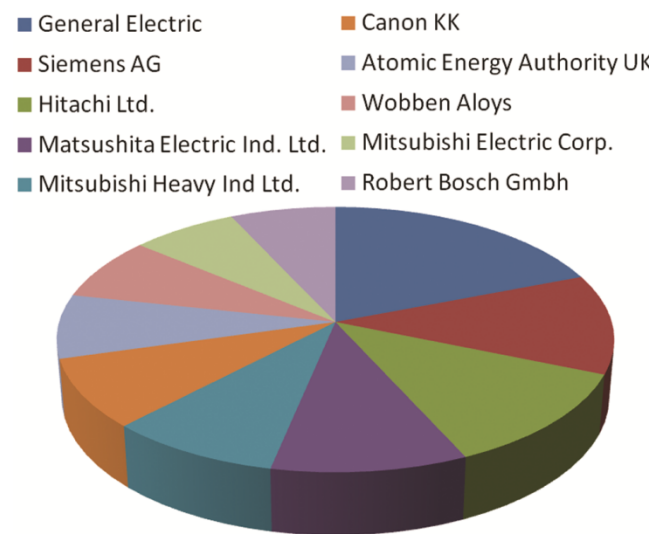


Fig. 2 — Distribution of patents amongst top 10 applicants

Table 2 — Worldwide distribution of patents amongst top 10 applicants

Assignee name	Number of patents/patent applications
General Electric	2634
Siemens AG	1676
Hitachi Ltd.	1646
Matsushita Electric Ind. Ltd.	1390
Mitsubishi Heavy Ind. Ltd.	1224
Canon KK	1164
Atomic Energy Authority UK	1073
Wobben Aloys	1056
Mitsubishi Electric Corp.	966
Robert Bosch GmbH	958

Source: <https://www.lens.org/>

are the most favoured technology subclasses amongst top assignees for improving their products. This also indicates that research in these subclasses is at a very advanced stage and extra caution should be exercised while starting or carrying out research activities within these technology subclasses.

Annual Patenting Trend

The annual patenting trend in the last fifteen years in the technological field of renewable energy based on the number of patent documents published highlights recent trends and growth in patenting pattern with respect to patent filing worldwide.

Table 4 illustrates that there is a gradual increase in each passing year in the patenting of renewable energy technologies. The initial phase was followed by a transition phase resulting in a substantial increase in the patenting activity. The transition phase was followed by a period of very large number of patenting filing during the period 2009-2011 showing a huge number of patenting activities during this period. The above trend means that the maximum research activity in the area of renewable energy was during the period 2008-2013. This may be attributed to the reason that the biggest prolific market players researching in the domain found maximum growth potential in the market for their respective products during this period.

White Space Analysis

White space analysis is performed mainly to identify the availability of technological areas that can be explored to carry out further research and development. The identification of available technological white space enables a corporation to utilize it to their advantage by investing resources in

