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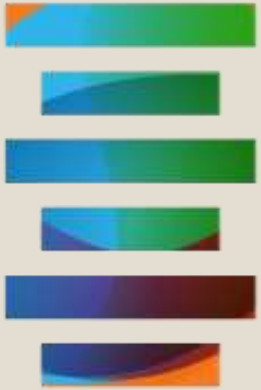
We Are "All In" on Energy Storage.

- **Full-service law firm**
- Our clients include battery innovators and battery integrators (e.g., auto manufacturers)
- **30+ IP attorneys**
- Battery materials, cells, modules, thermal systems, battery management systems



ADVANCED BATTERY & CAPACITOR PATENTEDGE

2018 Update

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ip CHECKUPS℠ an eye on invention

ABC PatentEdge Quarterly Report

What is Advanced Battery & Capacitor PatentEdge™?

ABC PatentEdge is the only competitive patent intelligence solution specifically designed for the Advanced Battery market.

The ABC PatentEdge contains six high-level battery technology categories, developed by IP Checkups' along with industry leading battery technology experts. Within these six categories, there are 200+ technology and market-related sub-categories containing more than 250,000 patents published from worldwide* patenting authorities.

- **Purpose:** The **ABC PatentEdge Quarterly** was developed to provide insight into recent advanced battery industry patent activity. As part of our partnership, IP Checkups provides this quarterly report to NAATBatt members as an exclusive value-add.
- **Methodology:** The **ABC PatentEdge Quarterly** utilizes data from the ABC PatentEdge database to report on advanced battery trends and recent patent filing activity in specific battery technology areas.
- **Sources:** Statistics reported in the **ABC PatentEdge Quarterly** were derived from the ABC PatentEdge database, which houses over 250,000 battery-related patents from the U.S. Patent & Trademark Office, the World Intellectual Property Organization, the European Patent Office.

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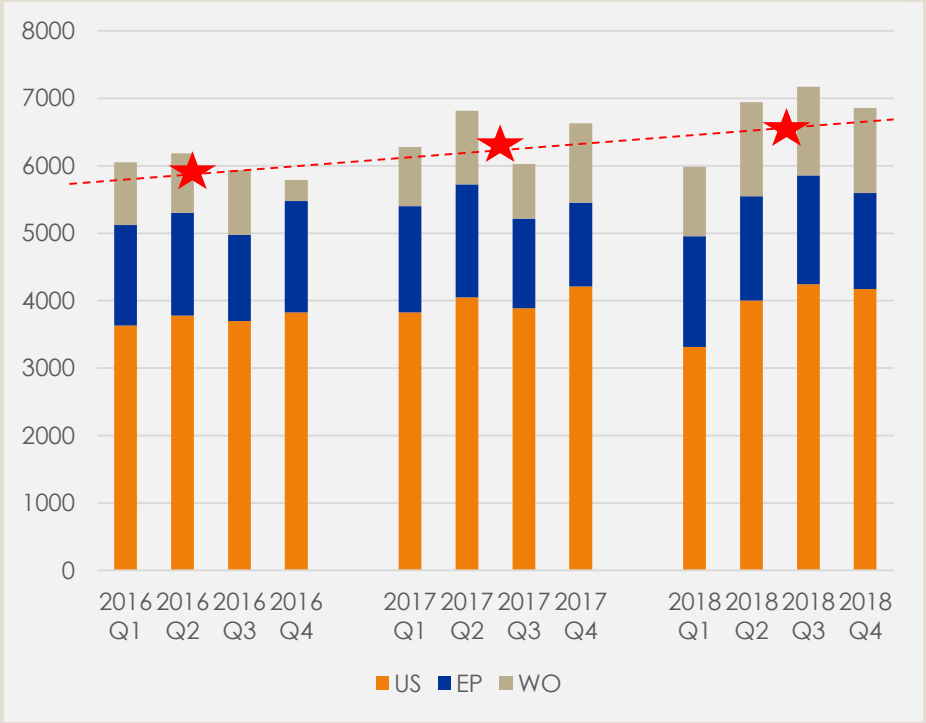
Worldwide Patent Publications: 2016 – 2018

