Sample Patent Landscape Study

Wireless Electric Vehicle Charging

April, 2020

IIPRO

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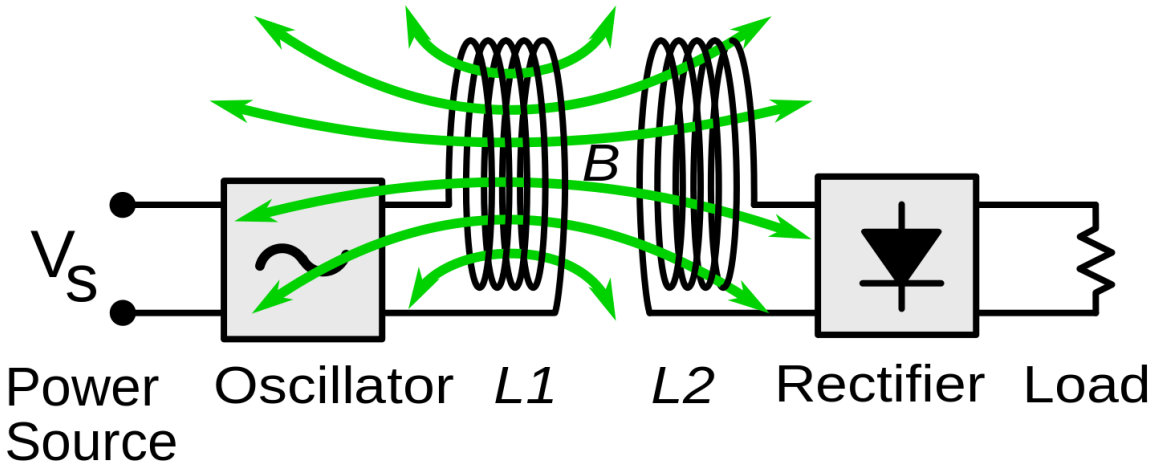
1. Wireless Charging

What is Wireless Charging?

Wireless charging is a process of electrically charging battery-powered devices and equipments without the need of a wired electrical power connection. It enables wireless transfer of electrical charge from a charging device or node to a recipient device.



Wireless charging can be:

Inductive Charging

Inductive Charging technique uses EM waves to transfer energy and charge between transmitter and receiver devices. Inductive charging requires device to be placed on a conductive charging pad/ equipment, which is directly connected to a wall socket. It is mainly used to charge low power small hand-held devices such as, smartphones, PDAs and mobile phones.

Radio Charging

Similar to Inductive Charging, Radio Charging uses wireless radio waves to transfer energy from transmitter device to a receiver device. Receiver device is placed on a radio wave emitting transmitter that transmits radio waves to charge the receiver device.

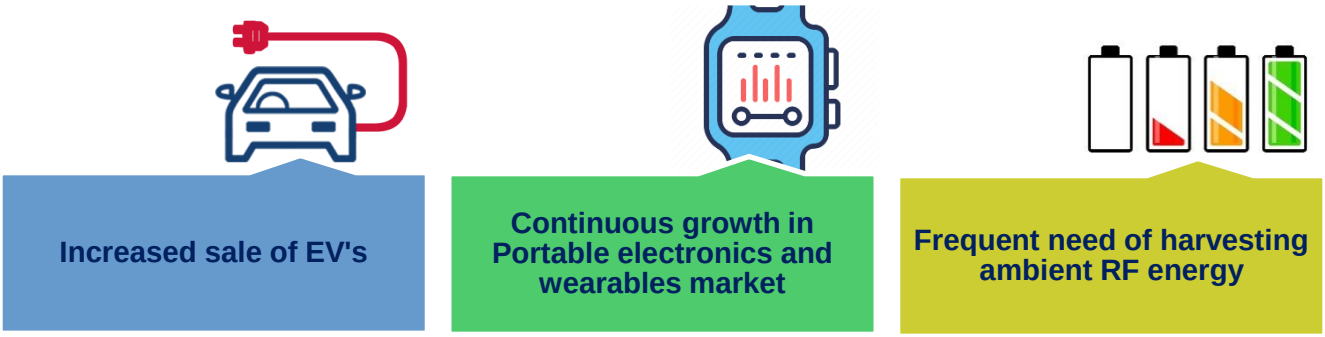
Resonance Charging

Resonance Charging uses strong coupling between resonant coils to transfer power from a sending (sender) copper coil to a receiving (receiver) copper coil. Unlike Inductive Charging, Resonance Charging technique does not require precise overlap of resonant coils, and magnetic field can be picked up from different areas by the receiving copper coil.

Market Growth

Global wireless charging market size was valued at $5.22 billion in 2017, and is projected to reach $71.21 billion by 2025, registering a CAGR of 38.7% from 2018 to 2025.

Top Impacting Factors



Key Investors in the technology domain	Samsung Electronics Co., Ltd.
	Qualcomm Incorporated.
	Texas Instruments, Inc.
	Integrated Device Technology, Inc.
	Powermat Technologies Ltd.
	WiTricity Corporation.
	Energizer Holdings, Inc.
	Murata Manufacturing Co. Ltd.
	Sony Corporation.
	Fulton Innovation LLC.

Technical Standards

In order to provide interoperability, which is a key requirement for wireless charging, it has been necessary to develop a standard that can be adopted by majority of the manufacturers.[3].

For Low power charging

Standards refer to different set of operating systems with which devices are compatible. There are two main standards for Low power wireless charging: Qi and PMA. These two standards operate almost in similar fashion but use different transmission frequencies and connection protocols. Because of this, devices compatible with one standard are not necessarily compatible with the other standard. However, there are some devices that are compatible with both the standards.

Qi-is an open interface standard that defines wireless power transfer using inductive charging over distances of up to 4 cm (1.6 inches), developed by the Wireless Power Consortium. The system uses a charging pad and a compatible device to be charged, wherein the device is placed on top of the charging pad. Many prominent mobile phone companies like Apple, Asus, Google, HTC, Huawei, LG Electronics, Motorola Mobility, Nokia, Samsung, BlackBerry, Xiaomi, and Sony are working rigoursly to enhance Qi based Wireless Power Transfer Technology.

AirFuel Alliance:

In January 2012, IEEE announced initiation of Power Matters Alliance (PMA) under IEEE Standards Association (IEEE-SA) Industry Connections. Airfuel alliance was formed to publish a set of standards for inductive power that are safe and energy efficient, and have smart power management. PMA is also focused on creation of an inductive power ecosystem[4].

For High Power Charging

Wireless charging efficiently charges battery of electric vehicles without plugging in. To design interoperable and compatible Wireless Electric Vehicle Charging (WEVC) system, many international organizations such as International Electro Technical Commission (IEC), the Society of Automotive Engineers (SAE), Underwriters Laboratories (UL) Institute of Electrical and Electronics Engineers (IEEE) are working closely with Electric Vehicle manufacturers to develop standards technology for Wireless Electric Vehicle Charging.

SAE J2954 standarddefines WPT for Light-Duty Plug-In EVs and Alignment Methodology. According to this standard, Level 1 offers maximum input power of 3.7 Kw, Level2 offers 7.7Kw, Level 3 offers 11Kw and Level4 offers 22Kw. Minimum target efficiency is greater than 85% when aligned properly with allowable ground clearance of up to 10 inches and side to side tolerance of upto 4 inches. Proper alignment is key to ensure maximum efficiency of charging system. Different companies have developed different charging methods. Most preferred alignment method is magnetic triangulation. We will discuss other methods in the upcoming sections.

SAE J1772 standard defines EV/PHEV Conductive Charge Coupler.

SAE J2847/6 standard defines Communication Between Wireless Charged Vehicles and Wireless EV Chargers.

SAE J1773 standard defines EV Inductively Coupled Charging.

SAE J2836/6 standard defines Use Cases for Wireless Charging Communication for PEV.

UL subject 2750 defines Outline of Investigation, for WEVCS.

IEC 61980-1 Cor.1 Ed.1.0 defines EV WPT Systems General Requirements.

IEC 62827-2 Ed.1.0 defines WPT-Management: Multiple Device Control Management.

IEC 63028 Ed.1.0 defines WPT-Air Fuel Alliance Resonant Baseline System Specification[5].

EV- Wireless Charging

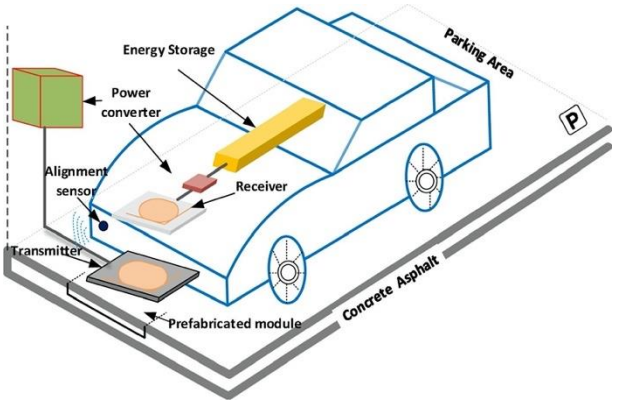
How it works: Instead of using a plug-in cable to charge an Electric Vehicle (EV), Wireless Electric Vehicle Charging (WEVC) technology uses the principle of magnetic induction to wirelessly charge vehicle's battery without contact. Power is transferred between a Base Charging Unit (BCU) that is installed either on or below the paved surface of charging bay and a Vehicle Charging Unit (VCU) fitted underside of the vehicle. A magnetic "Flux Pipe" couples power between BCU and VCU charging pads and energy is wirelessly transferred between the two units to charge the EV battery[6].

Based on the application, Wireless charging systems (WCSs) for EV can be distinguished into two categories[5][7],

1. Static Wireless Charging
2. Dynamic Wireless Charging

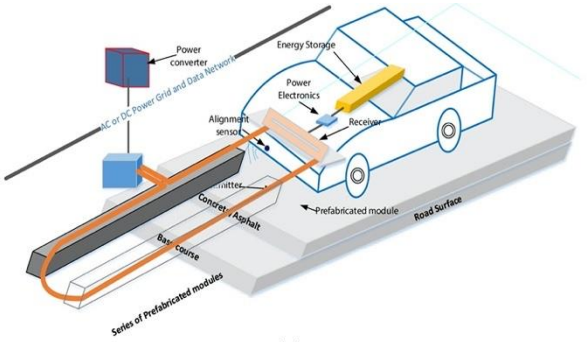
Static Wireless Charging

As the name suggests, using this technique, vehicle gets charged when it remains static. So here, we could simply park the EV at a parking spot or in a garage that is incorporated with WCS, wherein transmitter is fitted underneath the ground and receiver is arranged in vehicle's underneath. In order to charge the vehicle, the transmitter and the receiver are aligned and left for charging. The charging time depends on the AC supply power level, distance between the transmitter & the receiver and their pad sizes.

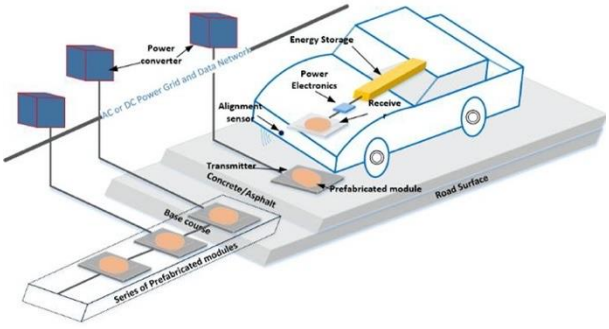


Dynamic Wireless Charging System (DWCS):

In DWCS, the vehicle get charged while in motion. The power transfers over-the-air from a stationary transmitter to a receiver coil in the moving vehicle. Since the battery is charged on the run, DWCS improves travelling range and allows user to efficiently use charging time. It also reduces the need of a large energy storage module, thereby reducing the weight of vehicle to a great extent.



