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# Emerging Technology of Blockchain for Energy Sector

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Since the Bitcoin whitepaper was published in 2009, blockchain has been the technology of the decade. This revolutionary technology assures decentralization and immutability, which helps in fraud-prevention. In addition, it provides independence from central coordination entities which further ensures transparency and accountability. Like many other sectors, there are various uses of blockchain in the energy sector such as in energy trading, smart meter, and micro grid. The current landscape study is based on qualitative exploratory research methodology and focuses on the patenting activity for the use case of blockchain in the energy/power sector.

**Keywords**: Blockchain, Energy, Patent, Patent Landscape, Power Sector, Patent Analytics

Blockchain technology has been the most hyped and talked technology of the decade.[1] It is one of the driving forces behind the fourth industrial revolution along with the Internet of Things (IoT).[2] Blockchain provides decentralized, immutable, traceable, transparent, and secure system; which can be utilized to overcome some of the major technical problems in different industry sectors.[3]

Energy sector is significant for the growth and development of the human race. The distributed system architecture of the blockchain matches wonderfully with the increasingly-decentralized energy industry. Blockchain can bring greater security in information technology (IT), efficiency, and potential cost reduction to the energy industry.[4–6] Many research and commercial organizations are currently pursuing blockchain innovation in the energy sector. New blockchain-based business models and applications are emerging fast. The speed, energy consumption, IT security, reliability, governance, interoperability, and cost-effectiveness of blockchain are also evolving rapidly.[7] The European Commission introduced EU blockchain observatory in 2018 to encourage cross border engagement with the technology and its various stakeholders.[8] Moreover, the green purchase program there allows customers to buy bundled energy and renewable energy credits from renewable energy projects. There are many blockchain initiatives in the USA.[9] India is also announcing blockchain based framework.[10] Consequently, research and development activities are being carried out for using blockchain in the energy sector, and patent applications have been filed.

Patent is an intellectual property right for the protection of an invention. The owner gets the right to exclude third parties, who do not have his consent, from making, using, and selling the invention. The analyses of patent information and making patent landscape reports are becoming increasingly important to understand a technological area.[11]Patent landscaping gives an overview of the patents that are pending or in force in a particular area. It brings significant insight into competitive edge, disruptive technology forecasting, and global management of invention portfolios. Therefore, patent analysis is very important for corporate entities as well as for academic study. The present study focuses on the use of blockchain technology in the energy sector, and provides a patent landscape analysis for the same.

Blockchain was first described in 1991 by a group of researchers who tried to timestamp digital documents so as to prevent backdating or tampering of the document.[12] However, the technology remained unused until Satoshi Nakamoto adapted it in 2009 to create the digital crypto currency, Bitcoin[1]. Blockchain is a digital list of records, called blocks that are connected using cryptography. The data structure contains several records of transactions in chronological order, and it is shared and distributed across various entities. Blockchain can provide robust

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solutions for preventing digital fraud by enabling the sharing of information in real-time and updating the ledger only upon the agreement of all parties.[13] Thus, it allows the verified contributors to store, view, and share data in a secured environment—fostering trust, accountability, and transparency in business relationships.[14] Since its application in the finance sector as Bitcoin resulted in a success, researchers tried to explore the technology further. Blockchain technology has the potential to replace the financial transaction system and provide better transaction models in different industrial sectors like health care, banking and finance, energy and power, etc.[15–23]

Over the last few decades, the energy industry has gone through several changes to supply the ever-increasing demand of electricity. With the depletion of conventional energy sources, renewable energy sources are continuously being developed.[24] However, proper and stable solutions are needed for efficient and low-cost power supply, grid maintenance, simplification of energy trading process, and prevention of electricity theft.[25] Moreover, the sector is demanding the integration of small-scale renewable resources, distribution of generation units, flexible services, and simultaneous participation of consumers and producers in the energy market. Blockchain can offer solutions to many challenges of the energy sector. It offers novel solutions for empowering consumers and small renewable generators to play an active role in sharing economy, which gave rise to novel market models and energy democratization.[26] The blockchain technology promises to organize and track infinitesimal energy flow and control signals at the lowest transaction costs.[27] However, it should be noted that currently almost all blockchain applications and projects are still far from having a high market penetration.