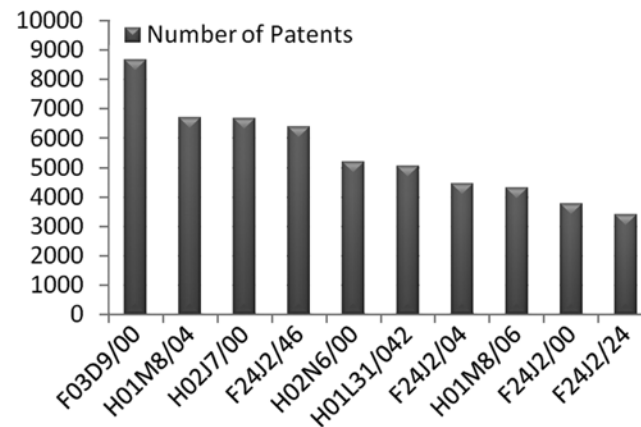


Fig. 3 — Distribution of patents across top 10 IPC

Table 3 — Worldwide distribution of patents across top 10 IPC

Relevant IPC	Definition of IPC	Number of patents/ patent applications
F03D9/00	WIND MOTORS; Adaptations of wind motors for special use; Combinations of wind motors with apparatus driven thereby	8686
H01M8/04	PROCESSES OR MEANS, e.g. BATTERIES, FOR THE DIRECT CONVERSION OF CHEMICAL ENERGY INTO ELECTRICAL ENERGY; Auxiliary arrangements or processes, e.g. for control of pressure, for circulation of fluids	6698
H02J7/00	CIRCUIT ARRANGEMENTS OR SYSTEMS FOR SUPPLYING OR DISTRIBUTING ELECTRIC POWER; SYSTEMS FOR STORING ELECTRIC ENERGY; Circuit arrangements for charging or depolarising batteries or for supplying loads from batteries	6682
F24J2/46	PRODUCTION OR USE OF HEAT NOT OTHERWISE PROVIDED FOR; Component parts, details or accessories of solar heat collectors	6404
H02N6/00	ELECTRIC MACHINES NOT OTHERWISE PROVIDED FOR; PV power plants; Combinations of PV energy systems with other systems for the generation of electric power	5190
H01L31/042	SEMICONDUCTOR DEVICES; ELECTRIC SOLID STATE DEVICES NOT OTHERWISE PROVIDED FOR; PV modules or arrays of single PV cells	5042
F24J2/04	PRODUCTION OR USE OF HEAT NOT OTHERWISE PROVIDED FOR; Solar heat collectors having working fluid conveyed through collector	4460
H01M8/06	PROCESSES OR MEANS, e.g. BATTERIES, FOR THE DIRECT CONVERSION OF CHEMICAL ENERGY INTO ELECTRICAL ENERGY; Combination of fuel cell with means for production of reactants or for treatment of residues	4320
F24J2/00	PRODUCTION OR USE OF HEAT NOT OTHERWISE PROVIDED FOR; Use of solar heat, e.g. solar heat collectors	3782
F24J2/24	PRODUCTION OR USE OF HEAT NOT OTHERWISE PROVIDED FOR; the working fluid being conveyed through tubular heat absorbing conduits	3387

Source: <https://www.lens.org/>

Table 4 — Annual patenting trends in the field of renewable energy across the globe

Year of publication	Number of patents/patent applications/ documents published
2013	38984
2012	36587
2011	30290
2010	26511
2009	21289
2008	17611
2007	14354
2006	11752
2005	10308
2004	10230
2003	9533
2002	8684
2001	6705
2000	6016
1999	5477

Source: <https://www.lens.org/>

these areas either by doing research purely in these technological classes, or by combining these technological classes with more popular and established technological classes. As a result, a corporation may be able to achieve dual goals of

avoiding infringement claims, and being the frontrunner in the newly emerging (available technological white space) technologies.

Based on the analysis of data in preceding sections, this section provides information with respect to presence of white space as per IPC for a particular invention under study. The least favored IPC classes as per comprehensive General Patent Search for a particular invention under study are:

For Patents/ Patent applications, the least favoured IPC class is F24J2/24 (PRODUCTION OR USE OF HEAT NOT OTHERWISE PROVIDED FOR; the working fluid being conveyed through tubular heat absorbing conduits) followed closely by F24J2/00 (PRODUCTION OR USE OF HEAT NOT OTHERWISE PROVIDED FOR; Use of solar heat, e.g. solar heat collectors). This shows that these areas are least worked upon as per the number of patent filings with respect to top 10 IPC sub-classes. The analysis also indicates that there is significant white space available amongst IPC classes mentioned above. The applicant can explore research possibilities in these classes, or consider integrating research in these classes, with other technologies to enhance the quality of existing products.

It is observed that China is leading in the renewable energy sector. Government policies in the form of guidelines, plans, strategies, approaches, schemes, and regulatory frameworks can accelerate patenting activity. The subsequent section briefly analyzes the renewable energy policy and framework in China.

Renewable Energy Policy in China

Table 5 and 6 show top Chinese applicants/assignees in China with respect to patents in solar and wind energy sector, respectively. It indicates that Chinese public as well as private sectors are also actively involved in patenting activities in China. These policy makers also encourage indigenous or in-house capacity building in renewable energy sector. Renewable energy policy in the forms of target, subsidy, tax incentive, and subsidies are available in various countries that include OECD countries and non-OECD countries.^{6,7} There exists a global renewable energy policy multi-stakeholder network that connects a wide range of key actors.⁸ The renewable energy initiatives started in China in 2004 when the country announced plans to develop a renewable energy law and to establish a renewable energy development fund. 'Small-hydro' and small-scale solar PV were identified as key areas for the encouragement of de-centralized projects at that times.⁹ It is reported that China's policy approach to renewable energies has placed priority first on