(a)



(b)

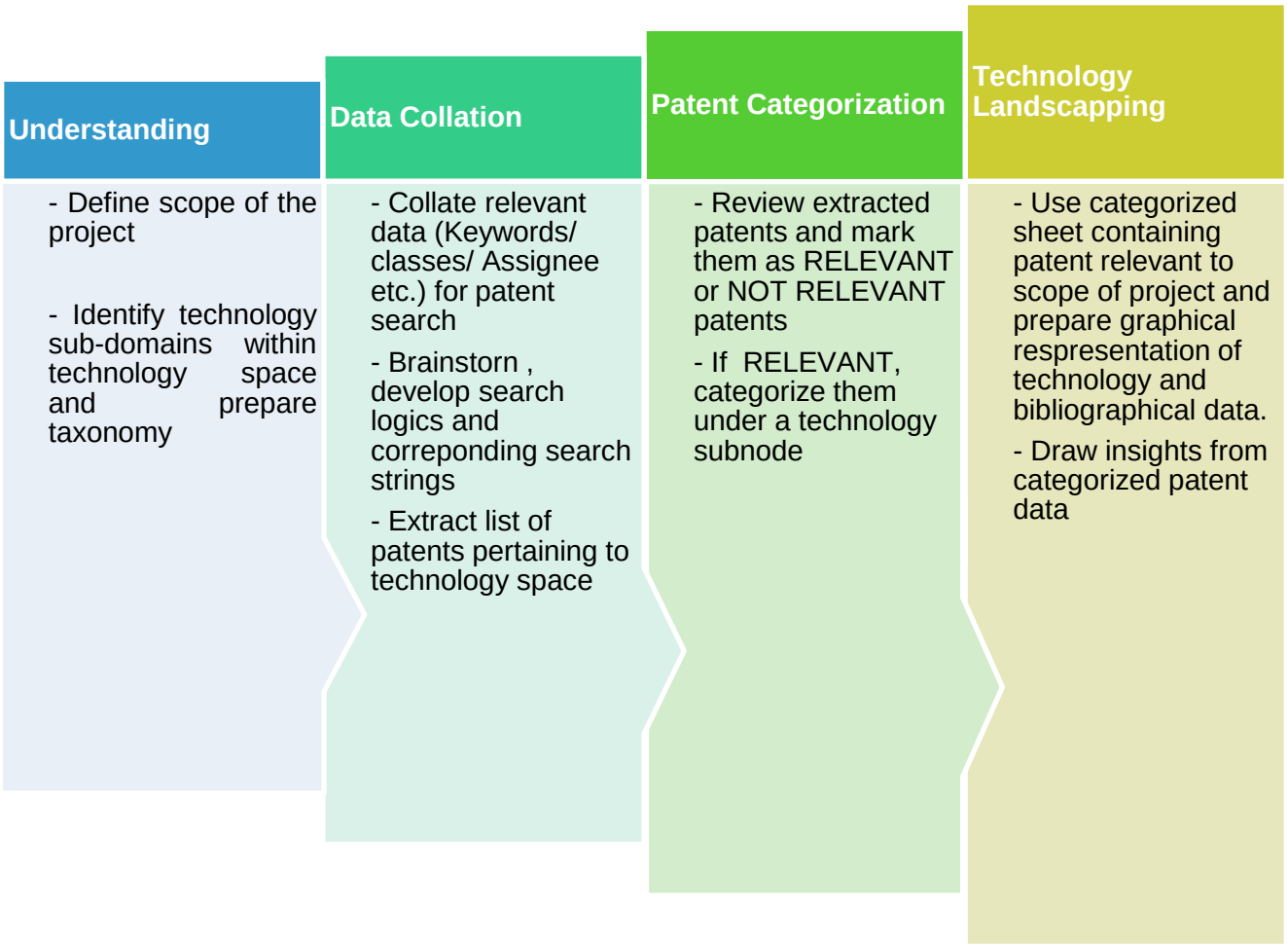
Companies-Currently Working on WCS

Evatran Group's	•Plugless Charging for passenger EVs like Tesla Model S, BMW i3, Nissan Leaf, Gen 1 Chevrolet Volt.
WiTricy Corporation	•WCS for Passenger cars and SUVs till now it is working with Honda Motor Co. Ltd, Nissan, GM, Hyundai, Furukawa Electric.
Qualcomm Halo	•WCS for Passenger, sport and race car and it is acquired by Witricity corporation
Hevo Power	•WCS for Passenger car
Bombardier Primove	•WCS for Passenger car to SUVs.
Siemens	•WCS for Passenger car.
BMW	•WCS for Passenger car.
Momentum Dynamic	•WCS for Commercial fleet and Bus.
Conductix-Wampfler	•WCS for Industry fleet and Bus[5].

2. Objectives

- To provide a brief overview of innovation trend in Wireless charging domain
- To provide patenting trend in Wireless charging and more specifically, in the WEVC domain
- Geography-wise / technology-wise split of patented/Patent pending technology in the domain
- A brief study on top players and their valuable technology in the WEVC domain
- A brief overview of the future of WEVC domain

3. Search Methodology



4. Summary

- This report explores a global landscape of patents / patent applications pertaining to EV- Wirless Charging Technology.

- A set of 565 patent families published in the year 2019-20 bifurcates to a total of 1414 individual patents/applications filed in the EV – Wireless Charging domain . The same have been analyzed extensively in this report

Focus of the Claimed Inventions

Transmitter	166
Receiver	146
Inductive Coupling	140
Control Circuit	124
Efficiency	113
Rectifier	77
Frequency	75
Magnetic Resonance Coupling	54
Dynamic Wireless Charging	54
Distance Range	52
Foreign Object Detection	40
Inverter Circuit	31
Power Capacity	26
Coil Alignment	24
Directivity	11
Capacitive Coupling	11
Bidirectional Wireless Charging	8
Dual-mode Charging	6
Miscellaneous	337

Key Report Findings

EV-Wireless Charging filings have grown each year. The year 2019-20 has witnessed a rise by 50% in patent publication.

In 2019-20, State Grid Corp of China emerged as the top global innovator in WEVC domain with 31 patent families.

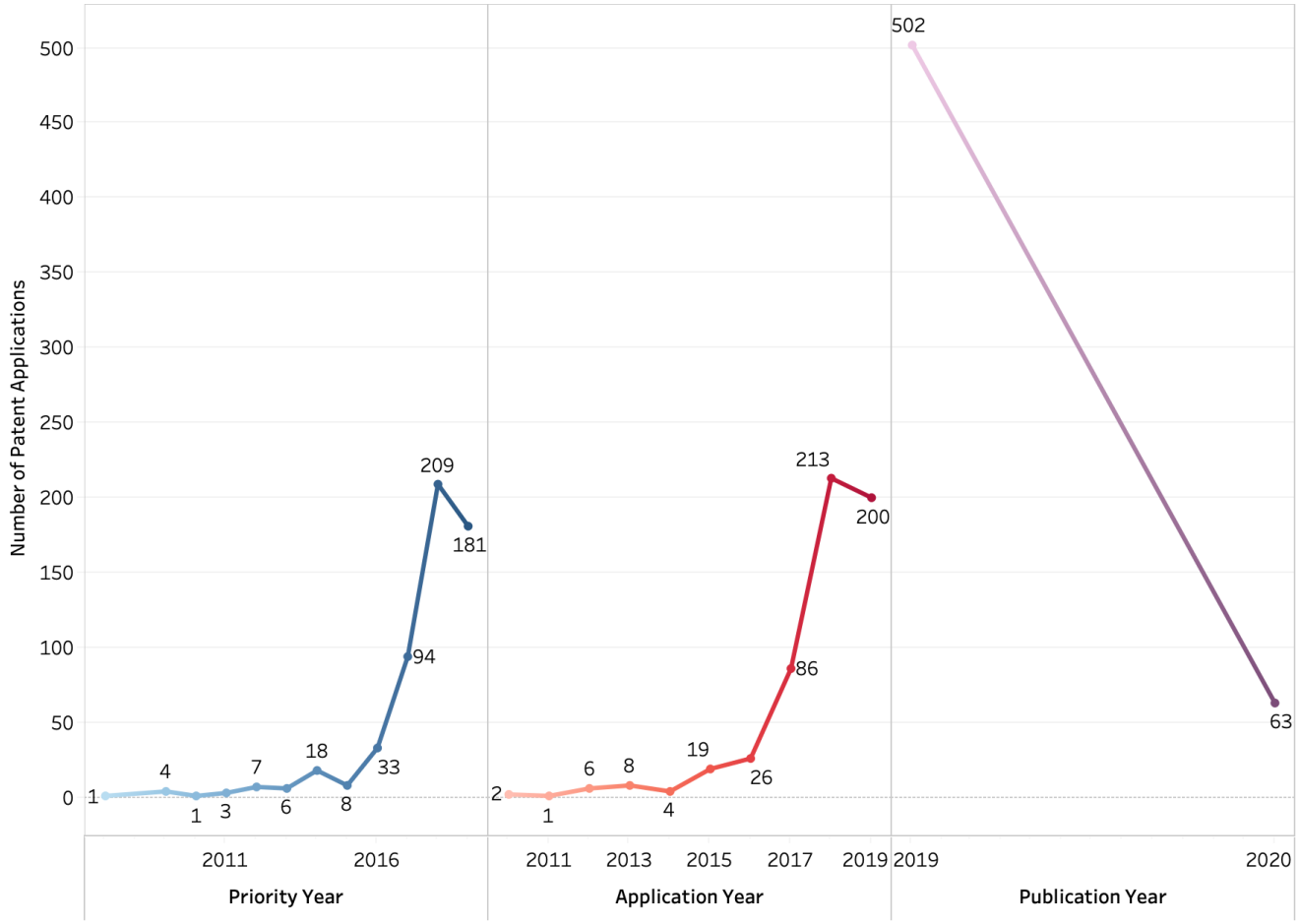
China (401 patent applications) is the biggest filing destination.

Wang Zhe, Ma Junchao, Lu Jun, He Fanbo and Ge Junjie; each with 30 patent are leading researchers in WEVC domain.

5. Non-Technical Analysis

5.1 Priority, Filing, Publication Year Based Trend Analysis

Below graph represents priority year, application year and publication year trends for the patent applications pertaining to EV- Wireless Charging Technology.



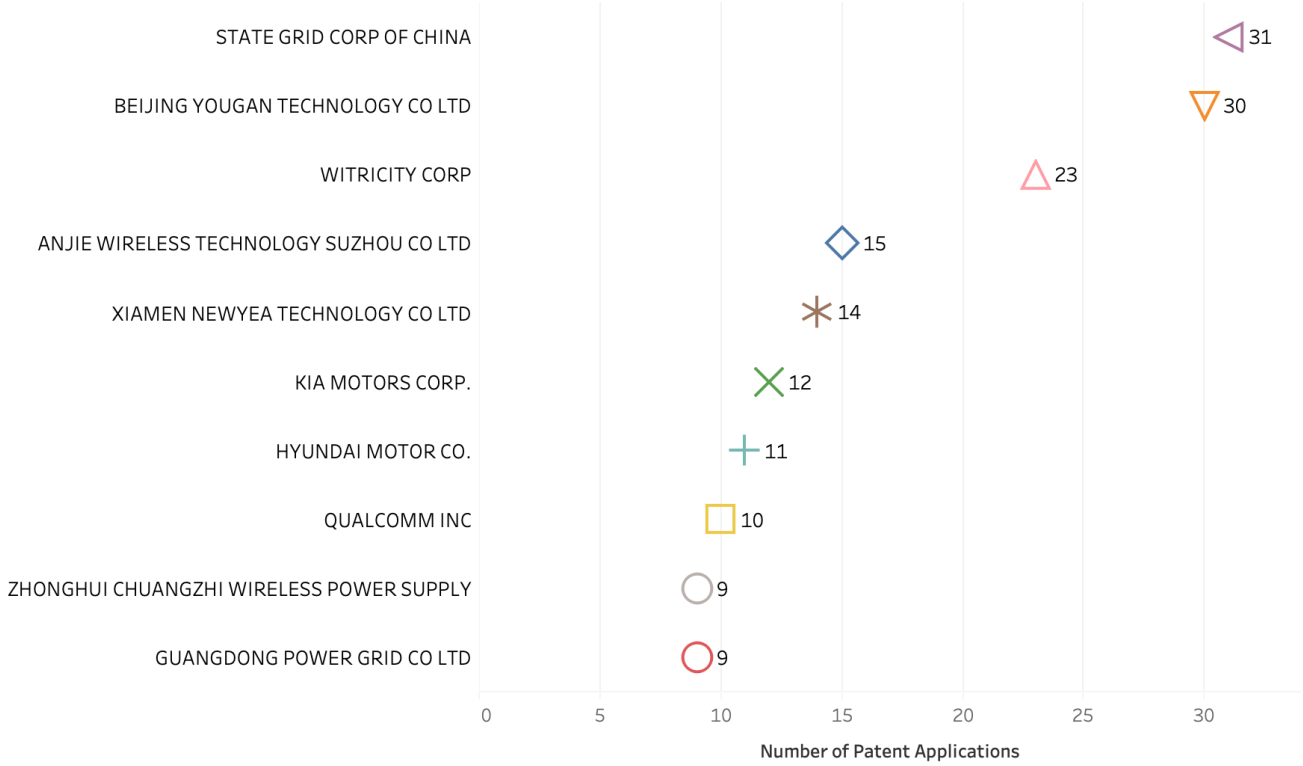
Note 1: The analysis is based on the patent applications published during the years 2019-20.
Note 2: Attributed to non-published patent applications, there may be a higher count in the years 2016-2019.