Researchers have followed qualitative exploratory research methodology here. The current study has focused on patent data available till April 2019. Secondary data sources were retrieved from various open databases viz., Google Patents, inPASS from Indian patent office, PatFT and AppFT from United States patent and trademark office (USPTO), and Espacenet from European patent office. Since the first global appearance of blockchain technology was in 2009, only the data from 2009 onwards have been considered. An initial search using keywords like blockchain in energy, power, electricity, micro grid, and smart grid acquired a total of 1178 patent applications. This sample was filtered out to 540 patent applications by studying the titles and abstracts of each application. Thereafter, a thorough reading of each application led us to select 89 most relevant patent applications for this study.

## Blockchain Patents Filing Trend

The study shows that most of the blockchain patents in the energy sector were filed in 2017, making it 43.2% of total patents filed in the last decade (Fig. 1).

Figure 2 shows the priority-country-wise filing trend of patent applications. Although, blockchain technology was introduced in 2009, it was being used in the finance and banking sector only. As can be seen, the first patent application employing blockchain in the energy sector was filed in the US in 2011. Although, China entered late in this field and filed its first application in 2016, the maximum number of files in 2018 is from China. Since, a patent application is published 18 months after the date of filing; it can be assumed that many patents have been filed in 2018 and 2019 which will be reflected after two years.

### Publication of Blockchain Patent Applications

The highest number of patents in the field of blockchain were published in 2018, making it 62.5% of total patents that have been filed in this domain (Fig. 3).

In 2019, already 25 patents have been published till March, implying an increasing trend. A very small number of patents were published in 2016 and 2017, and no publication was found before that. Therefore, the patents filed before 2016 were either published later or were abandoned. Figure 4 shows the country-wise publication trend. As expected, Chinese applications contributed the most.

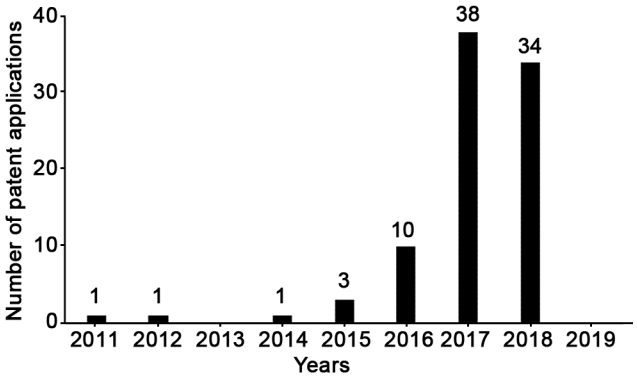


Fig. 1 — Priority wise data of blockchain patents filed

**Major Countries with Bloackchain Patents in Energy Sector**

The results show that the highest number of patent applications (52%) in the energy sector having blockchain as underlying technology is filed in China (Fig. 5).[28] It is then followed by the USA, where 24 applications are filed. The PCT applications have been grouped according to their priority countries. A very interesting observation is that although the blockchain innovation originated in the US and a huge number of patents are being filed pertaining to several usage of blockchain, China is the leader to employ blockchain technology in the field of power and energy. A total of 11 applications have been filed in the European region. The rest of the countries such as, Australia, France, Japan and Korea are jointly grouped as others (Fig. 5).

