SAMPLE LANDSCAPE STUDY

WIRELESS ELECTRIC VEHICLE CHARGING

APR, 2020

IIPRD

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1. WIRELESS CHARGING

WHAT IS WIRELESS CHARGING?

"Wireless charging" is the process of electrically charging battery-powered devices and equipment without the need for a wired electrical power connection. It enables the wireless transfer of electrical charge from a charging device or node to the recipient device. Wireless charging can be of different types:

Inductive Charging

- Uses EM waves to transfer energy and charge devices wirelessly. Inductive charging requires the device to be placed on a conductive charging pad/ equipment, which is directly connected to a wall socket. It is mainly used to charge small hand-held devices such as, smartphones, PDAs and mobile phones.

Radio Charging

- Similar to inductive charging, radio charging use wireless radio waves to transfer energy to small devices and equipment. The device is placed on a radio wave emitting transmitter that transmits radio waves to charge the device.

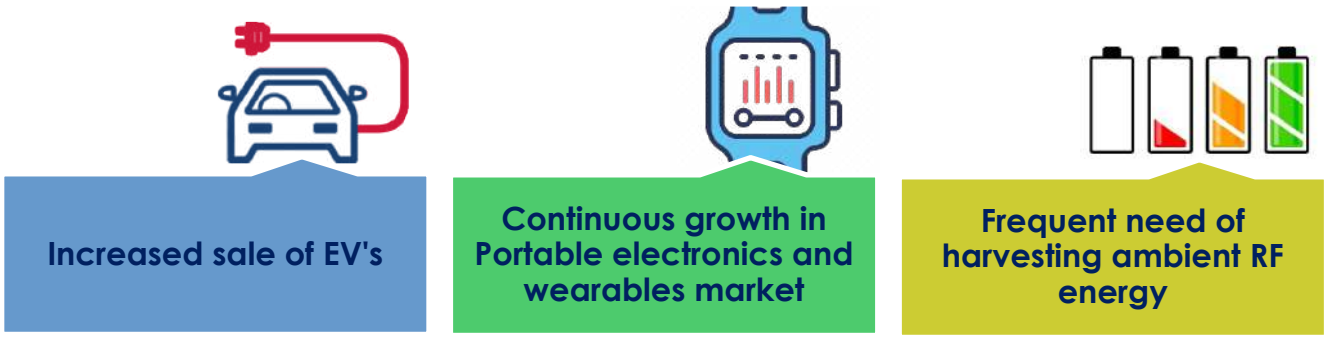
Resonance Charging

- Used for charging large devices and equipment such as laptops, robots, cars and more. It consists of a sending (sender) copper coil and a receiving (receiver) copper coil at the device end. The sender and receiver must configure the same electronic magnetic frequency to transfer electrical energy.

MARKET GROWTH

The 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, a key requirement for wireless charging, it was necessary to develop a standard that could be adopted by the major manufacturers. Standards refer to the different set of operating systems with which devices are compatible[3][4].

Small Personal Electronics - Wireless Charging Standards

There are two main standards: Qi and PMA. Both operate in a similar fashion but are using different transmission frequencies and connection protocols. Consequently, devices compatible with one standard are not necessarily compatible with the other standard. However, there are devices compatible with both 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, which is placed on top of the pad, charging via resonant inductive coupling. Mobile device manufacturers that are working with this standard include Apple, Asus, Google, HTC, Huawei, LG Electronics, Motorola Mobility, Nokia, Samsung, BlackBerry, Xiaomi, and Sony.

AirFuel Alliance:

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

EV- Wireless Charging Standards

Wireless charging helps EV's to charge without any need of plug in. In order to make wireless EV charging more effective and user friendly several international organizations like International Electro Technical Commission (IEC), the Society of Automotive Engineers (SAE), Underwriters Laboratories (UL), Institute of Electrical and Electronics Engineers (IEEE) are working on this standard, among other standards.

SAE J2954 defines WPT for Light-Duty Plug-In EVs and Alignment Methodology. According to this standard, level 1 offers maximum input power of 3.7 KW, level 2 offers 7.7 KW, level 3 offers 11 KW and level 4 offers 22 KW. The minimum target efficiency must be greater than 85% when aligned. Allowable ground clearance should be upto 10 inches and side to side tolerance is upto 4 inches. The most preferable alignment method is magnetic triangulation that assists to stay within charge range in manual parking and assists to find parking spots for autonomous vehicles.

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

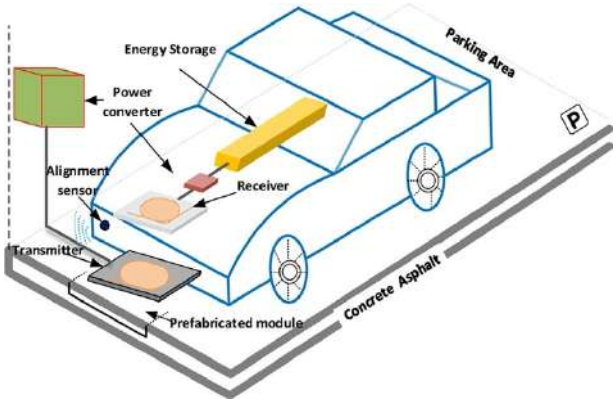
How it works: Instead of using a plug-in cable to charge the Electric Vehicle (EV), Wireless Electric Vehicle Charging (WEVC) technology uses the principle of magnetic induction to wirelessly charge the vehicle's battery. Power is transferred between a Base Charging Unit (BCU) installed either on or below the paved surface of the charging bay and a Vehicle Charging Unit (VCU) which is fitted to the underside of the vehicle. A magnetic "Flux Pipe" couples power between the 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 for EV can be distinguished into two categories: [5][7]

1. Static Wireless Charging
2. Dynamic Wireless Charging

Static Wireless Charging

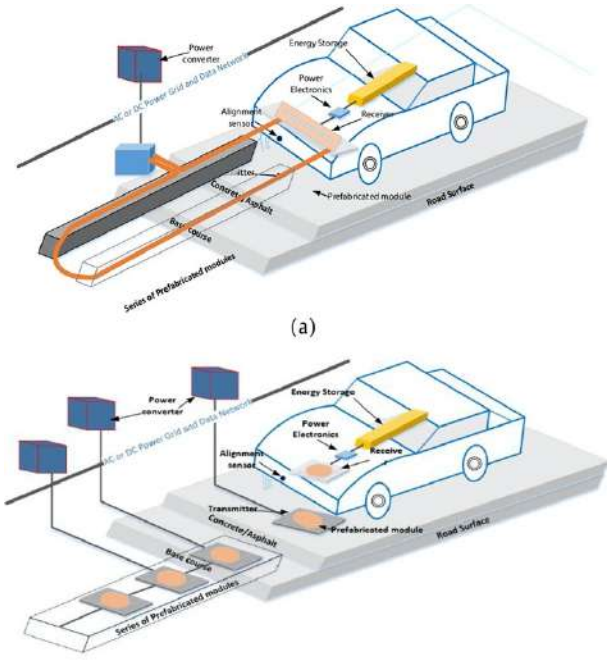
As the name indicates, the vehicle gets charged when it remains static. One can simply park the EV at the parking spot or in garage which is incorporated with wireless charging system (WCS). Transmitter is fitted underneath the ground and receiver is arranged in vehicle's underneath. To charge the vehicle, align the transmitter and receiver and leave it for charging. The charging time depends on the AC supply power level, distance between the transmitter & receiver and their pad sizes.



Static wireless electric vehicle charging system.

Dynamic Wireless Charging System (DWCS):

As the name indicates, vehicle get charged while its in motion. The power transfers over the air from a stationary transmitter to the receiver coil in a moving vehicle.



Dynamic wireless electric vehicle charging system.

By using DWCS EV's travelling range could be improved with the continuous charging of its battery while driving on roadways and highways. It reduces the need for large energy storage which further reduce the weight of the vehicle.

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 brief overview of innovation trend in Wireless Charging domain.
- To provide patenting trend in the Wireless Charging and more specifically, WEVC domain.
- To understand and evaluate geographywise / technologywise bifurcation of patented technology in WEVC domain.
- To study top players and their valuable technologies in the WEVC domain.

3. SEARCH METHODOLOGY

Understanding	Data Collation	Patent Categorization	Technology Landscapping
Define scope of the project Identify technology sub domains within technology space and prepare taxonomy	Collate relevant data (Keywords/ classes/ Assignee etc.) for patent search Brainstorm and develop search logics and correponding search strings Extract list of patents pertaining to technology space	Review extracted patents and mark them as RELEVANT or NOT RELEVANT patents If RELEVANT, categorize them under technology subnode	Use categorized sheet containing patent relevant to scope of project and prepare graphical respresentation of technology and bibliographical data. Draw insights from categorized patent data

4. SUMMARY

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

A set of 565 patent families (published in the years 2019-20) that bifurcates to a total of 1414 individual patents/applications filed in the EV – Wireless Charging domain were analyzed.

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 50% each year. The year 2018 has witnessed maximum number of patent application filings.