Since we have considered only those patent applications that were published in year 2019-20, it was found that most of these patent applications have been filed in year 2017-2018. Priority trend reflects a familiar pattern, which implies a high innovation rate in the technology domain. Technology nowadays is innovating at a really high pace and upon crticial analysis of the same, we found that more than 50% of patents in WEVC domain were published in year 2019-20.

5.2 Assignee Based Trend Analysis

5.2.1 Major Assignees – Companies

The below graph represents some major companies in the technology domain.



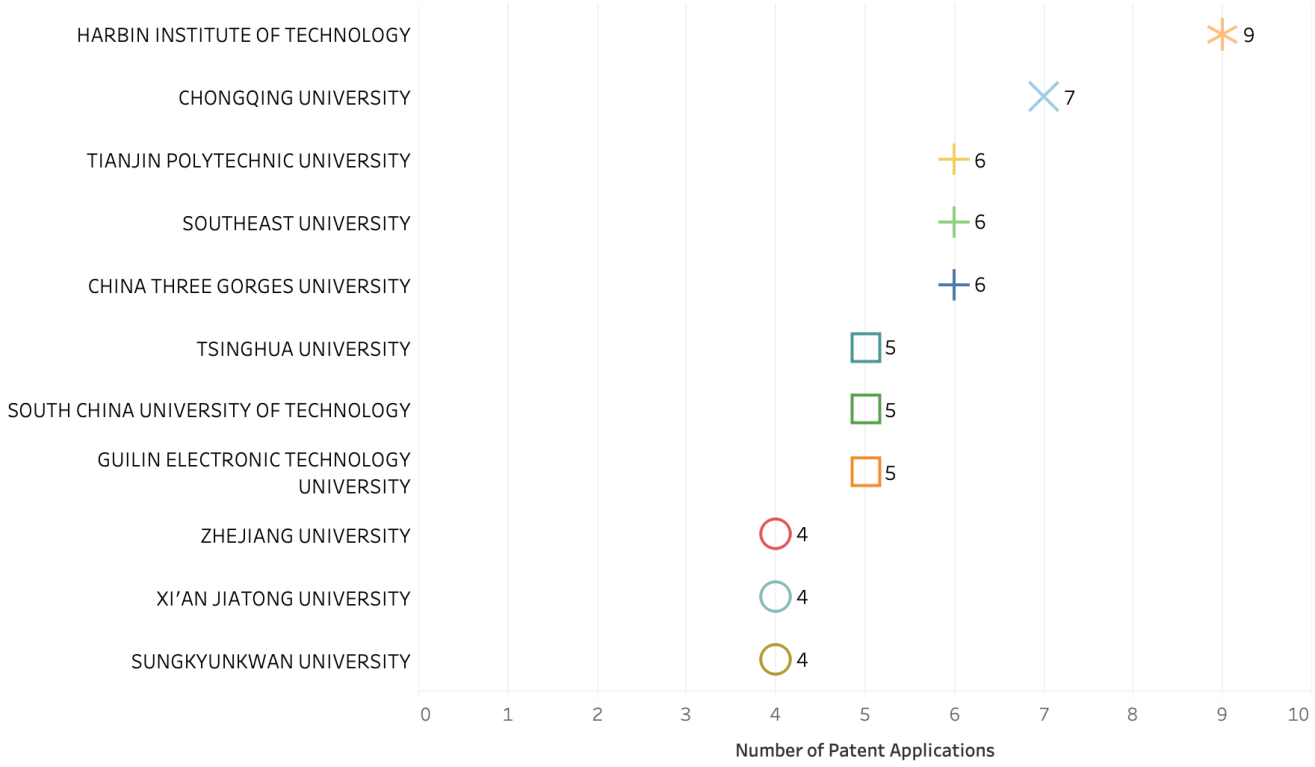
Note 1: The analysis is based on the patent applications published during the years 2019-20.
Note 2: Attributed to non-published patent applications, there may be a higher count in the years 2016-2019.

China's State Grid Corp of China (31 patent families) and Beijing Invispower Technology (30 patent families) are the leading players in the domain followed by WiTricity (23 patent families).

The Chinese central government promotes, development of EV charging networks as a matter of national policy. It sets timelines, milestones and provide provides major funding to research institutes and universities. This has hasresulted ia rise to development of wireless charging technology in China.

WiTricity, the industry pioneer in wireless power transfer (WPT), has acquired Qualcomm Halo, which will result in WITricity bringin more than 1,500 patents and patent applications related to wireless charging that WiTricity will own or control. Thus making Witricity a key player outside China.

5.2.2 Major Assignees – Universities & Research Institutes



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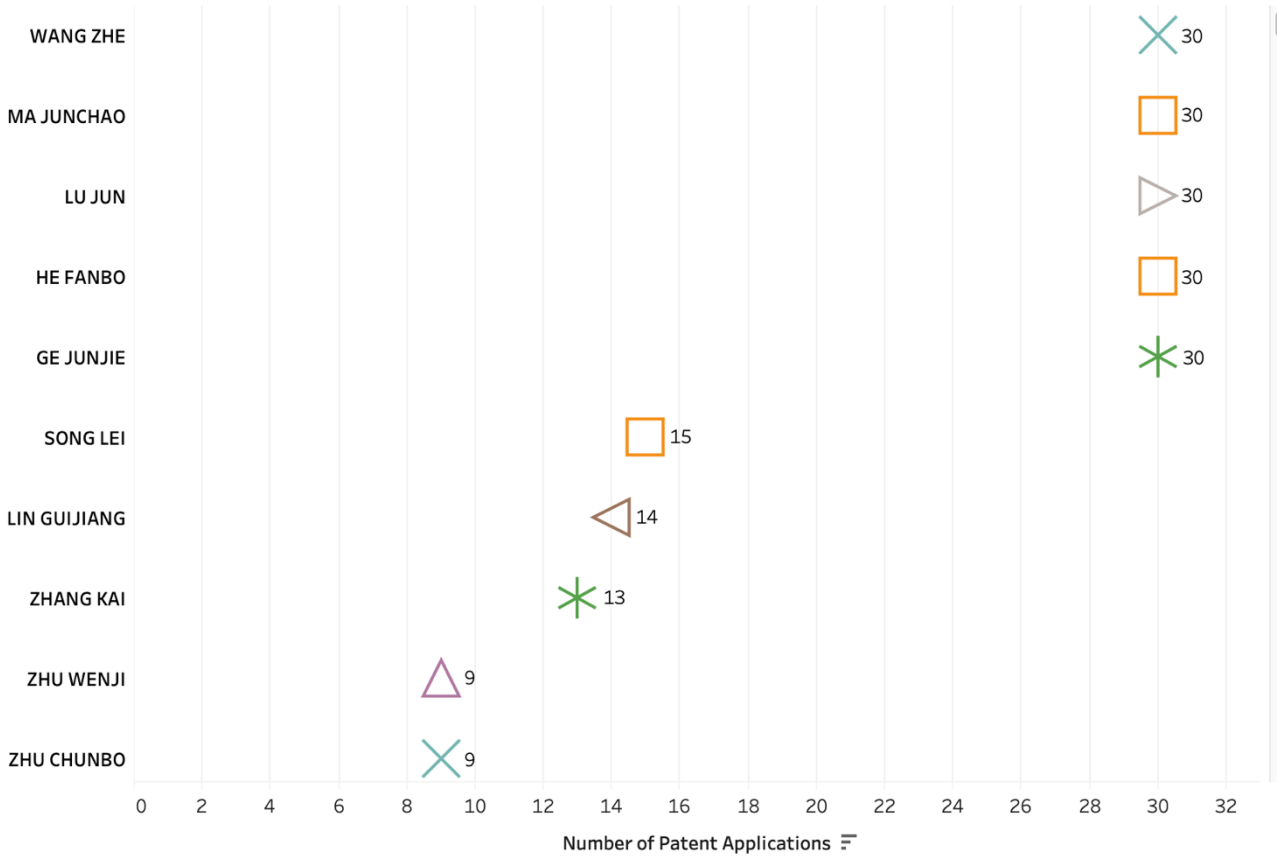
Chinese Institutions are actively supporting Government's ideology of promoting green energy sources. Interestingly, in the last couple of years, Chinese Univertities have predominantly shown interest in acquiring patent rights in WEVC domain.

Harbin Institute of Technology, Chongqing University, Tianjin Polytechnic University, Southeast University and China Three Gorges University are key university/ research institute are key some prominent Chinese academic bodies that have filed patents and published research papers on WEVC domain.

5.3 Key Inventors

The below graph names inventors with most number of innovations on their name.



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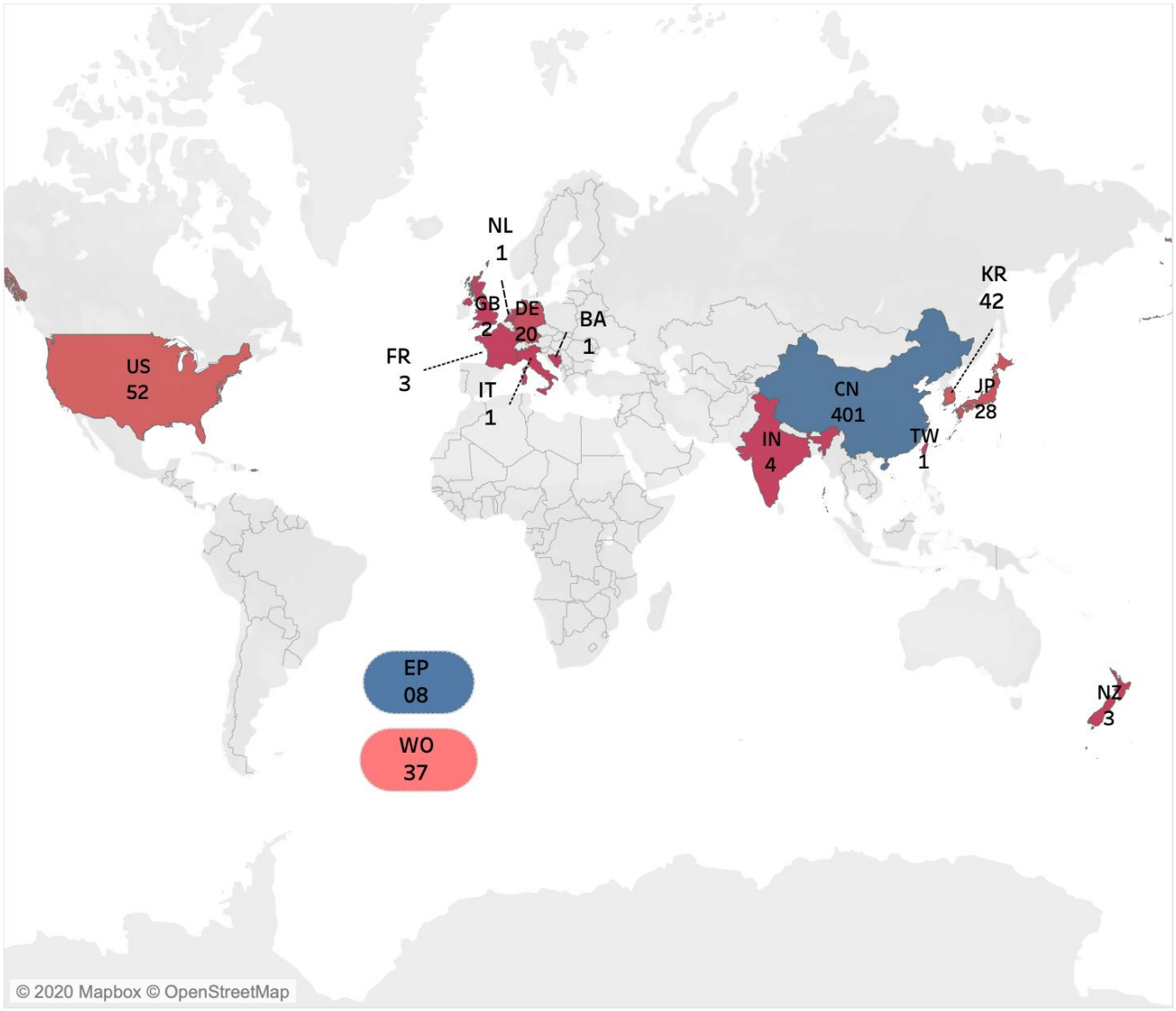
Chinese wireless EV charging start-up namely Invispower Co, founded in 2015 with its R&D team belonging to Tsinghua University, has been accelerating the industrialization of its wireless charging technology for years. In the year 2019-20, Ma Junchao, Lu Jun, He Fanbo and Ge Junjie of Beijing Invispower Technology (China) emerged as the top innovators with more than 100 patents being accredited to their CEO and founder Wang Zhe.