Table 5 — Patents filed/granted to Chinese assignee in China in the field of solar energy

Chinese organization	No. of patents filed/granted
State Grid Corporation of China (SGCC)	530
Zhejiang University	229
Wuxi Sunocean	202
South China University of Technology	196
Ocean S King Lighting Science & Technology	171

Source: <https://www.lens.org>

Table 6 — Patents filed/granted to Chinese Assignee in China in the field of wind energy

Chinese organization	No. of patents filed/granted
State Grid Corporation of China (SGCC)	875
MIDEA	395
Guangdong MIDEA Refrigeration Equipment	297
China Electric Power Research Institute	263
GREE Electric Appliances	238

Source: <https://www.lens.org>

developing a renewable energy manufacturing industry.¹⁰ The impact of renewable energy law is reflected in the form of China's renewable electricity capacity that grew rapidly. China's wind capacity installation also increased in 2006-2008.¹¹ Report suggests that China installed more renewable energy capacity in year, 2013 than all of the Europe and rest of the Asia Pacific region.¹² Technology focused policies to reduce renewable cost enhance government support for innovation and research and development.¹² The Renewable Energy Policy of China focuses on, (a) mandatory market share for renewables by market and technology, (b) Tariff based support mechanism, and (c) Government support on renewable energy projects.¹² The current policy framework of China includes, (i) Airborne pollution prevention and control action plan, (ii) Renewable energy policy, (iii) Transport sector related policy, (iv) Solar water heating for buildings, (v) Industrial policies for renewable energy sector, (vi) Carbon Policy, and (vii) Electricity pricing. Further, policy updates involve encouragement of local government in framing guidelines on distributed solar photo voltaics. Literature suggests that China's policies on renewable energy fall in three categories with first two levels established by Central Government whereas local/municipal government establishes third level of policy.¹² The first level policies focus on general direction and guidelines whereas second level policies specify goals, objectives and developmental plan. Third level policies are about practical and specific incentives and managerial guidelines.¹² Hence, it is observed that China is having well-structured renewable energy framework that may be stimulating patenting activities in China. However research reports that there is still a gap between renewable energy policy and renewable energy industrial policy.¹³

Renewable Energy Policy of UK

It is reported that renewable energy scheme in UK is supported through a Feed-in tariff, Contracts for Difference Scheme, Renewable Heat Incentive Scheme, a quota system and tax regulation mechanism.¹⁴ The country has enacted various legislative instruments that includes, the renewable heat incentive scheme and domestic renewable heat incentive scheme, the renewable transport fuel obligations order, the promotion of the use of energy from renewable sources, and non-domestic rate

regulation.¹⁵ Report suggests that legislative frameworks have been amended several times that leads to uncertainty to the market.¹⁶ This may be reason behind its slower growth compared to China.

Renewable Energy Policy of India

India is the first country to create separate ministry of new and renewable energy.¹⁷ Further, Section 86 of Electricity Act states about co-generation of electricity through renewable energy sources. Further, the renewable energy has been mentioned in various program and policy framework such as, National Electricity Policy, National Tariff Policy, National Action Plan on Climate Change, Jawaharlal Nehru Solar Mission, Accelerated Depreciation (AD) and Generation Based Incentive (GBI), and National Offshore Wind Energy Policy.¹⁸

Conclusion

Although, the penetration of renewable energy technology is increasing, but it still remains limited. This trend illustrates that most of the companies are considering China for patent filing that makes China the largest hub in renewable energy related components manufacturing, selling, importing, and exporting. This could be due to the reason that the inventors/assignees find bigger market here. It reveals that General Electric, and Siemens AG are the leaders amongst the applicants having 2634 patents/patent application and 1676 patents/patent application respectively in their patent portfolio. These two corporations are followed by Hitachi Ltd., Matsushita Electric Ind. Ltd., Mitsubishi Heavy Ind. Ltd., Canon KK having 1646, 1390, 1224 and 1164 patents/patent applications each in their respective patent portfolios. This analysis reveals that IPC F03D9/00 is the most favoured technological subclass having 8686 patent filings, followed by IPCs H01M8/04, H02J7/00, F24J2/46, H02N6/00, H01L31/042, F24J2/04 having 6698, 6682, 6404, 5190, 5042 and 4460 patent filings respectively. This indicates that development of Wind Motors; Adaptations of wind motors for special use; Combinations of wind motors with apparatus driven thereby is taking a major share. White space analysis directs research and development opportunity in renewable energy sector. Governments and policy makers across the world are introducing legislation and support mechanisms to accelerate the development of the sector. Many countries have sector-wise laws and ordinances for compulsory