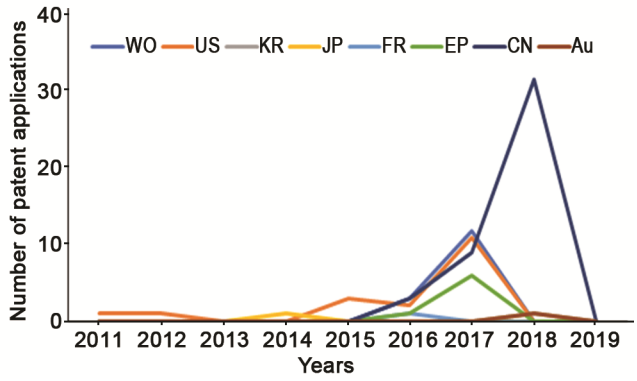


Fig. 2 — Country wise data of blockchain patents filed

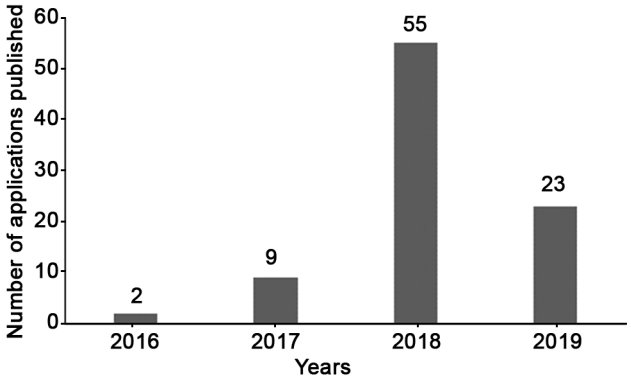


Fig. 3 — Blockchain patents published from 2016-1019

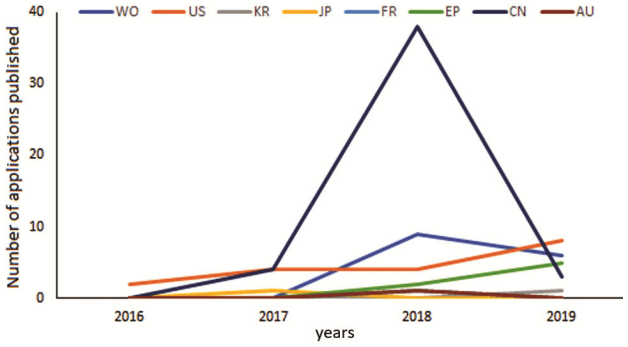


Fig. 4 — Country wise blockchain patents published from 2016-1019

**Technical Categorization**

In order to categorize all the patent applications, the titles, abstracts, and claims of each application have been analyzed. Subsequently, they have been broadly classified into 10 major areas in the field of energy/electricity viz., energy metrics, energy transaction, carbon trading, power trading, renewable energy, micro grid, energy management, energy supply, devices and methods, and gas & oil. The remaining categories are grouped as others. Figure 6 shows that considerable number of patents has been filed for 'devices and methods' to provide solutions to the technical problems underlying in the energy sector specifically in the electricity sector. It is followed by 'energy transaction' systems and methods that utilize blockchain technology to improve the transaction of