5.4 Geography Based Trend Analysis

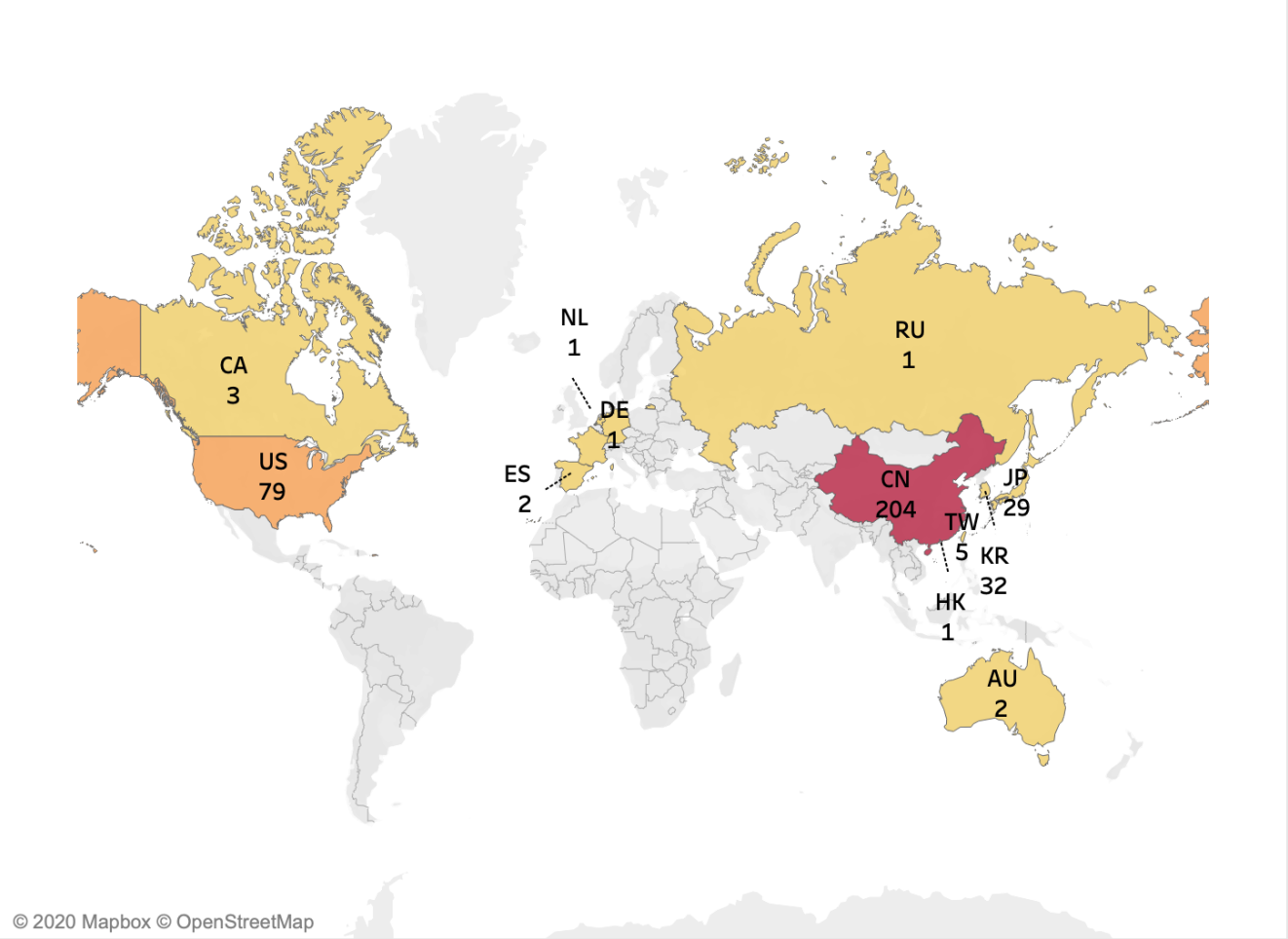
5.4.1 Geographical Distribution of Patent Application Filings



Note 1: The analysis is based on the patent applications published during the years 2019-20.
Note 2: Attributed to non-published patent applications, there may be a higher count in the years 2016-2019.

It is quite fascinating that out of 565 patents published in year 2019-20, China is birthplace of whopping 401 patents, followed by US and Japan. It is primarily due to Government's role and interest in promoting startups and universities enabaling them to explore in Technology in green energy sectors.

5.4.2 Geographical Distribution of Patent Grants

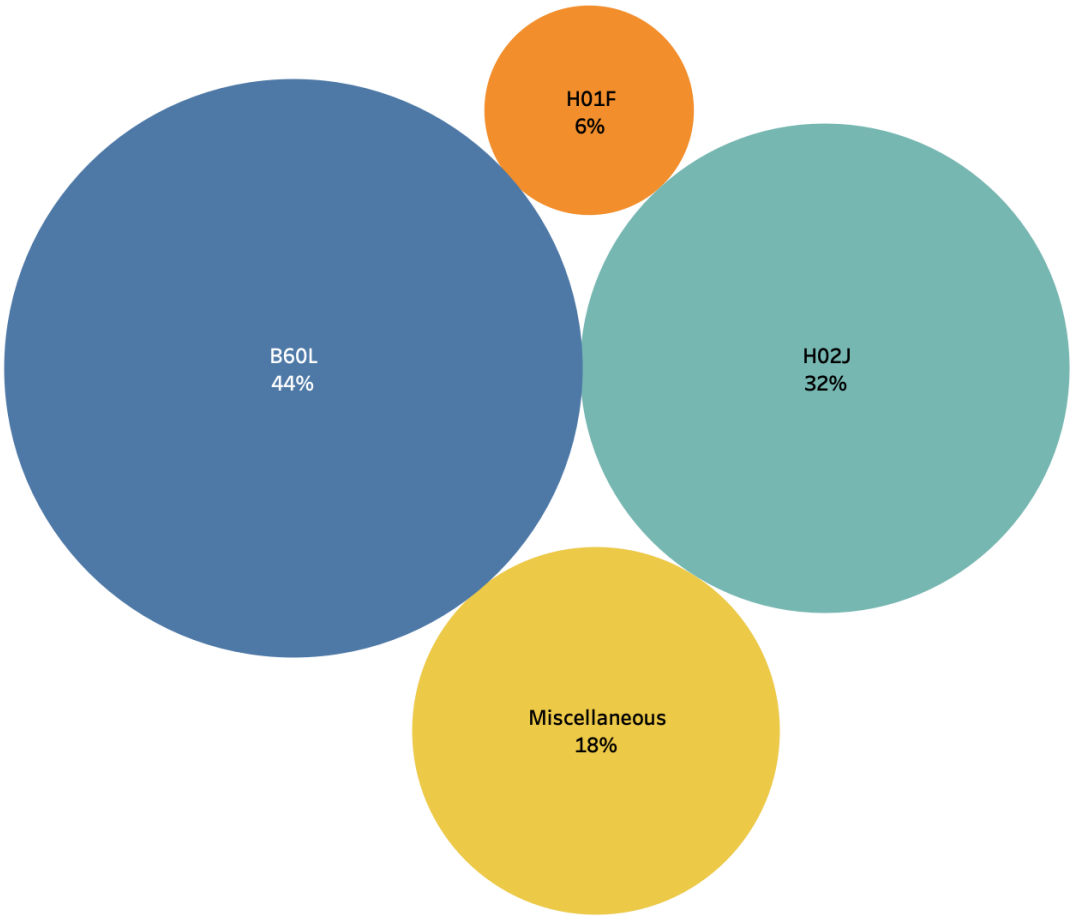


Trend related to geographical distribution of patent grants, demonstrate that the majority of patents originate from China (CN) followed by USA (US) and Korea (KR). Unlike China, where R&D activity is distributed among many small groups and startups; auto giants- Toyota, Nissan and Hyundai hold major chunk of WEVC patents in Japan.

In USA, before 2019, Qualcomm and MIT spinout WiTricity were separately developing WEVC technology. However, they collectively became largest group in the world for WEVC technologyin Feb 2019, when WiTricity, the industry pioneer in wireless power transfer, announced the acquisition of certain technology platform and IP assets from Qualcomm that were related to Qualcomm's own 'Halo Technology'. Now, the two hold a major portion of WEVC US patent portfolio.

5.5 International Patent Classification Based Trend

The below packed bubbles represents frequently assigned international patent classes.



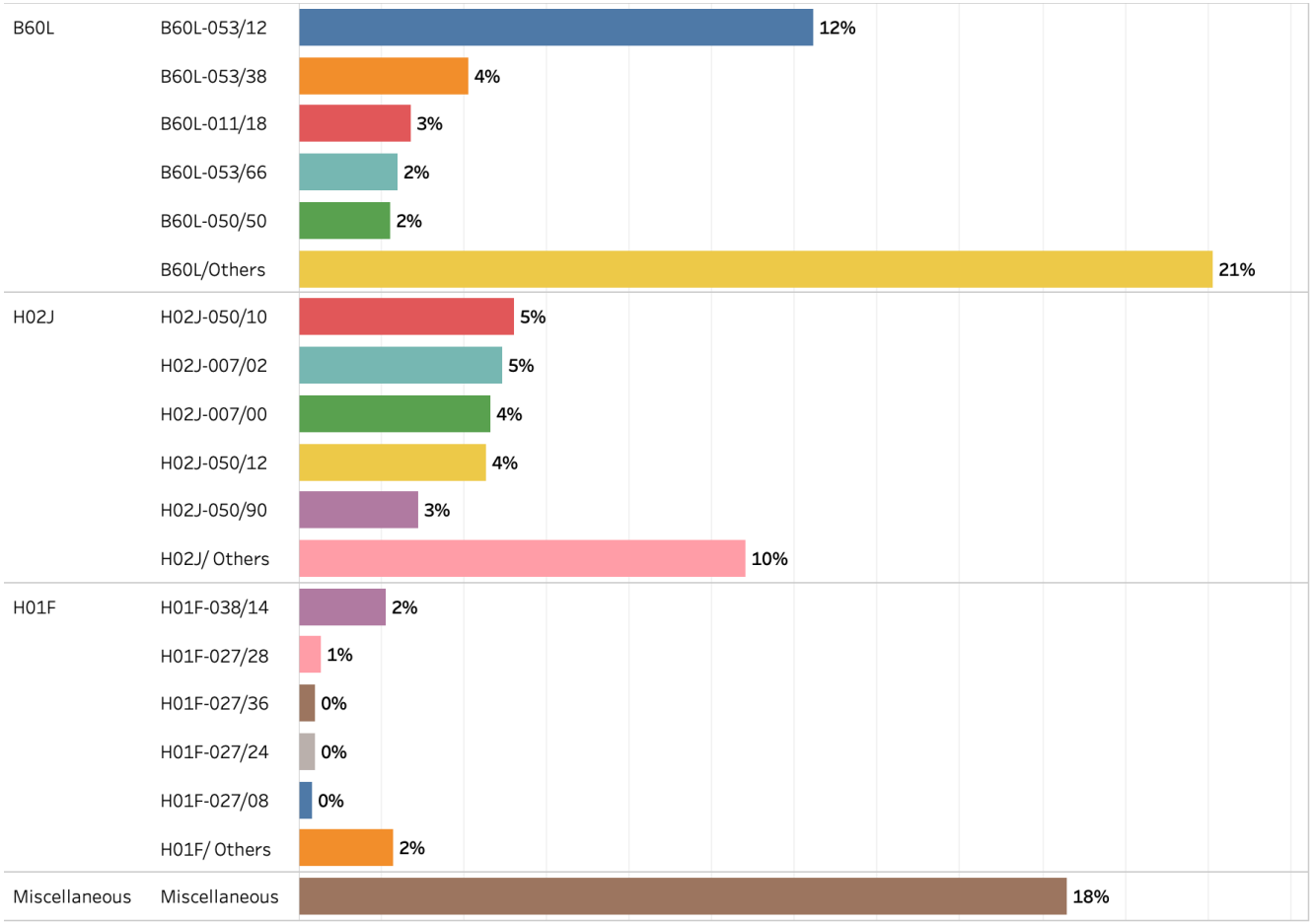
Majority of patent applications were assigned with IPC "B60L" followed by "H02J".