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

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

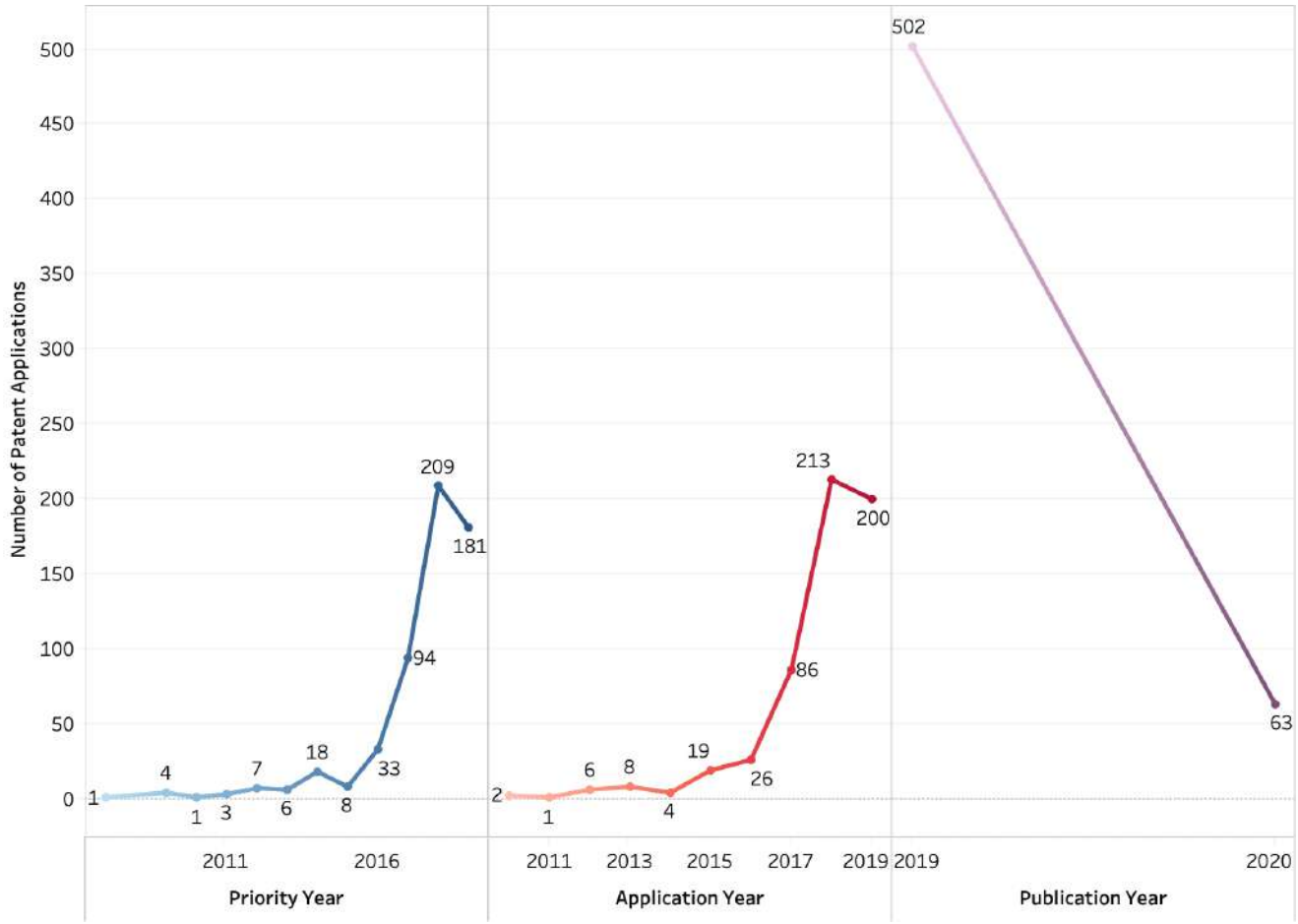
Wang Zhe, Ma Junchao, Lu Jun, He Fanbo, Ge Junjie; each with 30 patent are leading researchers in WEVC domain.

5. NON-TECHNICAL ANALYSIS

5.1 PRIORITY, FILING, PUBLICATION YEAR BASED TREND ANALYSIS

5.1.1 ANALYSIS BASED ON REPRESENTATIVE MEMBER PER INPADOC FAMILY

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



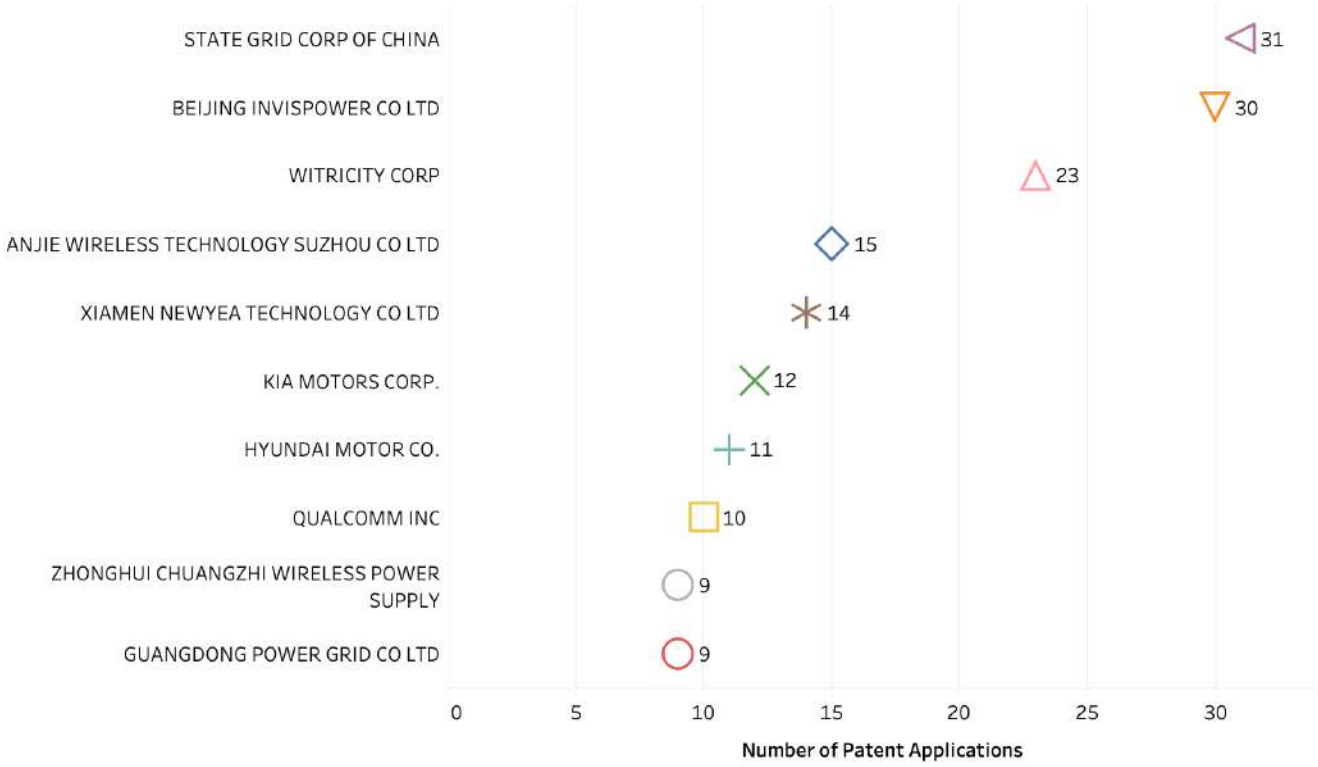
Note 1: The analysis is based on the patent applications published during the years 2019-20.
Note 2: Attributed to non-published patent applications, there may be a higher count in the years 2016-2019.

- Since we have considered only those patent applications published that were published in year 2019-20, we observed that most of patent applications were filed in year 2017-2018.
- However, the priority trend also shows similar pattern. Most of the publications claim priority from documents filed in year 2017 and 2018 suggesting high innovation rate during these years in this technology domain. The technological innovation is at really high pace in this domain and upon further analysis we found that around 50% of the patents in WEVC were published in year 2019-20.

5.2 ASSIGNEE BASED TREND ANALYSIS

5.2.1 MAJOR ASSIGNEES – COMPANIES (BASED ON REPRESENTATIVE MEMBER PER FAMILY)

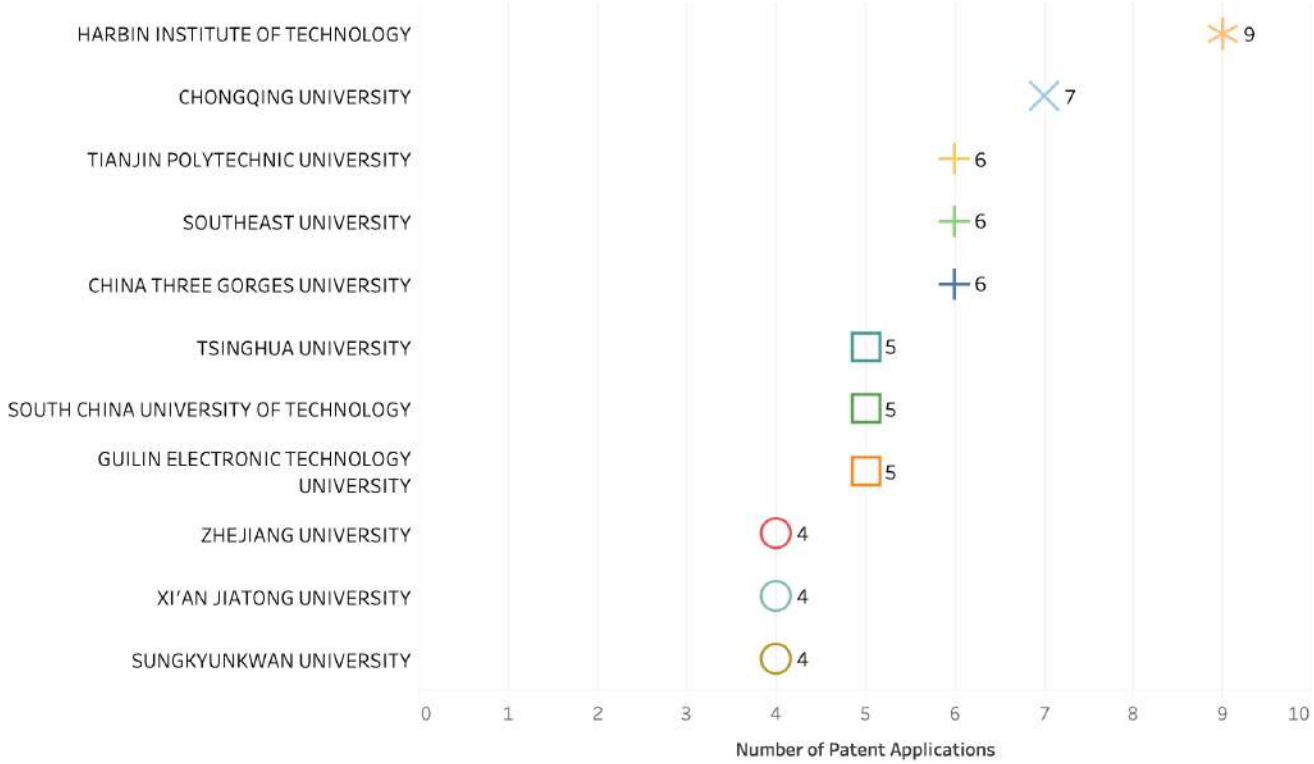
The below graph represents major assignees in the domain.