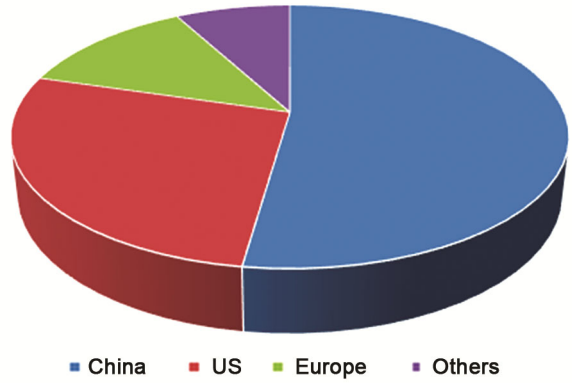


Fig. 5 — Major countries in blockchain patents

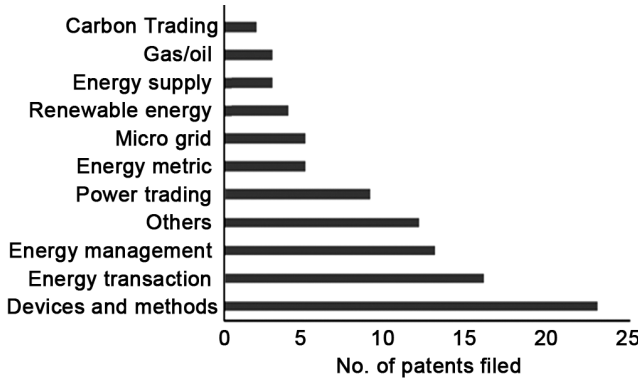


Fig. 6 — Blockchain patents filed in different categories

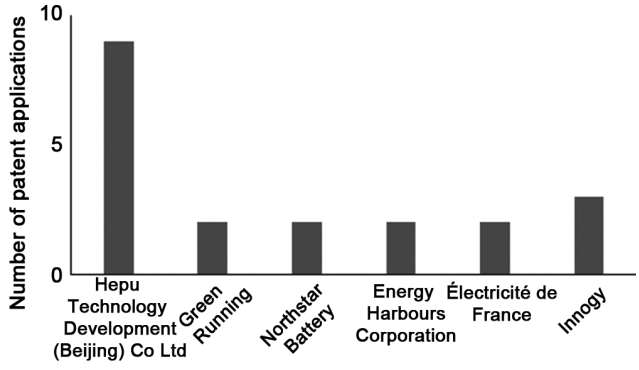


Fig. 7 — Major assignees in blockchain patents

energy in the market or propose the use of distributed and decentralized energy transaction system. Another important domain is 'energy management' as it controls the usage. 'Power trading' and 'carbon trading' are also growing domains in the energy sector and have inherent characteristics of having multiple players. Blockchain can be best employed here as it provides multiple systems, called nodes in the language of blockchain, to operate simultaneously. In these sectors, 11 applications have been filed as of now which directly uses blockchain technology for auctioning and bidding of power and carbon in the market.

Interestingly, the 'renewable energy' sector also realized the importance and advantage of utilizing blockchain technology. The patent (EP 3459038-A1) proposes a method to match the renewable energy production with end-user consumption by implementing blockchain. Since the renewable-energy parameters vary a lot due to atmospheric conditions, it becomes difficult to match the energy generation with user consumption value. With the help of blockchain, it is possible to tally both the values at real time which in turns saves a lot of energy and thus wastages are minimized.

'Micro grid' (or smart grid) is another challenging and developing domain which promises better transmission of energy for optimum utilization and thus prevents electricity theft. Here, 5 patent applications have been found, which is likely to increase in upcoming years due to the ever-increasing demand for reliable, clean, and green energy at affordable cost. Patent applications falling under the rest of the groups were very scattered and could not be grouped under one category. This scenario clearly indicates that a lot of R&D work is being carried out effectively and successfully utilizing blockchain technology at different levels and segments of the energy sector.

**Major Assignees**

The top assignee came out to be *Hepu Technology Development (Beijing) Co Ltd*, with 9 patent applications (Fig. 7). Next in line are *Innogy Innovation Gmbh, Green Running ltd, Northstar Battery Company, Energy Harbor Corp,* and *Electricite de France* having more than one patent.

However, it is to be noted that since it is comparatively a new field of technology, not much assigning trend can be observed now. The proper assigning trend will need a few more years to be reflected.

## Conclusion

Through this study, it was observed that blockchain technology has successfully solved many technical issues that were faced by the energy sector. The filing of patent applications for use cases of blockchain in the energy sector has substantially increased in the last four years. The maximum number of published patents was in 2018, which indicates that most of the patents in this sector were filed back in 2016. Although the maximum number of blockchain patents is filed in the USA, China has the maximum number of patents for using blockchain technology in energy/power related inventions. This may be a result of the utility model patent strategy in China.[28] The study shows that most of the patents are filed as devices and methods which are employed in the electricity or power sector followed by energy management. Hence, it is concluded that blockchain technology is being successfully implemented in the energy sector and there has been a paradigm shift in the innovation and research strategy in the energy and power sector after the success story of Bitcoin and more specifically after 2016. However, it is to be mentioned that blockchain technology is an emerging technology and therefore evolving every day. Moreover, since a patent application gets published after 18 months of filing, it limits the access to the state of art, and those data could not be considered.

The current landscape study gives an outline of the blockchain-based patenting scenario in the energy sector. The study may help researchers to plan their future research activities in this area and help those who are planning to enter this particular technical field. Since it is relatively a new field of study, the dataset used was comparatively small. Therefore, there may be some biased pattern in the results obtained here. It is assumed that this field will continue to grow in the coming years, and an

increasing number of applications are going to be filed in this area as the blockchain technology further evolves. It will be possible to decipher the in-depth trend when more data comes in.

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