IPC Definitions

IPC	Definition
B60L	Propulsion of electrically-propelled vehicles
H02J	Circuit arrangements or systems for supplying or distributing electric power; systems for storing electric energy
H01F	Magnets; inductances; transformers; selection of materials for their magnetic properties.

5.6 International Patent Sub-Classification Based Trend

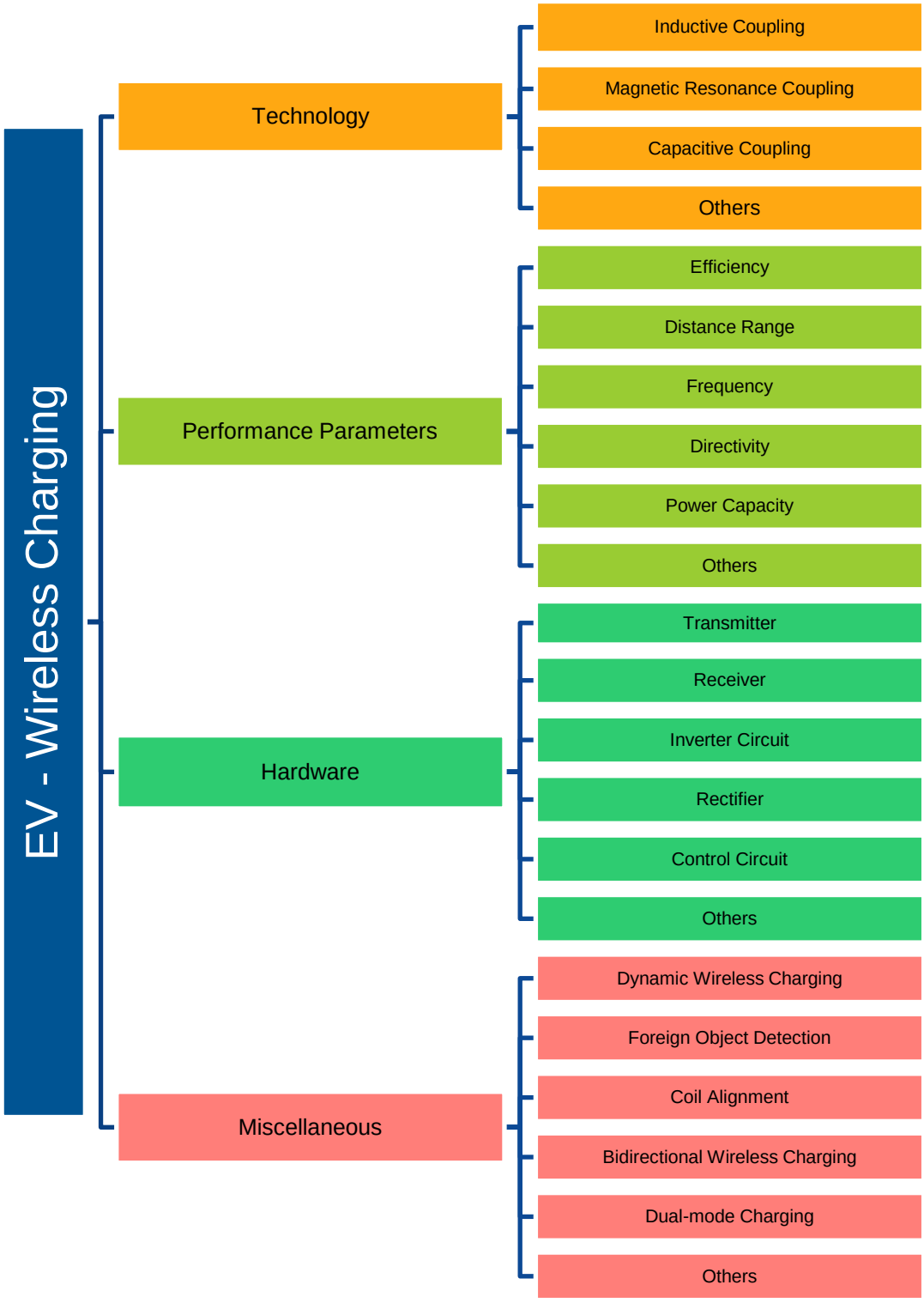
The below graph represents sub-classes pertaining to one of the top/main patent classes.



6. Technical Analysis

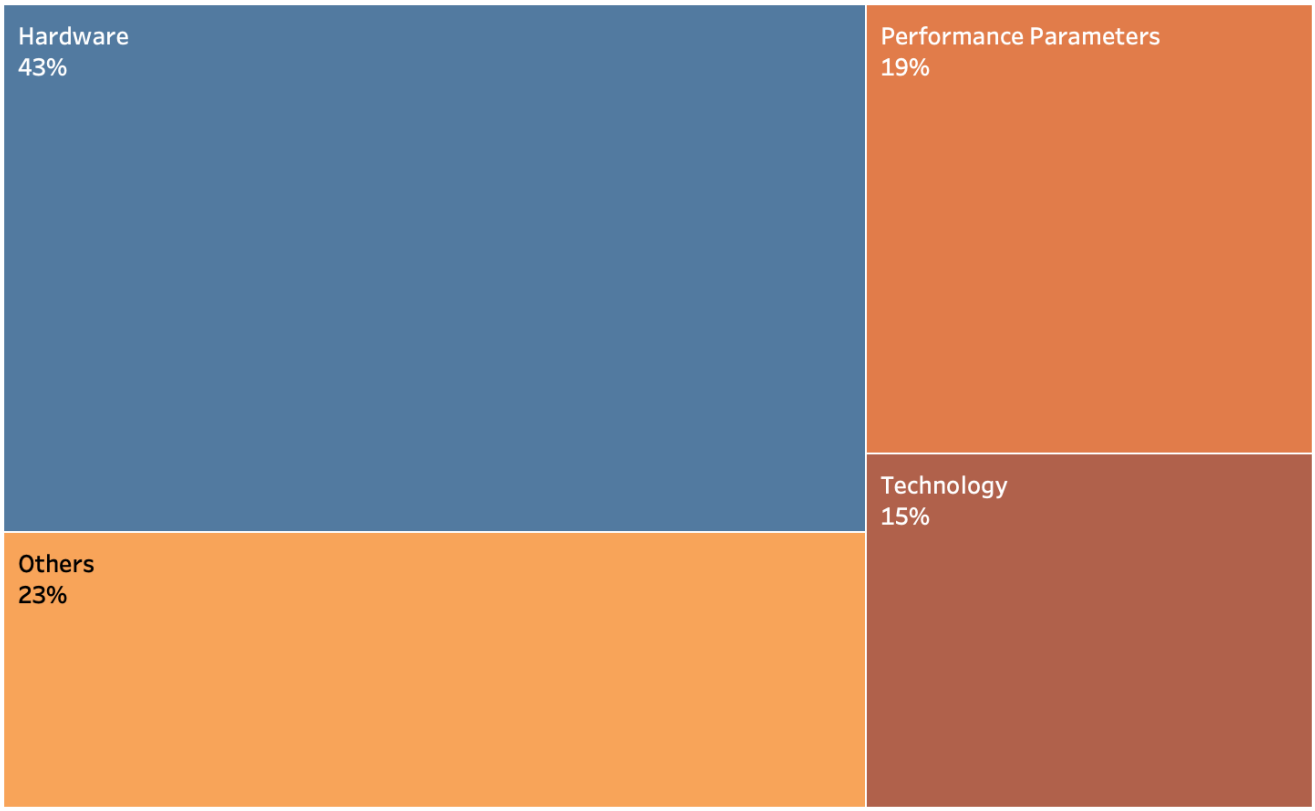
6.1 Taxonomy Developed for Bucketing of Relevant Patent Documents

A set of 565 patent families were analyzed in depth to identify the focus areas of the Patents related to WEVC.



6.2 Distribution of Patents/Applications Pertaining to EV-Wireless Charging

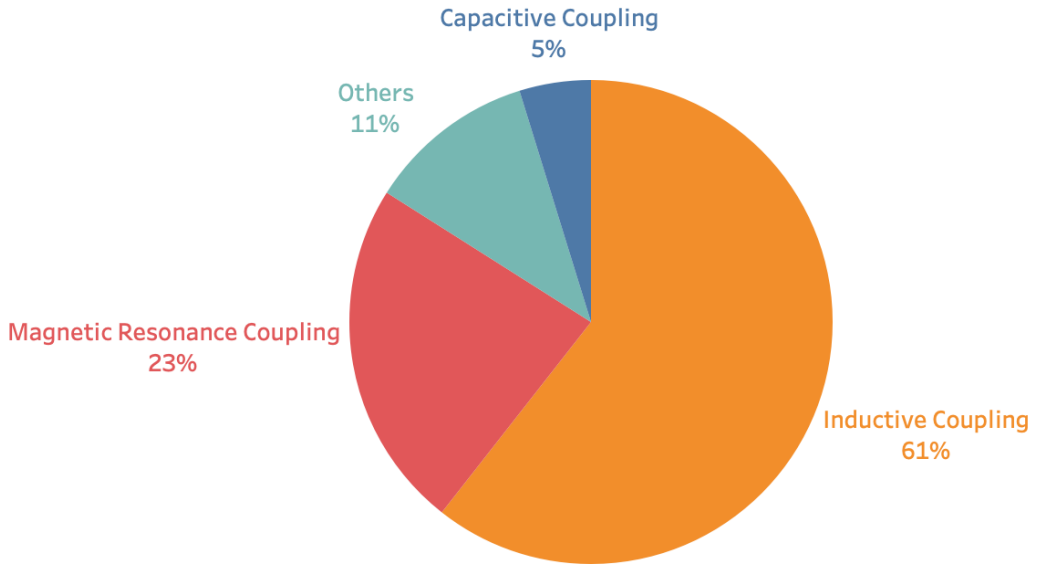
This category summarizes patents/applications pertaining to dissection of EV-Wireless charging technology. Below representation shows the dissection in terms ofHardware, Technology, Performance Parameters and Miscellaneous.



Majority of patents/applications published in 2019-20 relates to Hardware (43%) section of WEVC module, followed by Performance Parameters (19%) and Technology (15%).