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 the development of EV charging networks as a matter of national policy. It sets targets, provides funding and mandates standards which has given rise to development of wireless charging technology in China
- WiTricity, the industry pioneer in Wireless Power Transfer (WPT), has acquired Qualcomm Halo, which will bring more than 1,500 patents and patent applications related to wireless charging that WiTricity will own or control.

5.2.2 MAJOR ASSIGNEES – UNIVERSITIES & RESEARCH INSTITUTES (BASED ON REPRESENTATIVE MEMBER PER FAMILY)

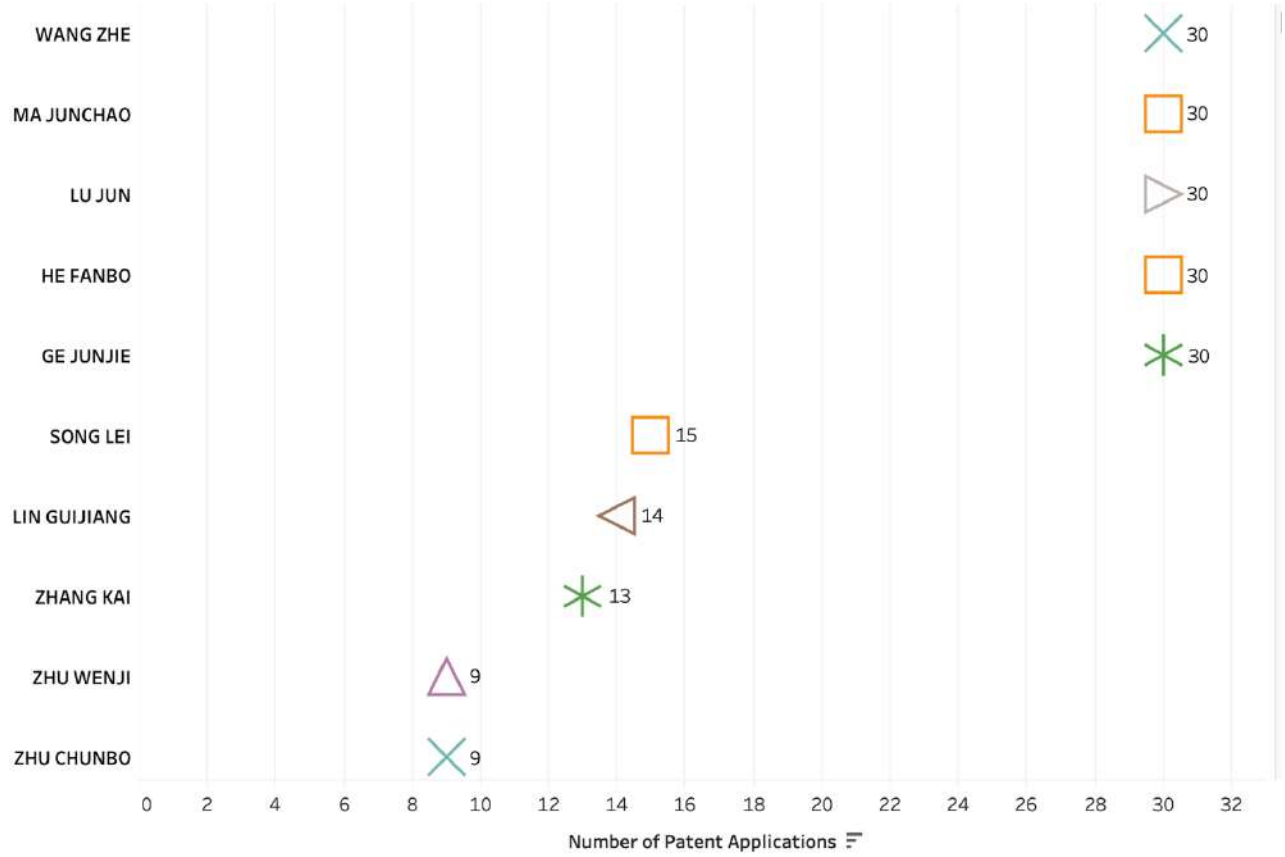


Note 1: The analysis is based on the patent applications published during the years 2019-20.
Note 2: Attributed to non-published patent applications, there may be a higher count in the years 2016-2019.

- As evident from the chart herein above,"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 key University/ Research Institute applicants

5.3 KEY INVENTORS

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

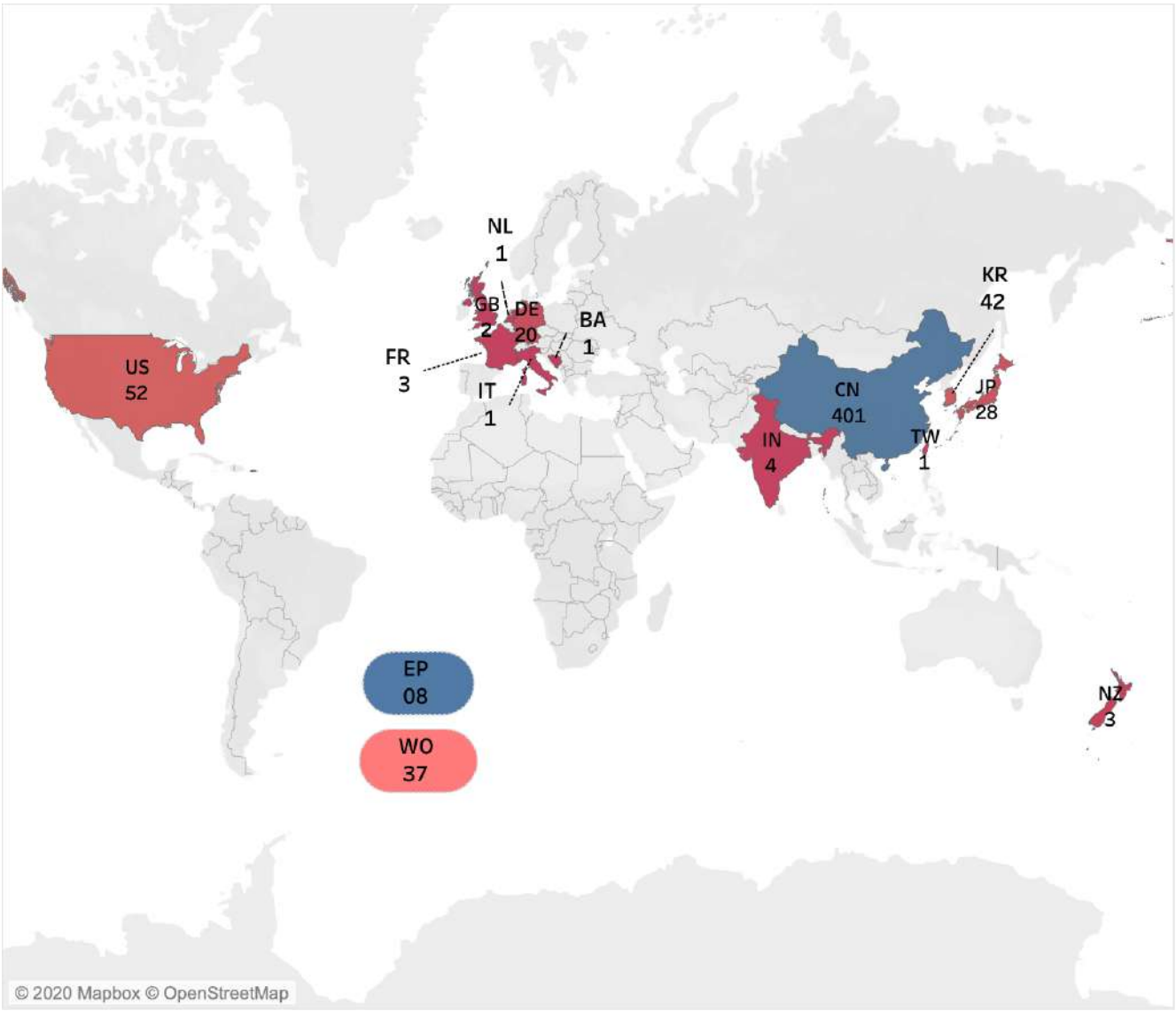


Note 1: The analysis is based on the patent applications published during the years 2019-20.
Note 2: Attributed to non-published patent applications, there may be a higher count in the years 2016-2019.