- Battery-related patent filings increased last year, with nearly 27,000 new publications in 2018 (there were about 25,000 in 2017).
- 2018 quarterly publication volume fluctuated between about 6,000 and 7,000 combined US, EP, and WO publications.
- EP publications generally remained steady during 2018.
- Since 2016, PCT (WO) publications have increased by about 1000 publications per year.

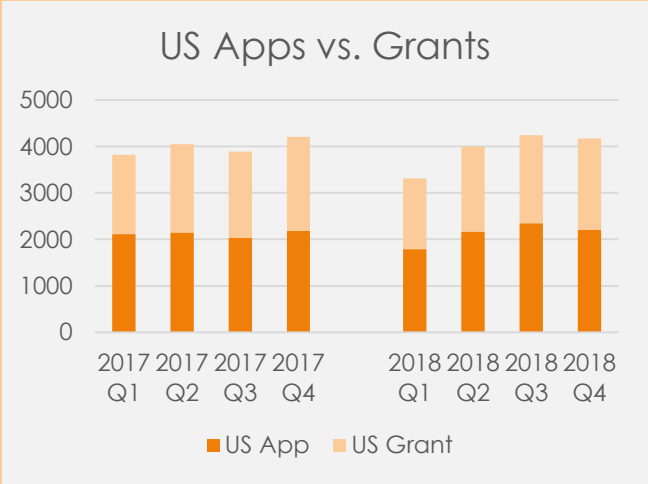


*Worldwide = U.S. published applications, U.S. granted patents, European (EP) published applications, European (EP) granted patents, World Intellectual Property Organization (WO) published applications

Worldwide Patent Publications: 2017 – 2018 US & EP App vs. Grant

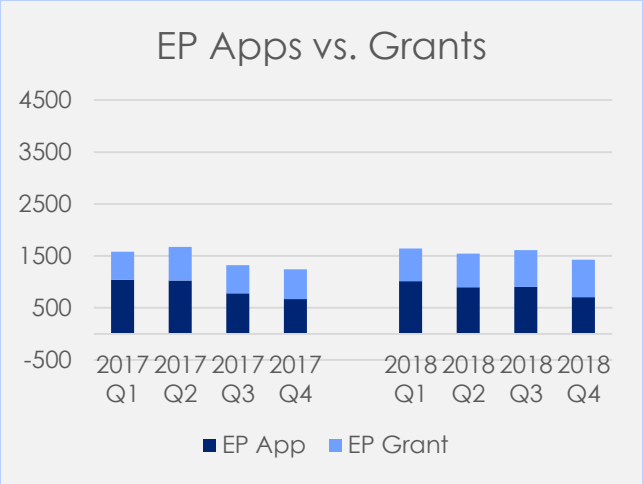
US filing trends in Battery technology appear to be steady, as there were about 2,000 published applications per quarter for the past two years.

The US patent issuance rate increased slightly each quarter in 2018.



The quarterly volume of EP published applications decreased over 2018, similar to the 2017 trend.

However, about 15% more granted EP patents were issued in 2018 than the previous year