6.2.1 Distribution of Patents/Applications Pertaining to 'Technology'

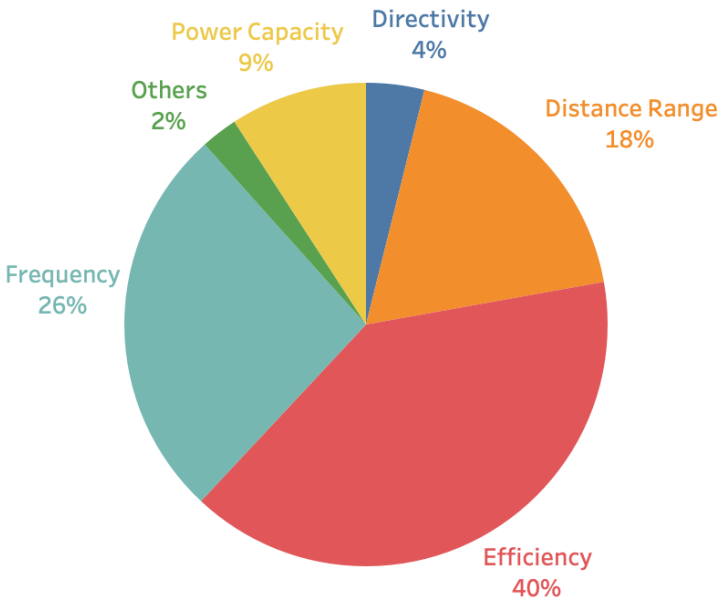
This category deals with patents/applications pertaining to 'Technology'being incorporated in the EV-Wireless Charging. Below representation shows sub-categories, such as, Inductive Coupling, Magnetic Resonance Coupling, Capacitive Coupling and others.



Maximum number of patents/applications published in year 2019-20 relate to Inductive Coupling (61%) followed by Magnetic Resonance Coupling (23%) and Capacitive Coupling (5%). The key benefit of a Inductive wireless charging system is its relatively high efficiency. A carefully designed system can transmit 30 to 60 percent of the power (depending on where the measurement is made) driving the primary coil to the secondary coil.

6.2.2 Distribution of Patents/Applications Pertaining to 'Performance Parameters'

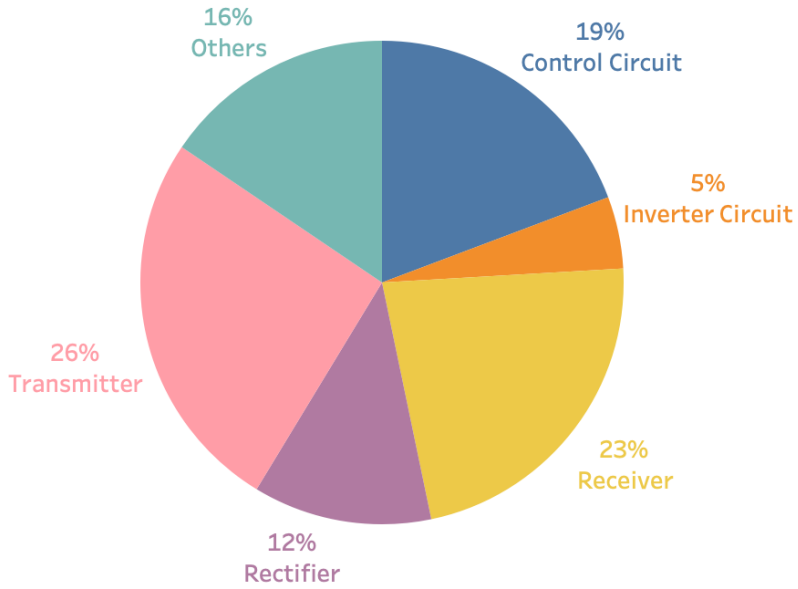
This category deals with patents/applications pertaining to Performance Parameters being incorporated in EV -Wireless Charging Technology. Below representation shows sub-categories such as Efficiency, Frequency, Distance Range, Directivity, Power Capacity and others.



As expected, most of the patents published in 2019-20 relate to improvement in efficiency of WEVC systems. And, a good chunk of patent revolve around inventions relating to frequency considerstions, which indicates that chinese innovators are actively looking forward for alternate frequencies for transmission and to develop a standard technology for the group of users.

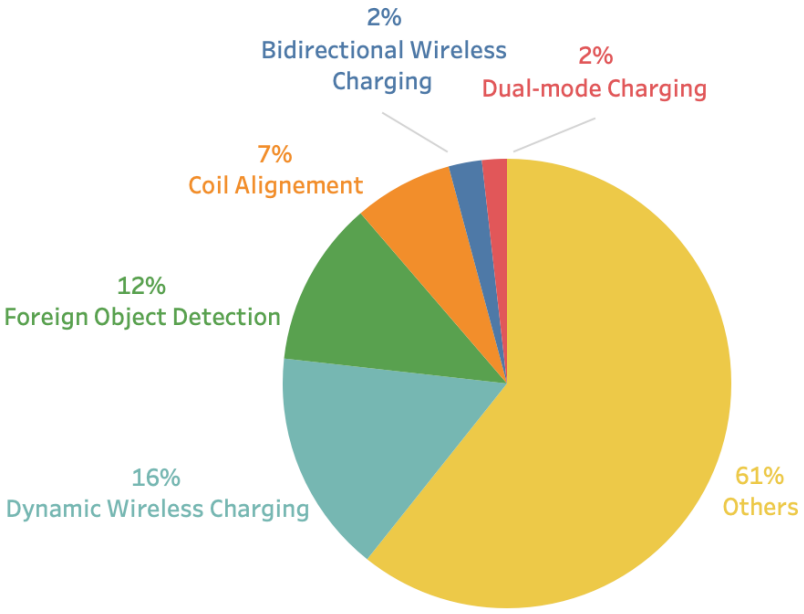
6.2.3 Distributionof Patents/Applications Pertaining to 'Hardware'

This category deals with patents/applications pertaining to 'Hardware' based EV- Wireless Charging Technology. Below representation shows sub-categories of hardware patents namely of Transmitter, Receiver, Control Circuit, Inverter Circuit, Rectifier and Others.



Since WEVC technology is growing at a fast pace, researchers have filed patents related to each aspect of the technology.

6.2.4 Distribution of Patents/Applications Pertaining to 'Miscellaneous'

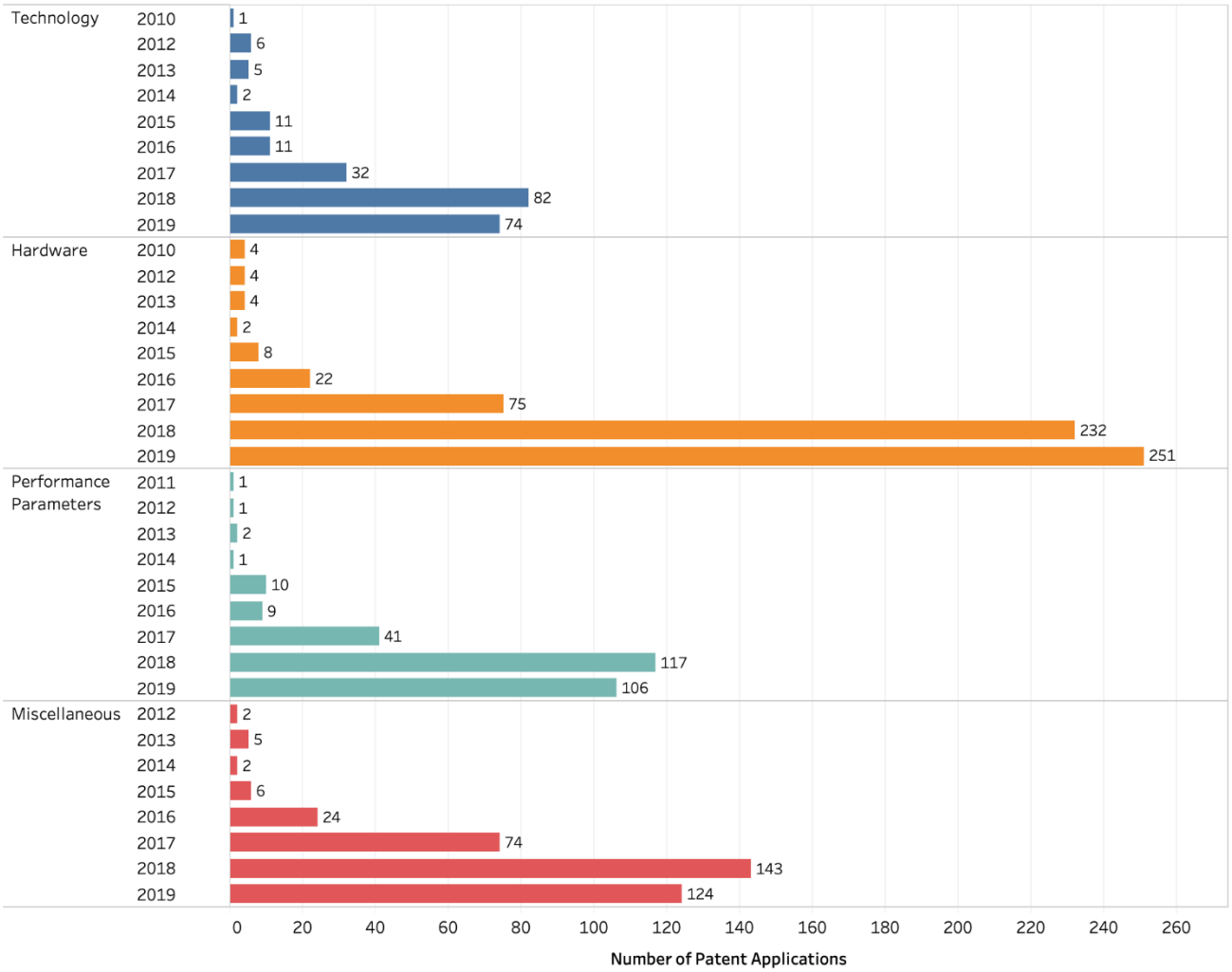


In comparison to other additional improvement in the technology domain, Dynamic Vehicle Charging seems to be the most promising one and the prominent one. In 2018-19, we saw a few Dynamic Vehicle Charging Tests in the European countries, however, nothing substantial culminated out of those tests and it seems as if the EU nations are heavily dependent on Chinese players with respect to Dynamic Vehicle Charging Technology.

Guangdong Power Grid Co Ltd [CN], State Grid Corp of China [CN], Harbin Institute of Technology [CN] and Guilin Electronic Technology University [CN] are few companies that are actively developing Dynamic Wireless Charging Technology.

6.3 Technology Distribution V Filing Date

The below graph demonstrates the technology distribution of patent applications across the years.



6.4 Technology Distribution V Major Assignee (Companies)

The below highlighted tabaular chart demonstrates the technology distribution of patent applications against major assignee companies in the technology domain.

		STATE GRID CORP OF CHINA	BEIJING INVISPOWER TECHNOLOGY CO LTD	WITRICITY	ANJIE WIRELESS TECHNOLOGY SUZHOU CO LTD	XIAMEN NEWYEA TECHNOLOGY CO LTD
Technology	Inductive Coupling	7	8	7	1	1
	Magnetic Resonance Coupling	6	4	2		
	Others	1	2	1		
	Capacitive Coupling	1	1			
Hardware	Transmitter	9	15	4	1	6
	Receiver	8	11	1	1	6
	Control Circuit	6	10	2		4
	Rectifier	9	3			
	Others	1	6		1	2
	Inverter Circuit	3				
Performance Parameters	Frequency	15	3	1	1	
	Efficiency	9	7	1		
	Distance Range	8	4			1
	Power Capacity	3	2	2		
	Directivity	1		1		
	Others			1		
Miscellaneous	Others	16	15	19	12	5
	Foreign Object Detection	1	4	6	1	5
	Dynamic Wireless Charging	4				
	Coil Alignment		4			
	Dual-mode Charging					3
	Bi-directional Wireless Charging	3				

The Major assignees in the EV- Wireless Charging Technology are “State Grid Corp of China” (31 patent families), “Beijing Invispower Technology Co Ltd” (30 patent families), “WiTricity Corp” (23 patent families)”, “Anjie Wireless Technology” (15 patent families), and “Xiamen Newyea Technology” (12 patent families).