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

5.4 GEOGRAPHY BASED TREND ANALYSIS

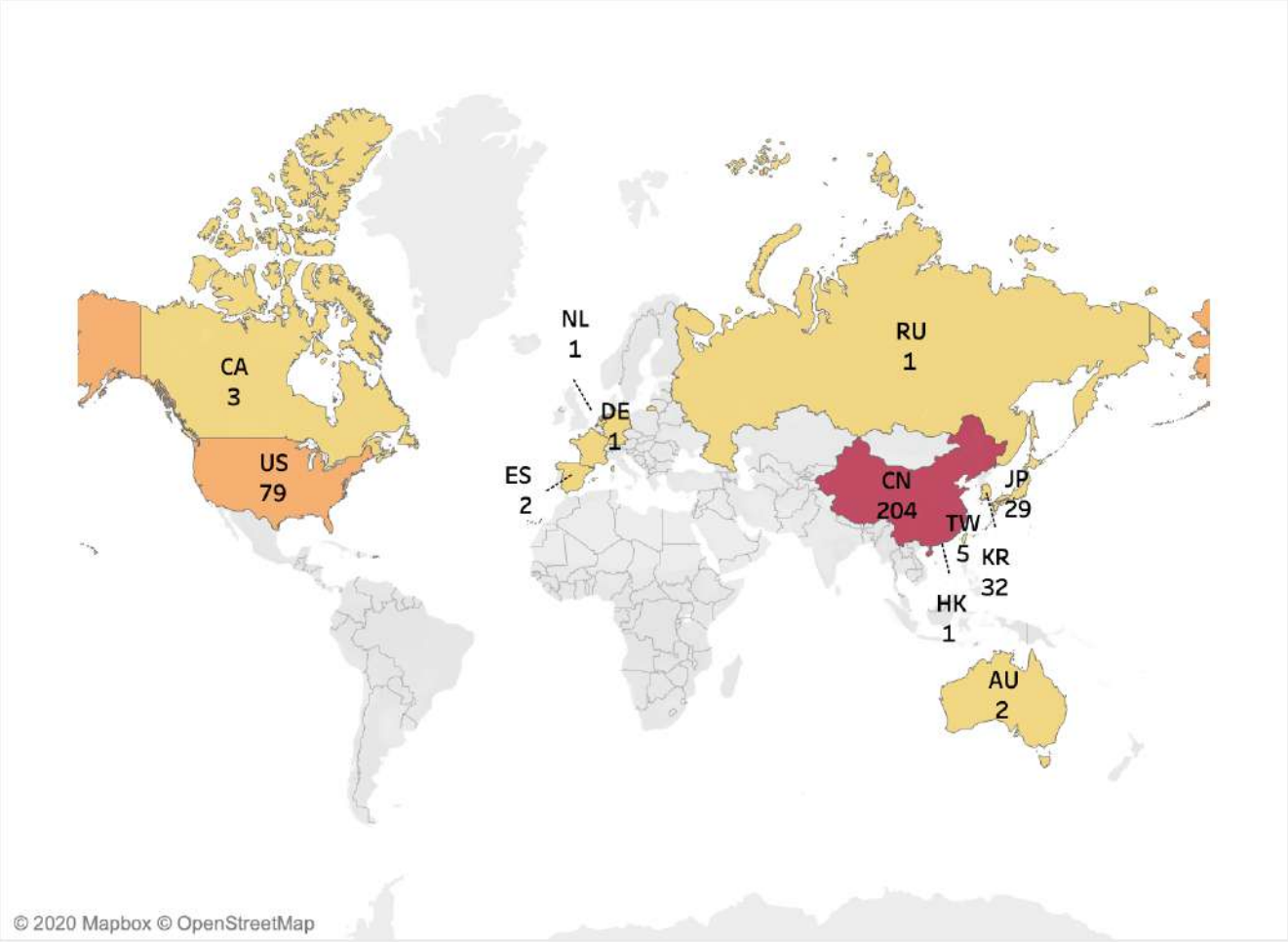
5.4.1 GEOGRAPHICAL DISTRIBUTION OF PATENT APPLICATION FILINGS



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.

- China is the leader in patent filing in the year 2019-20, followed by US and Japan.

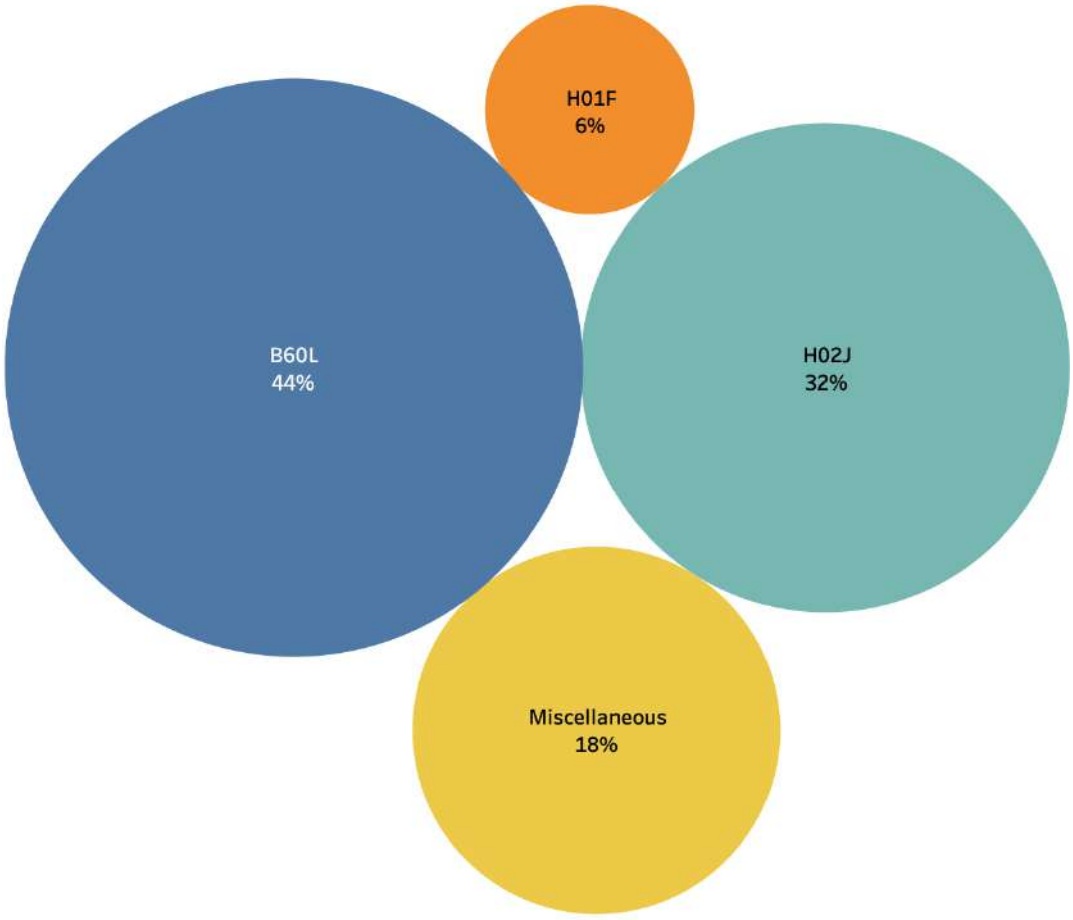
5.4.2 GEOGRAPHICAL DISTRIBUTION OF PATENT GRANTS



Trend related to Geographical distribution of patent grants demonstrates that the maximum number of patents originated 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, Qualcomm and an MIT spinout WiTricity were separately developing WEVC technology. However, in 2019, WiTricity became largest group in the world for WEVC technology after acquisition of certain technology platform and IP assets from Qualcomm that were related to Qualcomm's own 'Halo Technology'.

5.5 INTERNATIONAL PATENT CLASSIFICATION BASED TREND

The below packed bubbles represents frequently assigned international patent classes.