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Top Worldwide Innovators

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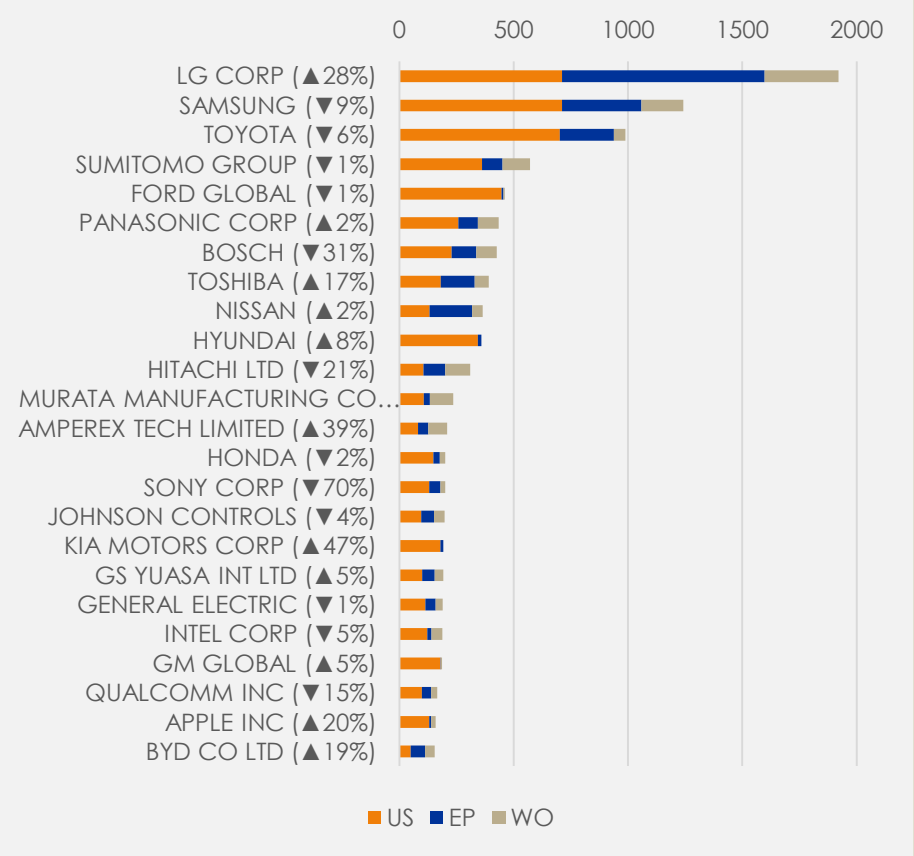
Top 20 Overall Assignees 2018: **Worldwide Patent Publications**



- In 2018, **LG**, **Samsung**, and **Toyota** continued to be the top assignees, together accounting for nearly 15% of worldwide battery-related patent publications.
- Among top-filing companies, the highest gains over 2017 were made by **Murata Mfg. (+72%), Sony (+70%), Kia (+47%),** and **Amperex (+39%).**

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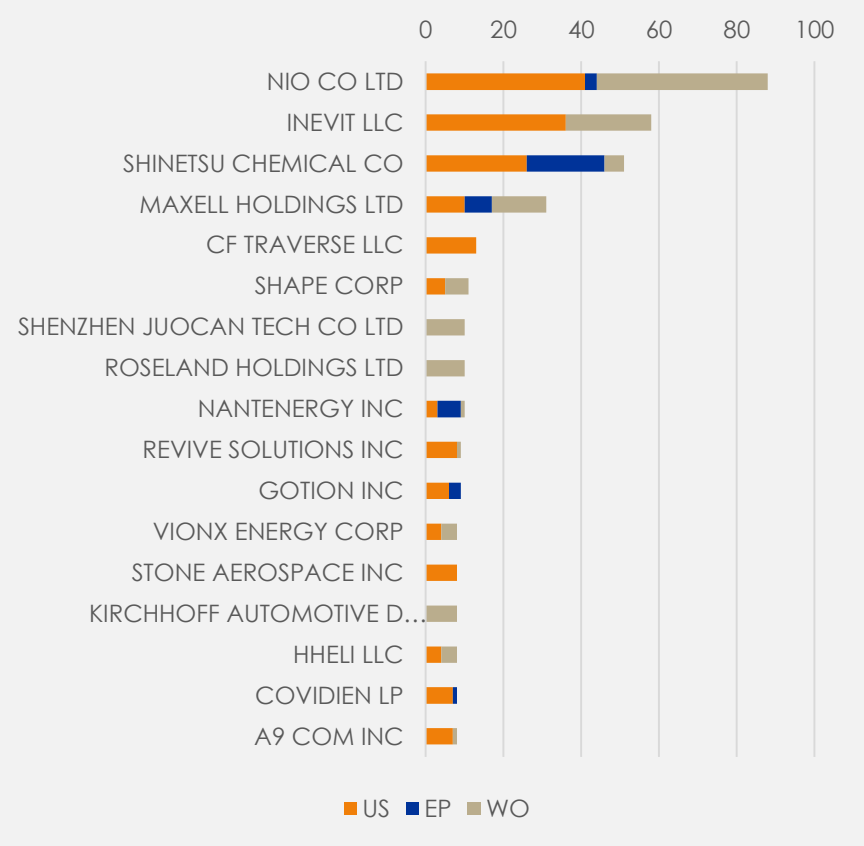
New Entrants 2018:
Worldwide Patent Publications