6.5 Technology Distribution V Major Assignee (Universities & Research Institutes)

The below highlight tables demonstrate the technology distribution of patent applications against major assignees (universities & research institutes) in the technology domain.

		HARBIN INSTITUTE OF TECHNOLOGY	CHONGQING UNIVERSITY	TIANJIN POLYTECHNIC UNIVERSITY	SOUTHEAST UNIVERSITY	CHINA THREE GORGES UNIVERSITY
Technology	Capacitive Coupling					1
	Inductive Coupling	2		2		3
	Magnetic Resonance Coupling	3	1			
	Others				1	
Hardware	Control Circuit		3	1	1	2
	Others		3		2	4
	Receiver	2	1			5
	Rectifier				1	2
	Transmitter	1	2			5
Performance Parameters	Distance Range		2			
	Efficiency		1	1	1	6
	Frequency	2		1	2	3
	Power Capacity	1			1	1
Miscellaneous	Bidirectional Wireless Charging				2	
	Dynamic Wireless Charging	5	3		1	
	Foreign Object Detection			5		
	Others	2	5			1

"Harbin Institute of Technology" (9 Patent Families,)"Chongqing University" (7 patent families), "Tianjin Polytechnic University" (6 patent families), "Southeast University" (6 patent families) and "China Three Gorges University" (6 patent families) are the major university/ research institute applicants.

6.6 Key Patents

Publication Number	Title	Assignee	Quick Note
CN110116643A	Electric automobile dynamic bidirectional wireless charging system, has emitting device fixed on ground side, receiving device fixed on electric vehicle, first control module connected with power PFC circuit and bidirectional circuit	WENZHOU UNIVERSITY	A dynamic two-way wireless charging system which simultaneously supports the dynamic charging of the electric vehicle and the dynamic feeding function to the power grid, thereby achieving stable operation of the power grid and reducing energy waste.
CN107571753B	Electric bus stop process based dynamic wireless charging automatic alignment system, has vehicle plane movement mechanism for receiving electric signal and driving vehicular wireless charging device to move in movable range	JIANGSU UNIVERSITY	A dynamic wireless charging automatic alignment system.
CN110641296A	Method for dynamic-wireless charging of AGV using mobile intelligent charging robot traffic intersection, involves utilizing server platform internet-of-things or wired internet or 4G/5G of wireless network for data interaction	OPPO ELECTRONICS CORP	A smart traffic intersection with dynamic wireless charging. Adding a wireless charging device to the road at a traffic intersection can solve the problem of charging pure electric vehicles.
CN209381812U	V2X electric automobile dynamic wireless energy bidirectional push system, has vehicle-mounted energy receiving end device located on electric automobile, where energy receiving end device is triggered by trigger signal to supply energy to emitting end device	STATE GRID CORP OF CHINA	An electric vehicle dynamic V2X wireless energy bi-directional push system, solves the interaction problems of energy between the grid and electric vehicles.
US20190255966A1	Charging system of wireless electric vehicle e.g. car, generates magnetic field in response to change in voltage, current, or phase associated with operation of base-side equipment to indicate fault condition at vehicle-side equipment	WITRICITY CORP	Fault detection and monitoring methods for safe operation of a wireless electric vehicle charging (WEVC) system.
CN106787249B	Electric automobile dynamic multi-level wireless charging system, has	WUHAN RESONANCE	An electric vehicle dynamic multi-level wireless charging

	position detecting and processing module connected with head of grading guide rail, and current detecting and processing module located at end of grading guide rail	TECHNOLOGY CO LTD	system.
CN109715434A	Wired and wireless charging apparatus for electric vehicle, has wireless charging unit provided with inverter, and changeover switch connected with vehicle in which charge is wirelessly possible such that wire charge part is operated	HITACHI ZOSEN CORP.	A wired and wireless charging device for an electric vehicle, capable of identifying a charging mode of an electric vehicle.
US20200021144A1	Power transfer device used in wireless power transfer system for charging electric vehicle has at least one auxiliary coil coupled in series with at least one of first coil or second coil to reduce magnetic field emission of charging field	WITRICITY CORP	An apparatus for reducing magnetic field emission from double-D inductive couplers.
CN109774520A	Electric vehicle coil interoperability transmitting end position enhancing type adaptive adjustment method, involves performing adjustment along Y direction, and completing position adjust procedure and starting charging process of system	HARBIN INSTITUTE OF TECHNOLOGY	The electric vehicle wireless charging coil for improving interoperability method.

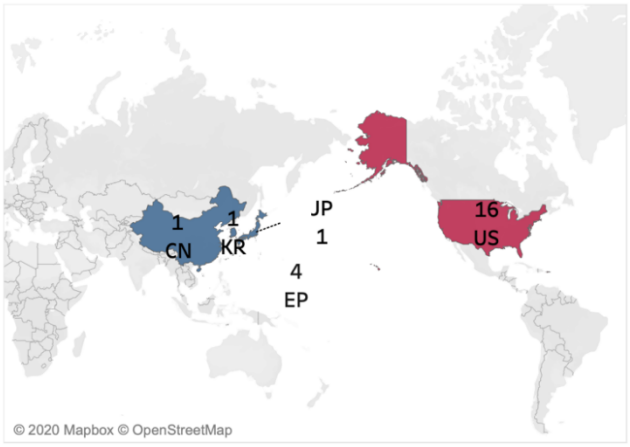
7. Patent Portfolio Analysis

7.1 WiTricity

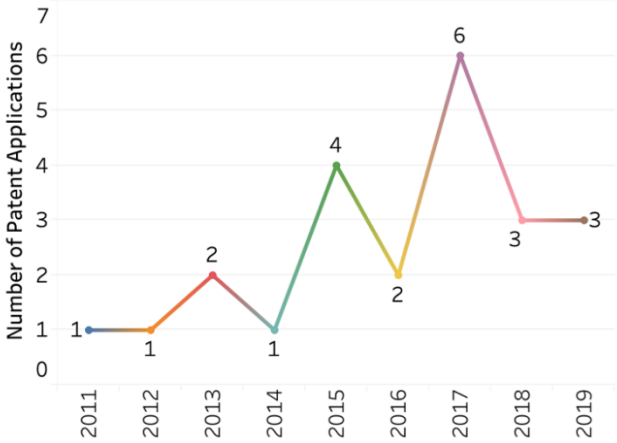
Company Profile:

WiTricity Corporation founded in 2007, commercialized the technology relating to wireless chargingwhose innovation was done by a team of physicists from the Massachusetts Institute of Technology (MIT), led by Professor Marin Soljačić working in collaboration with WiTricity. WiTricity acquired Qualcomm Halo in Feb 2019, which brought more than 1,500 patents and patent applications related to wireless charging under its belt. The patents are now owneds and controled[9] entirely by Witricty.

Geographical Distribution of Patents



Patent Filing Trend



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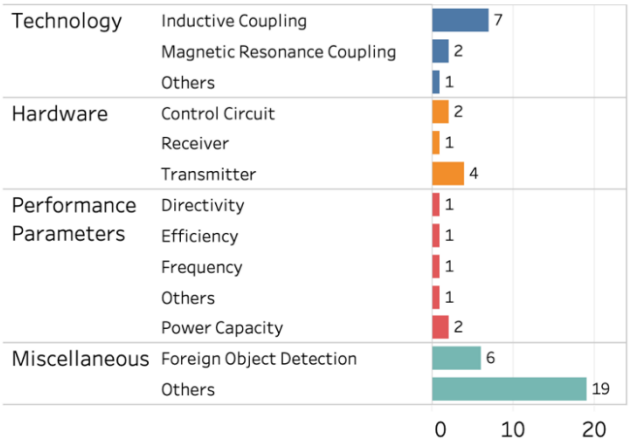
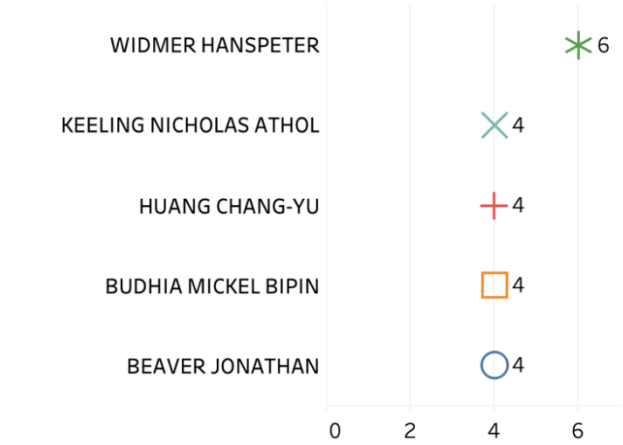


Key Inventors



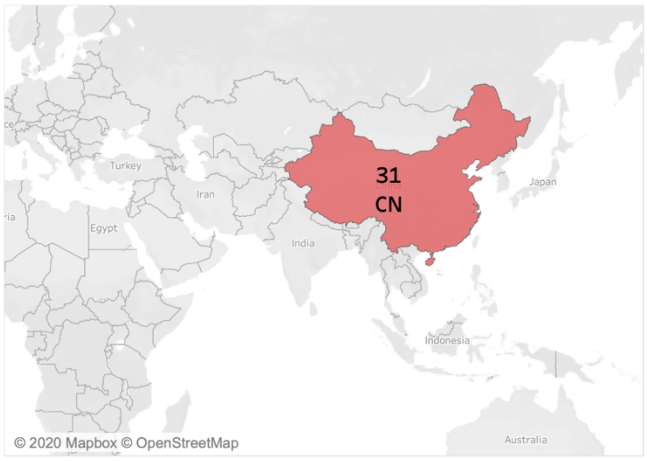
Presently, Witricity is developing technologies related to Inductive Coupling along with other technical aspects like foreign object detection and communication techniques.

7.2 State Grid Corporation of China

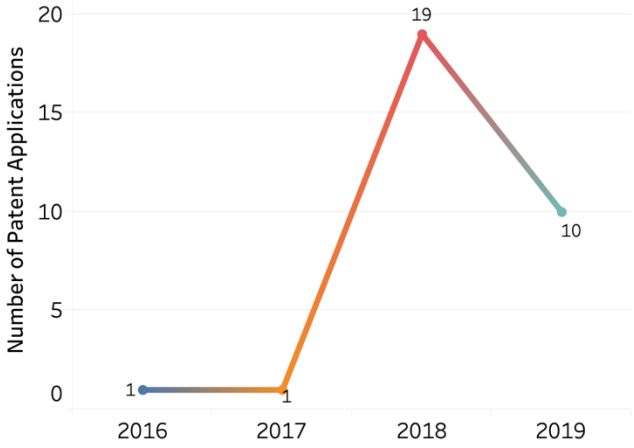
Company Profile:

The State Grid Corporation of China (SGCC), commonly known as the State Grid, is a state-owned electric utility in China. It is the largest utility company in the world, and as of 2019, the world's fifth largest company overall by revenue. In 2016/17 it was reported to having as much as 927,839 employees, 1.1 billion customers and a revenue equivalent to 363.125 billion[10] USD.