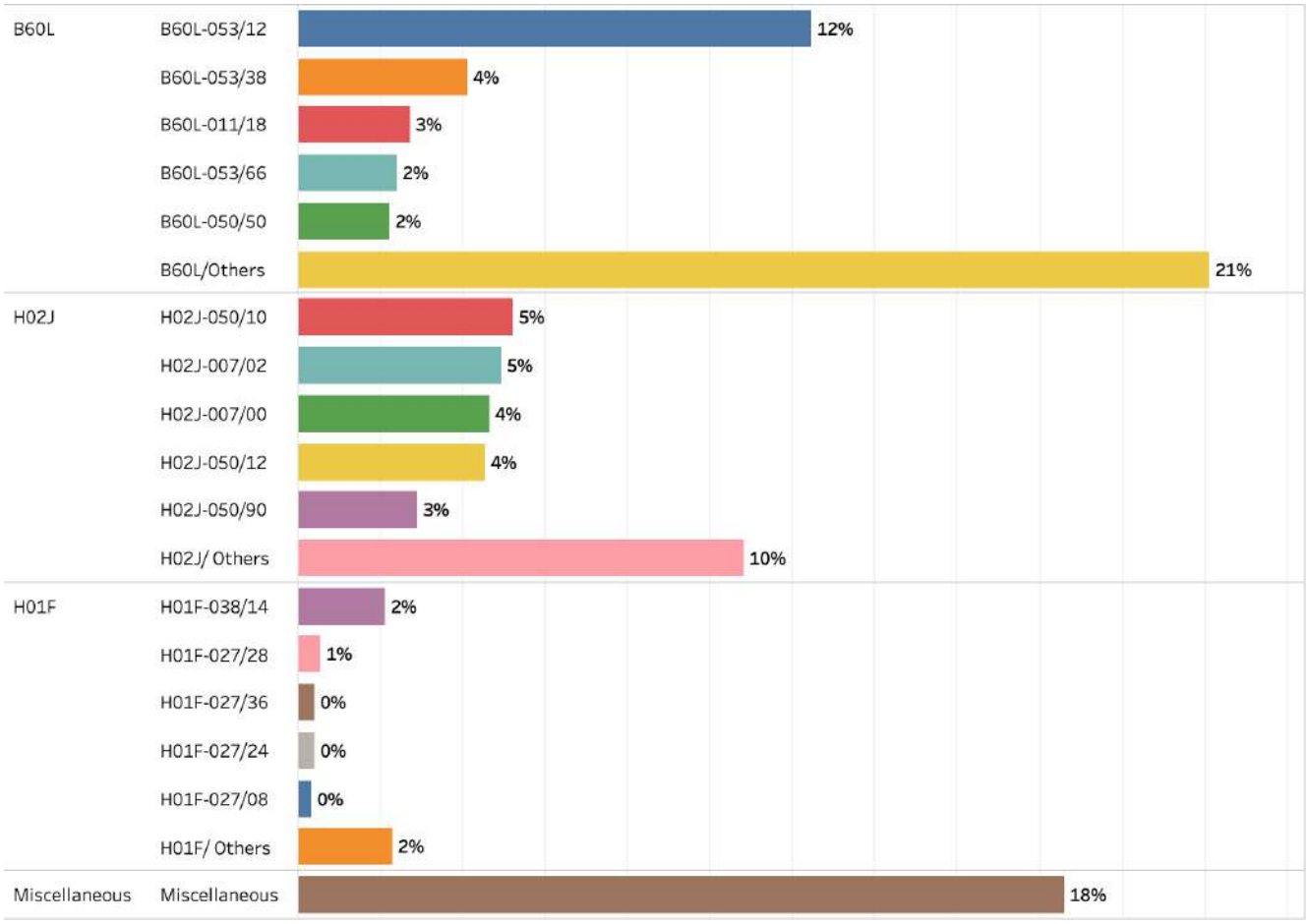
- Majority of patent applications were assigned with IPC "B60L" followed by "H02J".

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.

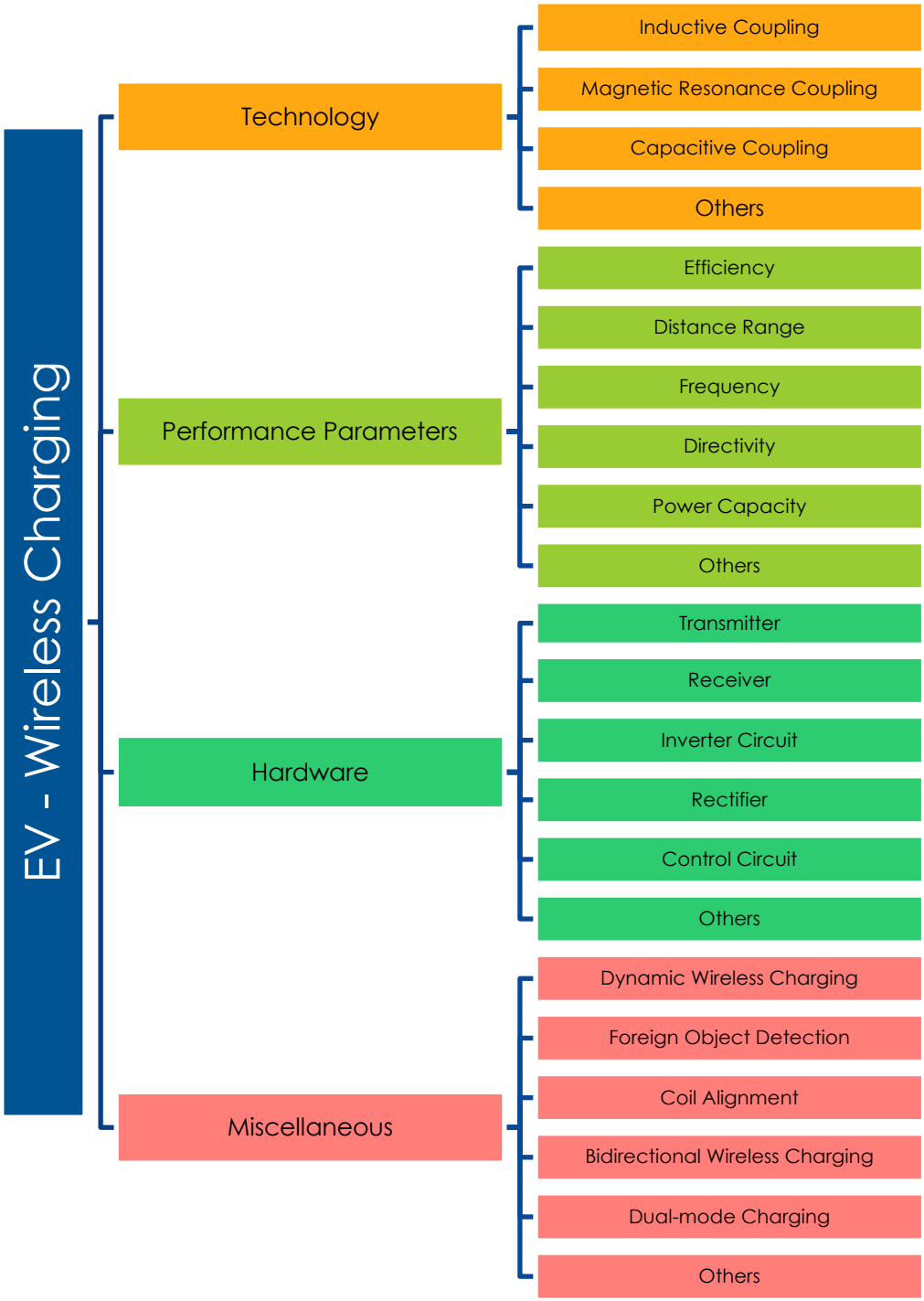


Note: The IPC Class/sub-class definitions are provided in Appendix-A

6. TECHNICAL ANALYSIS

6.1 TAXONOMY DEVELOPED FOR BUCKETING OF RELEVANT PATENT DOCUMENTS

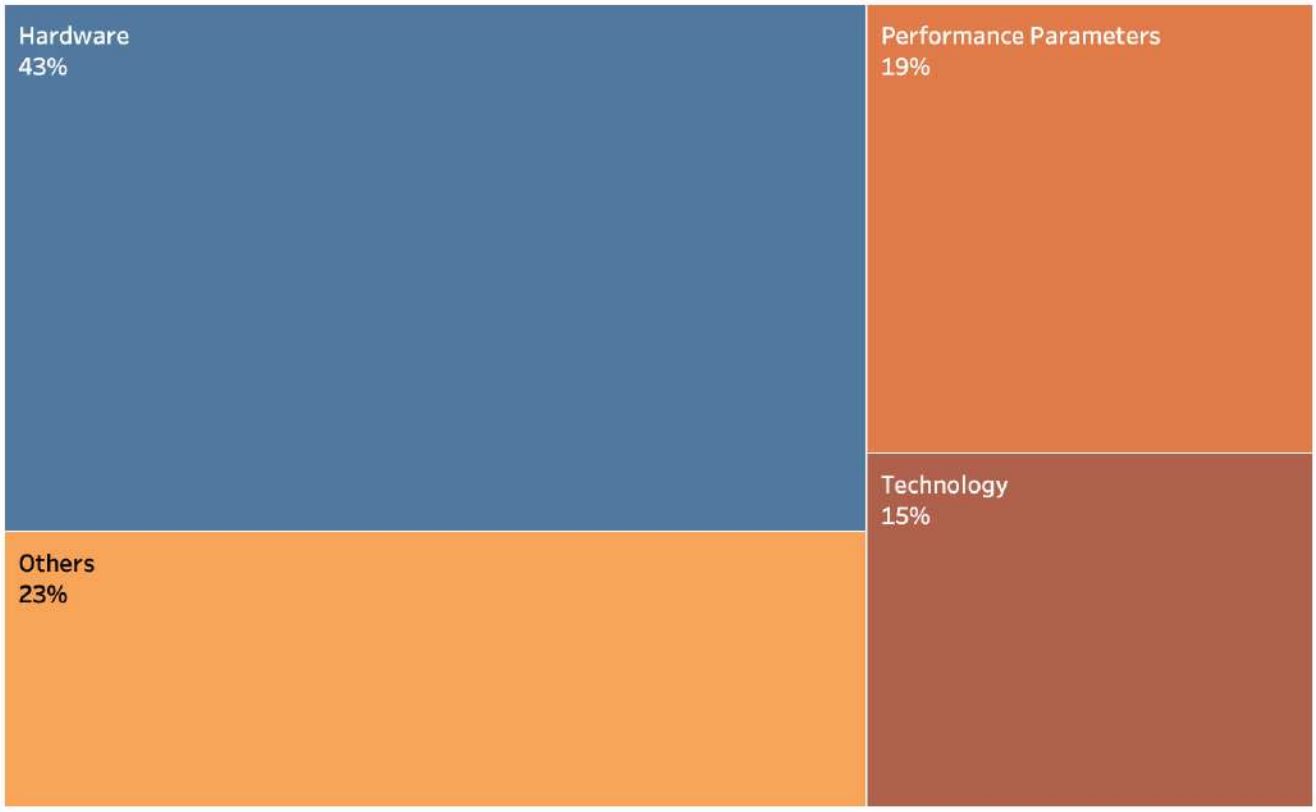
A set of 565 patent families were analyzed in depth to identify the focus areas of the patents related to EV-Wireless Charging.