purchase of renewable power, promotion of specific technologies like biomass, wind power, geothermal energy, etc. All these countries have General Electricity Acts/Energy Acts and yet they have decided to enact separate legislation for promotion of renewables. The analysis is a step for devising a better and improved methodology that will produce reliable and continuously updated data for renewable energy technologies. This study might help in contributing, in the medium and long term, to evidence-based debate on the role of IPRs in the development and deployment of technology in the field of non-conventional energy. In conclusion, reliable and accurate patenting and technology data is not sufficient in itself. The limitations of using such data for technology acquisition are well known. However, such information is an important component – among others - of an enabling environment for innovation and technology transfer. Government policy framework plays a pivotal role in accelerating the patenting activity. However, in order to take the fruit of renewable energy, there is a requirement of coherent renewable energy industrial policy along with renewable energy policy.

References

- 1 Wendy K, Solar and wind innovation reflected in booming patents, *USA TODAY*, <https://www.usatoday.com/story/news/nation/2013/10/12/solar-wind-renewable-patents-surge/2967985/> (accessed on 22 September 2017).
- 2 Cole P & Banki G, Renewable energy programmes in the South Pacific – Are these a solution to dependency? *Energy Policy*, 110 (2017) 500.
- 3 Report, *Patenting Invention: Clean Energy Innovation Trends and Priorities for the Trump Administration and Congress*, <https://www.brookings.edu/research/patenting-invention-clean-energy-innovation-trends-and-priorities-for-the-trump-administration-and-congress/> (accessed on 22 September 2017).
- 4 <https://www.oecd.org/sti/sci-tech/24508541.pdf> (accessed on 12 November 2017).
- 5 https://www.rand.org/pubs/rgs_dissertations/RGSD347.html (accessed on 12 November 2017).
- 6 Five countries comparison of renewable energy policies and progress, http://pdf.wri.org/renewable_energy_chart.pdf (accessed on 22 September 2017).
- 7 Mahmure Övül Arıoğlu Akan, Ayşe Ayçim Selam, Seniye Ümit Oktay Firat, Merve Er Kara & Semih Özel, A comparative analysis of renewable energy use and policies: Global and Turkish perspectives, *Sustainability*, 7 (2015) 16379; doi:10.3390/su71215820.
- 8 Renewable 2016, *Global Status Report*, http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf (accessed on 22 September 2017).
- 9 Wang F & Yin H, China's renewable energy policy: Commitments and challenges, *Energy Policy*, 38 (April 2010) 1872.

- 10 Zhang S, Andrews-Speed P, Zhao X & He Y, Interactions between renewable energy policy and renewable energy industrial policy: A critical analysis of China's policy approach to renewable energies, *Energy Policy*, 62 (2013) 342.
- 11 Report, *China Market Overview*, https://www.irena.org/DocumentDownloads/Publications/IRENA_GWEC_WindReport_China.pdf (accessed on 22 September 2017).
- 12 Report, *REMap 2030*, A Renewable Energy Road Map, Renewable Energy Prospects: China, https://irena.org/remap/IRENA_REmap_China_report_2014.pdf (accessed on 22 September 2017).
- 13 [https://www.researchgate.net/publication/273698168_Interactions_between_renewable_energy_policy_and_renewable_](https://www.researchgate.net/publication/273698168_Interactions_between_renewable_energy_policy_and_renewable_energy_industrial_policy_A_critical_analysis_of_China's_policy_approach_to_renewable_energies)
- 14 [http:// www. Renewable energy policy database and support_United Kingdom.html](http://www.RenewableEnergyPolicyDatabase.org) (accessed on 12 November 2017).
- 15 <http://www.legislation.gov.uk/title/renewable?page=3>.
- 16 [http://www. IEA - Renewable Energy.html](http://www.IEA.org/REnewableEnergy) (accessed on 12 November 2017).
- 17 <http://www.mnre.gov.in/> (accessed on 12 November 2017).
- 18 [www.cprindia.org/papers/RE%20Regulatory%20and%20Pol
icity%20Framework%20..pdf](http://www.cprindia.org/papers/RE%20Regulatory%20and%20Policy%20Framework%20..pdf).