Geographical Distribution of Patents



Patent Filing Trend



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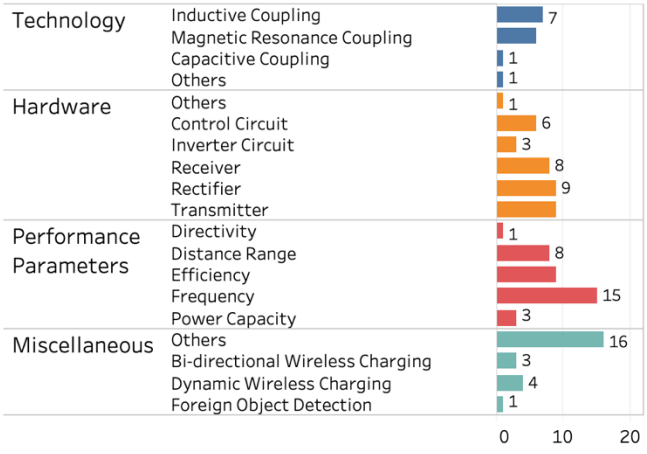
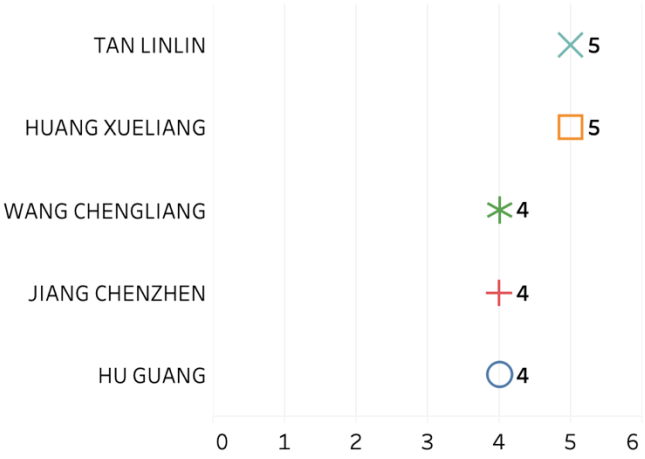


Key Inventors



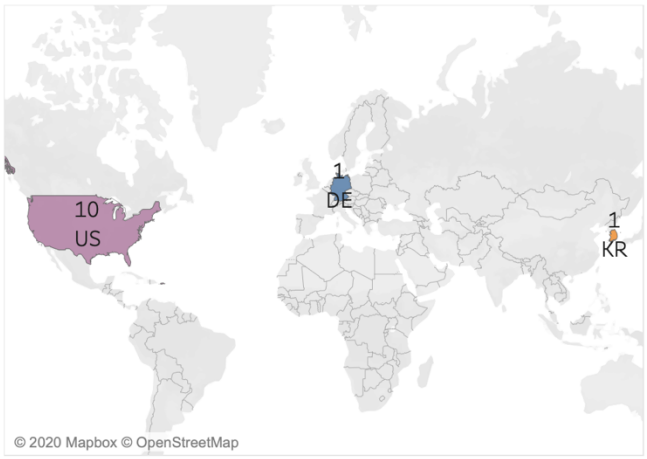
For the last couple of years, state owned body SGCC has focused its research on frequency consideration phenomanaly. The research indicates development of a new technical standard which would eventually result in the technology being adopted by group of companies to facilitate WEVC.

7.3 Kia Motors

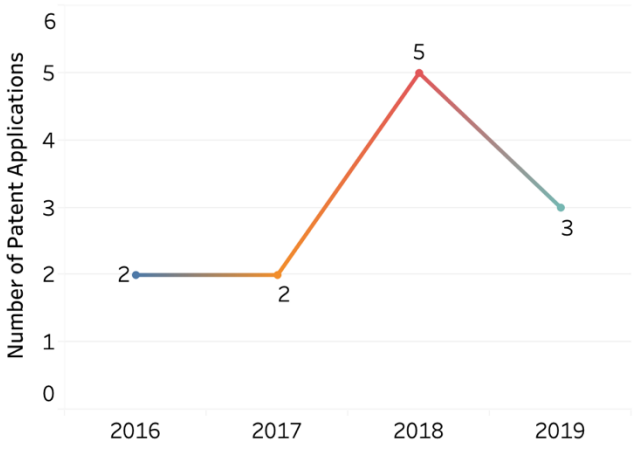
Company Profile:

Kia Motors Corporation, commonly known as Kia Motors is a South Korean multinational automotive manufacturer headquartered in Seoul. It is South Korea's second-largest automobile manufacturer following the Hyundai Motor Company[11].

Geographical Distribution of Patents



Patent Filing Trend



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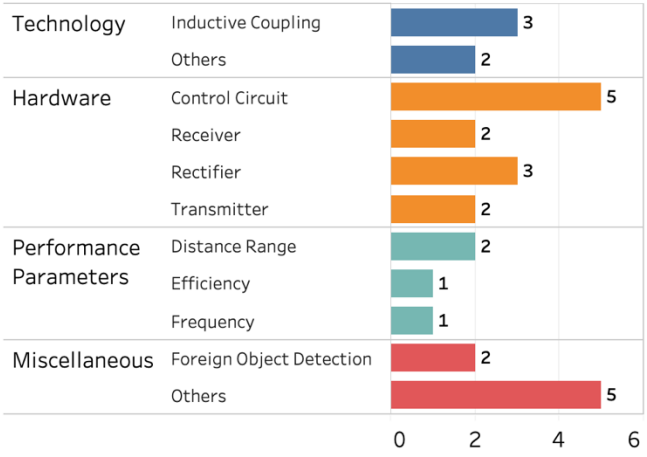
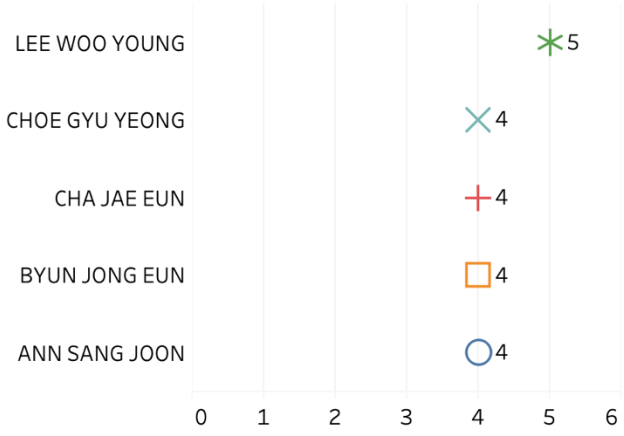


Key Inventors



Kia Motors is actively exploring all areas of WEVC technology.

8. The Future

8.1 Wireless Vehicle to Grid (W-V2G)

Expansion of pure electric vehicles (PEVs) have resulted in a growth of technologies that relates to fast and efficient charging / power transfering methods. With increasing number of PEVs, power requirements from distributor networks has risen rapidly. In order to compensate the power requirements, renewable energy sources (RES) have been introduced to the microgrid but they have limited support facilities.

Industry News

- WiTricity Wireless Charging Featured in Honda's Vehicle-to-Grid Energy Management System
  WiTricity has collaborated with Honda for its bi-directional, wireless Vehicle-to-Grid (V2G) energy management system.

- Qualcomm Halo Wireless charging for electric vehicles
  A Qualcomm Halo (Now Part of WiTricity) WEVC system can also transfer energy from the electric vehicle battery to the electricity grid, in what is known as Vehicle to Grid (V2G) charging.

8.2 Dynamic Wireless Charging

In DWCS, vehicle get charged while in motion. The power transfers over-the-air from a stationary transmitter to a receiver coil in the moving vehicle. Since battery is charged on the run, DWCS improves travelling range and allows user to efficiently use charging time. It also reduces need of large energy storage module hence reducing the weight of vehicle to a greater extent.

Industry News

- Qualcomm Demonstrates Dynamic Electric Vehicle Charging:
  Based on the Qualcomm Halo™ (Now Part of WiTricity) wireless electric vehicle charging technology (WEVC), Qualcomm Technologies designed and built a wireless DEVC system capable of charging an electric vehicle (EV) dynamically at up to 20 kilowatts at highway speeds.

- ElectReon Conducts Successful Electric Truck Wireless Charging Tests
  ElectReon AB has successfully managed to charge a fully electric 40-tonne truck and trailer wirelessly at a test facility near Stockholm. The company says its next step is to charge the truck through dynamic wireless power transfer on a public road at Gotland, Sweden.

9. Take Away's

Scope of Landscape study	Report explores patent landscape of innovations relating to Electric Vehicle Wireless Charging technology published in the year 2019-20
Extracted Patents	A set of 565 patent families (published in the years 2019-20) that bifurcates to a total of 1414 individual patents/applications filed in EV – Wireless Charging domain were analyzed.
Patenting Trend	As inferred from the analyzed dataset, there is a rise in patent filing activities in EV– Wireless Charging domain. 2018 has witnessed maximum number of patent application filings.
Birthplace of technologies	WEVC technology is dominated by Chinese Groups, making up more than 70% of the total families published in year 2019-20.
Key Players	Globally, top players within this technology are State Grid Corp of China with 31 patent families, followed by Beijing Yougan Technology Co Ltd (30 patent families). Other applicants that have significant numbers of patent application are WiTricity, Anjie Wireless Technology Suzhou Co Ltd, Xiamen Newyea Technology Co Ltd, and Kia Motors Corp.
Top Innovators	In 2019-20, Wang Zhe, Ma Junchao, Lu Jun, He Fanbo, Ge Junjie are leading innovators in EV – Wireless Charging domain. Song Lei, Lin Guijiang, Zhang Kai, Zhu Wenji, and Zhu Chunbo also have significant contributions.
Highlighted Technologies	Patent publications particularly focus on Transmitter (166), Receiver (146), Inductive Coupling (140), Control Circuit (124), Efficiency (113), Rectifier (77), Frequency (75), Magnetic Resonance Coupling (54), Dynamic Wireless Charging (54), Distance Range (52), Foreign Object Detection (40), Inverter Circuit (31), Power Capacity (26), Coil Alignement (24), Capacitive Coupling (11), Directivity (11), Bidirectional Wireless Charging (8), Dual-mode Charging (6), and Miscellaneous (337).
Future of the technology	Based on available patent data, significant growth and further IP certainty in EV – Wireless Charging is expected in coming years. Further monitoring of the patent landscape will allow the field to be fully appreciated.

Appendix- B

Taxonomy Definitions:

Taxonomy	Definition
Inductive Coupling	Inductive coupling uses magnetic fields that are a natural part of currents movement through wire. Any time electrical current moves through a wire, it creates a circular magnetic field around the wire. Bending the wire into a coil amplifies the magnetic field.
Magnetic Resonance Coupling	Magnetic resonance coupling technique is a near-field magnetic inductive coupling methods considering the same resonance frequency at both transmitter and receiver which then known as the mid-range MRC.
Capacitive Coupling	Capacitive coupling is the transfer of energy within an electrical network or between distant networks by means of displacement current between circuit(s) nodes, induced by the electric field. This coupling can have an intentional or accidental effect.
Efficiency	It is simply the ratio of power received by the receivers to the power transmitted by the transmitter.
Distance Range	Distance range refers to that performance parameter that denotes the range, that is, the distance up to which transmission of power can be achieved effectively.
Frequency	This parameter mostly refers to power transmission technique that involves resonance and electromagnetic radiation. For example in the case of microwave power transmitter frequency becomes the primary decisive factor that determines the power transmission range.
Directivity	Directivity refers to directional power transmission that is employed in far field power transmission. It is a parameter of performance for wireless power transmitters.
Power Capacity	The power capacity is the maximum power that can be effectively transmitted by a wireless power transmitter.
Transmitter	A circuit that accepts signals in form of electric current and translates them into a magnetic field or an electric field or a radio wave that can be sent across a medium.
Receiver	Circuits that receive transmitted signals from a transmitter and convert it into a usable form of electric power.
Inverter Circuit	Inverter, is a power electronic device or circuitry that changes direct current (DC) to alternating current (AC)
Rectifier	A rectifier is an electrical device that converts alternating current, which periodically reverses direction, to the direct current, which flows in only one direction.
Control Circuit	A type of circuit that uses the control devices to determine when loads are

	energized or de-energized by controlling current flow to the transmitters from the receivers.
DynamicWireless Charging	Dynamic Charging refers to inductive charging of electric vehicles at high power levels enabling charging of electric vehicles while in motion.
Foreign Object Detection	Method for detecting object in wireless charging area of electric vehicle.
Coil Alignment	Electric vehicle wireless charging system in a coil-aligning structure.
Bidirectional Wireless Charging	A Bidirectional IPT(Inductively Coupled Power Transfer) system which is appropriate for Vehicle to Grid (V2G) systems.
Dual-mode Charging	Integrated wire/wireless dual-mode electric vehicle charging system

Appendix- C

References & Credits:

[1] Definition - What does Wireless Charging mean?
[2] Wireless Charging Market Outlook - 2025
[3] Qi Wireless Charging Standard
[4] Inductive Charging
[5] Wireless Electric Vehicle Charging System (WEVCS)
[6] Wireless Charging: The Future of Electric Vehicles
[7] Review of static and dynamic wireless electric vehicle charging system
[8] Icons Courtesy: Flat Icon

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