Note: The Taxonomy definitions are provided in Appendix-B

6.2 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO EV- WIRELESS CHARGING

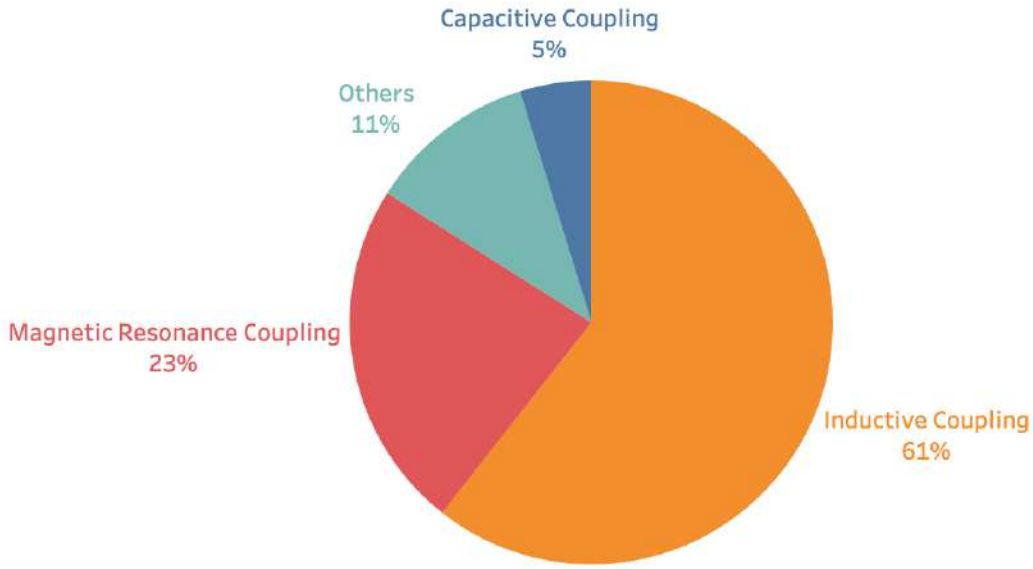
This category deals with patents/applications pertaining to dissection of EV- Wireless charging technology. Below representation reflects the dissection in terms of Hardware, Technology, Performance Parameters, and Miscellaneous.



- As evident from the tree map, maximum number of patents/applications are falling under Hardware (43%) 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.

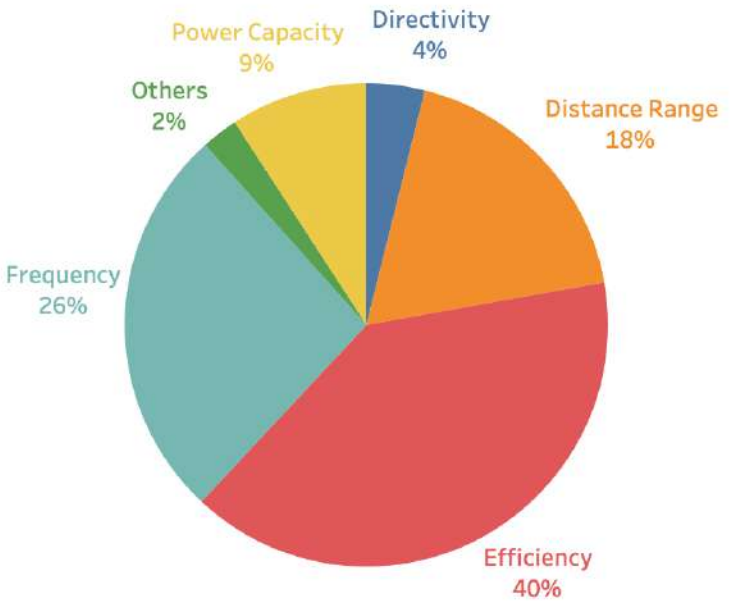


- As evident from the chart, maximum number of patents/applications are falling under Inductive Coupling (61%), Magnetic Resonance Coupling (23%), Capacitive Coupling (5%), and Others (11%).

- The key benefit of a closely coupled inductive wireless charging system is its relatively higher 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'

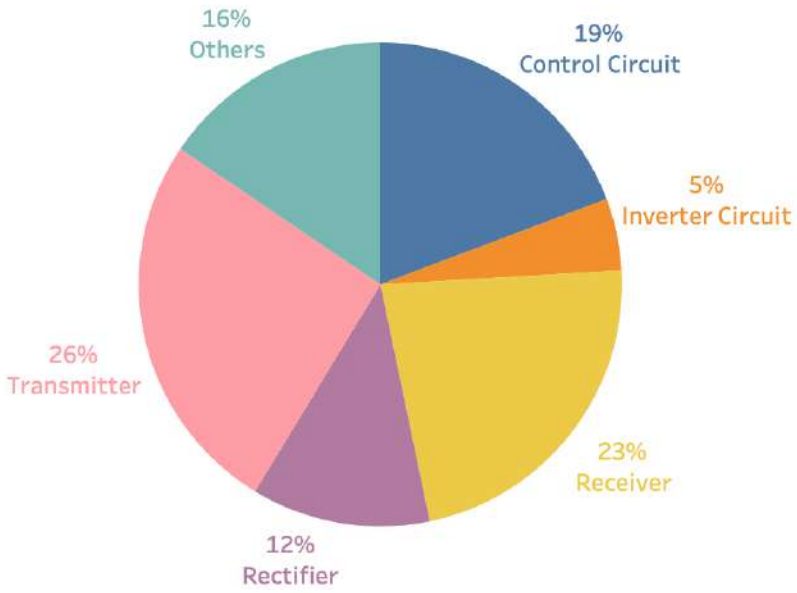
This category deals with patents/applications pertaining to 'Performance Parameters' being incorporated in EV - Wireless Charging Technology. Below representation shows sub-categories such as Efficiency, Frequency, Distance Range, Directivity, Power Capacity, and others.



- As evident from the chart, maximum number of patents/applications are falling under Efficiency (40%), followed by Frequency (26%), and Distance Range (18%).

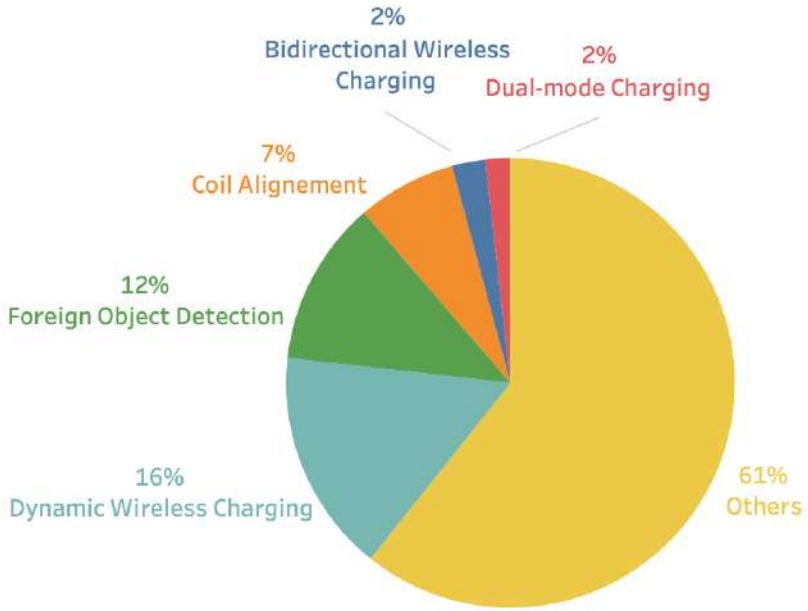
6.2.3 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO 'HARDWARE'

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



- As evident from the chart, maximum number of patents/applications are falling under Transmitter (26%) followed by Receiver (23%), and Control Circuit (19%).

6.2.4 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO 'MISCELLANEOUS'

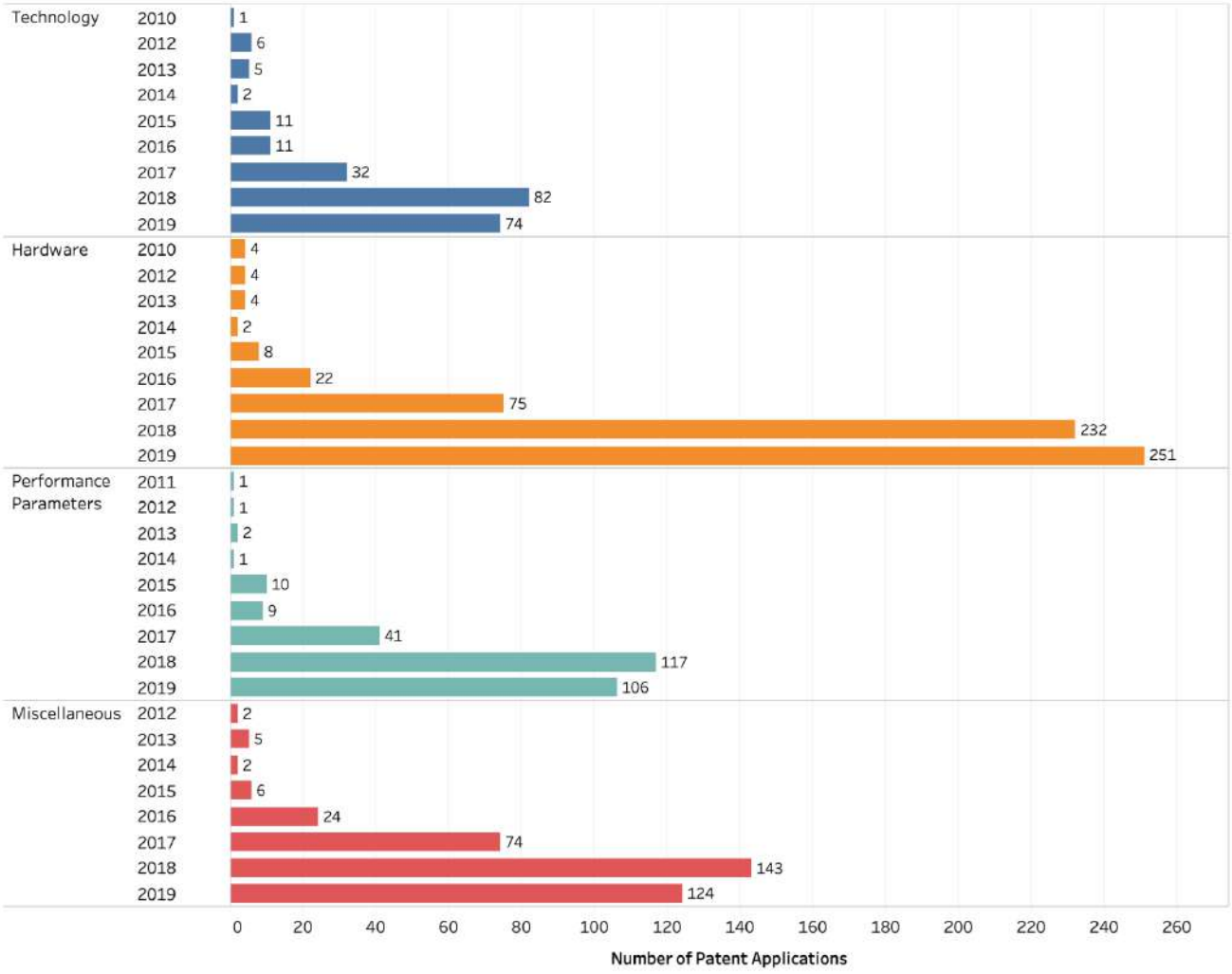


- As evident from the chart, maximum number of patents/applications are falling under Dynamic Wireless Charging (16%) followed by Foreign Object Detection (12%), and Coil Alignment (7%).

- Guangdong Power Grid Co Ltd [CN], State Grid Corp of China [CN], and Harbin Institute of Technology [CN] and Guilin Electronic Technology University [CN] are a few companies focussing on 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 highlight tables demonstrates the technology distribution of patent applications versus major assignees (companies) in the 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 demonstrates the technology distribution of patent applications versus major assignees (universities & research institutes) in the 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

Patent 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 support 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 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	WUHAN RESONANCE TECHNOLOGY CO LTD	An electric vehicle dynamic multi-level wireless charging system.
CN109715434A	Wired and wireless charging apparatus for electric vehicle, has wireless charging unit provided with inverter, and	HITACHI ZOSEN CORP.	A wired and wireless charging device for an electric vehicle, capable of identifying whether a

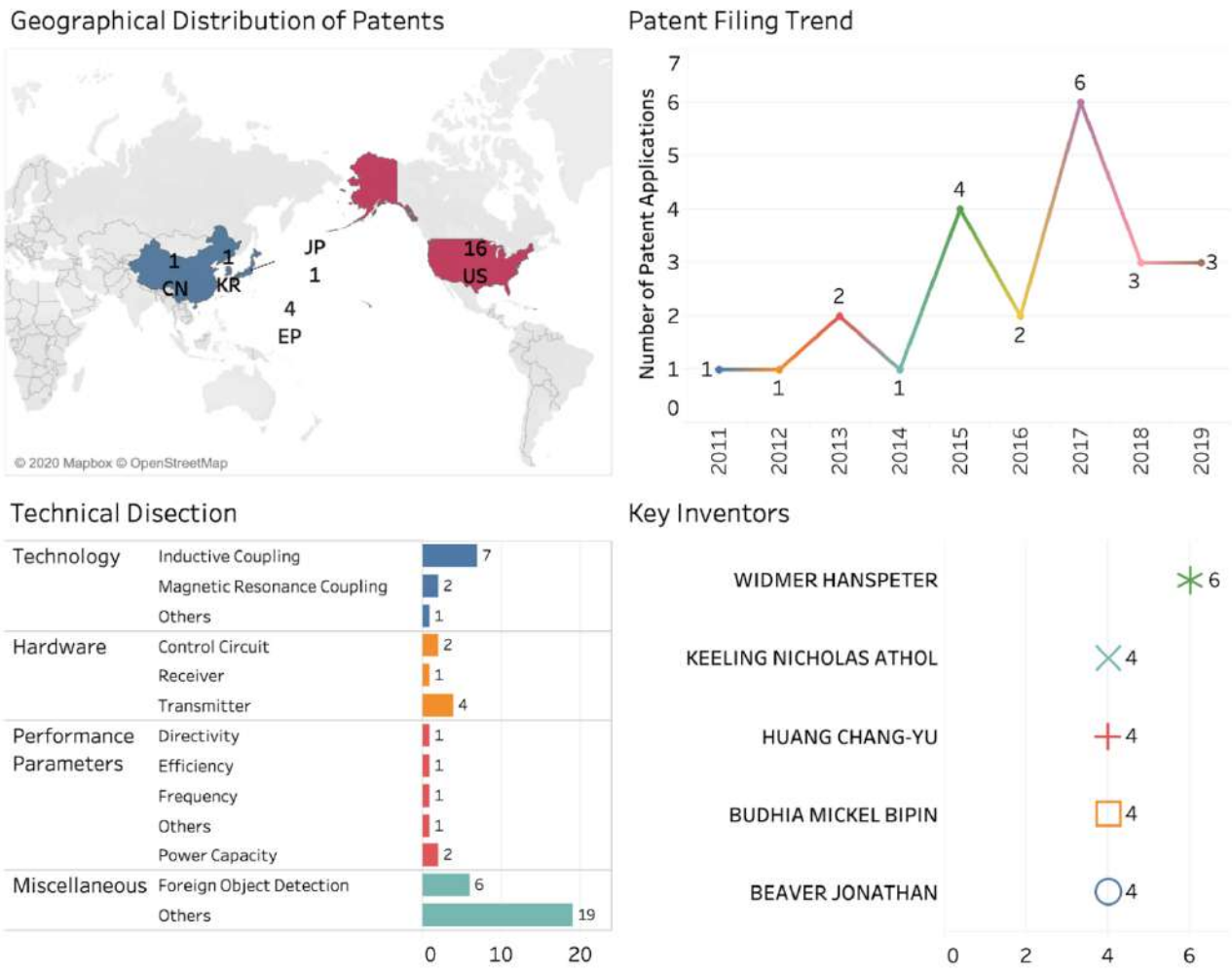
	changeover switch connected with vehicle in which charge is wirelessly possible such that wire charge part is operated		charging mode of an electric vehicle.
US202000211 44A1	Power transfer device used in wireless power transfer system for charging electric vehicle has at least one auxiliary coil coupled 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 emissions 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 was founded in 2007 to commercialize a new technology for wireless electricity invented and patented two years earlier by a team of physicists from the Massachusetts Institute of Technology (MIT), led by Professor Marin Soljačić. WiTricity has acquired Qualcomm Halo, which will bring more than 1,500 patents and patent applications related to wireless charging that WiTricity will own or control[9].



- The above dashboard demonstrates the trends related to the geographical distribution of patents, patent filing across the years, technical dissection of the patents, and the key inventors.

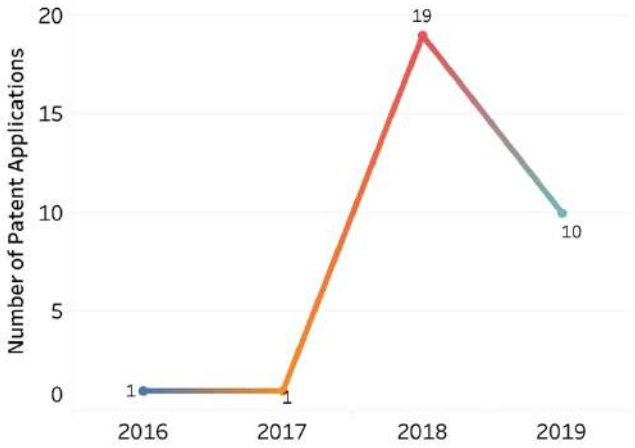
7.2 STATE GRID CORPORATION OF CHINA

COMPANY PROFILE:

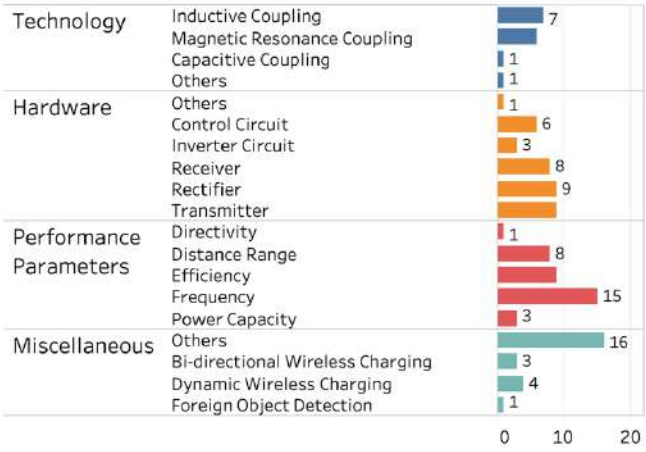
The State Grid Corporation of China (SGCC), commonly known as the State Grid, is the state-owned electric utility monopoly of China. It is the largest utility company in the world, and as of 2019, the world's fifth largest company overall by revenue. In 2016/17 it was reported as having 927,839 employees,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

Geographical Distribution of Patents

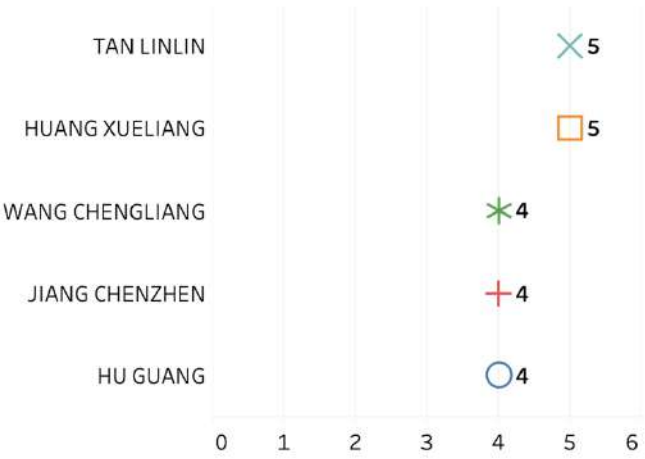
Patent Filing Trend



Technical Dissection



Key Inventors

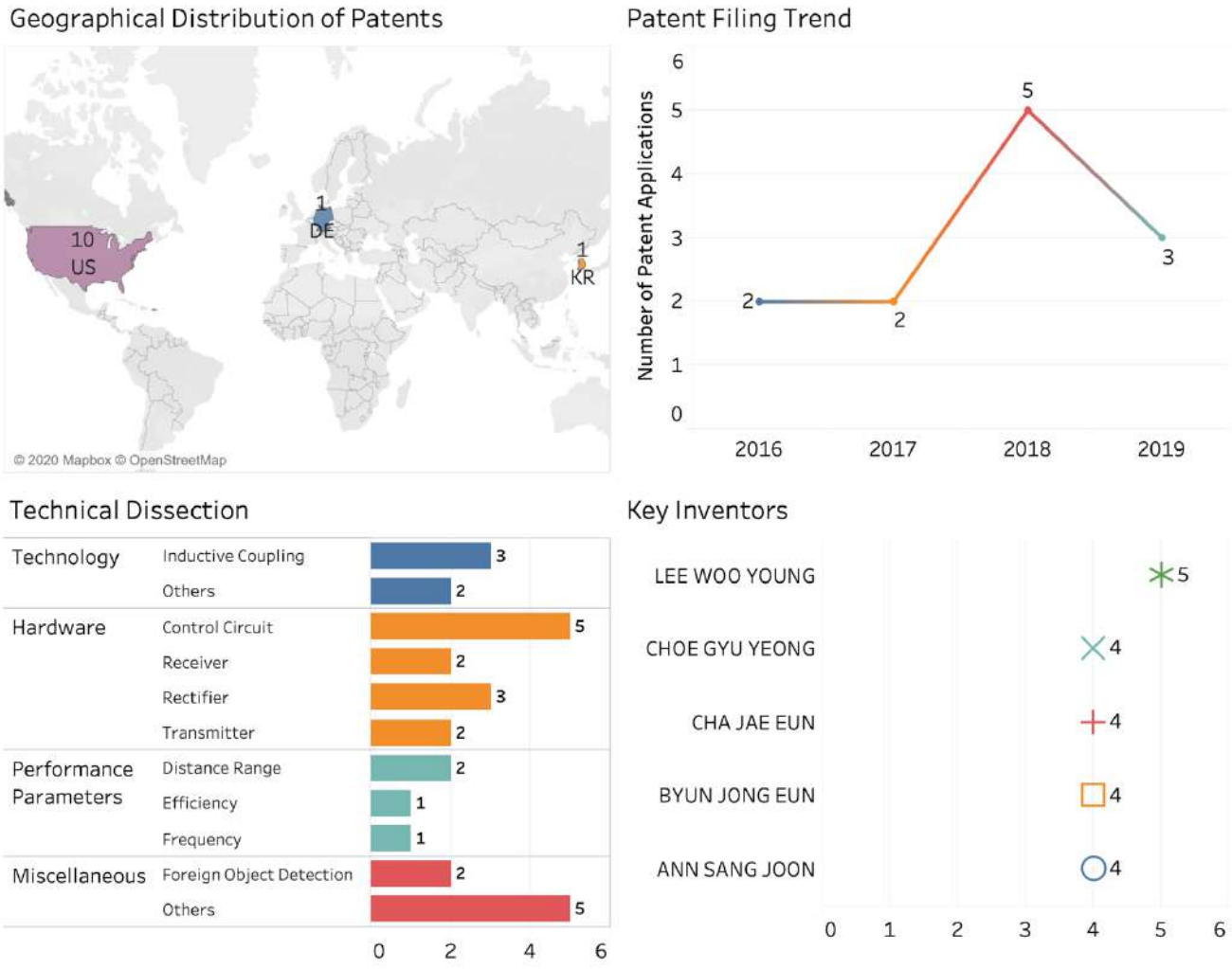


- The above dashboard demonstrates the trends related to the geographical distribution of patents, patent filing across the years, technical dissection of the patents, and the key inventors.

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[111].



- The above dashboard demonstrates the trends related to the geographical distribution of patents, patent filing across the years, technical dissection of the patents, and the key inventors.

8. THE FUTURE

8.1 WIRELESS VEHICLE TO GRID (W-V2G)

The express expansion of pure electric vehicles (PEVs) has resulted in the need for fast and efficient charging and power transfer methods. With the increasing number of PEVs, the power requirements from distribution networks has risen rapidly and created a detrimental impact on it. In order to compensate for the additional power requirements, renewable energy sources (RES) have been introduced to the microgrid but they have limited support facilities. The vehicle-to-grid (V2G) concept can offer a solution alongside advanced scheduling for charging and discharging to the distribution network[7].

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

The dynamic electric vehicle charging (DEVC) is also a future trend in wireless charging, which allows vehicles to get charged while in motion. The technology could drastically improve the travelling range for electric cars as the EV battery can be charged while driving on roads and highways. Also, DEVC eliminates the need for large energy storage, making vehicles more lightweight and compact.

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	○ The report explores the 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 the EV – Wireless Charging domain were analyzed.
Patenting Trend	○ As inferred from the analyzed dataset, there is a significant rise in patent filing activities in EV– Wireless Charging domain. The year 2018 has witnessed maximum number of patent application filings.
Birthplace of technologies	○ The technology is dominated by Chinese applicants, making up more than 70% of the total families captured within the report. Also, China (with 401 patent applications) has registered itself as the country with most numbers of inventions in EVWC domain.
Key Players	○ Globally, the top players within this technology are State Grid Corp of China with 31 patent families, followed by Beijing Invispower 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	○ From of analyzed dataset, Inventors Wang Zhe, Ma Junchao, Lu Jun, He Fanbo, Ge Junjie are the leading innovators in EV – Wireless Charging domain. Song Lei, Lin Guijiang, Zhang Kai, Zhu Wenji, and Zhu Chunbo are additional significant contributors.
HIghlighted Technologies	○ Patent publications particularly have 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 the available patent data, significant growth and further IP certainty in EV – Wireless Charging is expected in the coming years. Indepth monitoring of this patent landscape will allow the field to be fully appreciated.

APPENDIX- A

IPC DEFINITIONS:

IPC Class/ Sub-class	Definition
B60L	Propulsion of electrically-propelled vehicles; Supplying electric power for auxiliary equipment of electrically-propelled vehicles ; Electrodynamic brake systems for vehicles in general; magnetic suspension or levitation for vehicles; Monitoring operating variables of electrically-propelled vehicles; Electric safety devices for electrically-propelled vehicles;
B60L-053/10	Methods of charging batteries, specially adapted for electric vehicles; Charging stations or on-board charging equipment therefor; Exchange of energy storage elements in electric vehicles
B60L-053/12	Inductive energy transfer
B60L-053/18	Cables specially adapted for charging electric vehicles
B60L-053/38	Specially adapted for charging by inductive energy transfer
B60L-050/00	Electric propulsion with power supplied within the vehicle
B60L-050/50	Using propulsion power supplied by batteries or fuel cells
B60L-050/66	Arrangements of batteries
H02J	Circuit arrangements or systems for supplying or distributing electric power; systems for storing electric energy
H02J-007/00	Circuit arrangements for charging or depolarising batteries or for supplying loads from batteries
H02J-007/02	For charging batteries from ac mains by converters
H02J-050/00	Circuit arrangements or systems for wireless supply or distribution of electric power
H02J-050/10	Using inductive coupling
H02J-050/12	Using inductive coupling; of the resonant type

H02J-050/90	Involving detection or optimisation of position, e.g. alignment
H01F	Magnets; Inductances; Transformers; Selection Of Materials For Their Magnetic Properties
H01F-027/00	Details of transformers or inductances, in general
H01F-027/08	Cooling; Ventilating
H01F-027/24	Magnetic cores
H01F-027/28	Coils; Windings; Conductive connections
H01F-027/36	Electric or magnetic shields or screens (movable for varying inductance H01F 21/10)
H01F-038/00	Adaptations of transformers or inductances for specific applications or functions
H01F-038/14	Inductive couplings

APPENDIX- B

TAXONOMY DEFINITIONS:

Taxonomy	Definition
Inductive Coupling	Inductive coupling uses magnetic fields that are a natural part of current's 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 direct current, which flows in only one direction.
Control Circuit	A type of circuit that uses control devices to determine when loads are energized or de-energized by controlling current flow to the transmitters and from the receivers.
Dynamic Wireless Charging	Dynamic Charging refers to inductive charging of electric vehicles at high power levels enables 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 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

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[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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Contact Person

Tarun Khurana

iiprd@iiprd.com, info@khuranaandkhurana.com

Contact No.: +91-120-4296878, 2399113, 2399010

Contact Details

Noida (NCR) Office – Head Office

E-13, UPSIDC Site – IV, Behind Grand Venice, Greater Noida, 201308

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