- This chart shows "New Entrants" - top companies filing in 2018 companies with no filings in the previous two years.
- **Nio Co** is a Chinese automobile manufacturer headquartered in Shanghai, specializing in designing and developing electric autonomous vehicles.
- **InEvit** is an electrical vehicle battery modularization started headed by former Tesla CEO Mertin Eberhard.

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Active Academic & Research Institutions: 2018

Academic/Research Institution	#
UNIV CALIFORNIA	84
MASSACHUSETTS INSTITUTE OF TECH	63
UNIV TSINGHUA	36
INDUSTRIAL TECH RESEARCH INSTITUTE	35
UNIV MICHIGAN REGENTS	32
UCHICAGO ARGONNE LLC	31
UNIV TEXAS	29
BATTELLE MEMORIAL INSTITUTE	25
UNIV CORNELL	24
UNIV LELAND STANFORD JUNIOR	22
UNIST ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECH	19
UNIV ILLINOIS	16
UNIV KING ABDULLAH SCI & TECH	15
UNIV MARYLAND	15
SEOUL NATIONAL UNIV R&DB FOUNDATION	13
UNIV CASE WESTERN RESERVE	12
UNIV RICE WILLIAM M	12
UNIV DE NANTES	12
GRADUATE SCHOOL SHENZHEN TSINGHUA UNIV	12
UNIV NORTHWESTERN	11
RESEARCH INSTITUTE OF INDUSTRIAL SCIENCE & TECH	11

Academic/Research Institution	#
UNIV SOUTHERN CALIFORNIA	10
HARVARD COLLEGE	10
RESEARCH & BUSINESS FOUND SUNGKYUNKWAN UNIV	10
UNIV SOUTH CHINA TECH	9
UNIV KING FAHD PET & MINERALS	9
UNIV WASHINGTON	9
UNIV TOKYO	8
UNIV PRINCETON	8
ZHEJIANG GEELY AUTOMOBILE RES INSTITUTE CO LTD	8
UNIV NANYANG TECH	8
NAT UNIV SINGAPORE	8
RAMOT AT TEL AVIV UNIV LTD	8
THE REGENTS OF THE UNIV OF COLORADO	7
UNIV DE PICARDIE JULES VERNE	7
UNIV WASEDA	7
UNIV NEW YORK STATE RES FOUND	7
UNIV ARIZONA STATE	7
UNIV MICHIGAN STATE	7
KOREA INSTITUTE OF INDUSTRIAL TECH	7
HANYANG UNIV	7

These academic universities and research institutions were the leaders in advanced battery related published patent applications in 2018.

*Worldwide = U.S. published applications, U.S. granted patents, European (EP) published applications, European (EP) granted patents, World Intellectual Property Organization (WO) published applications

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Patent Activity in Key Battery Technology Sectors

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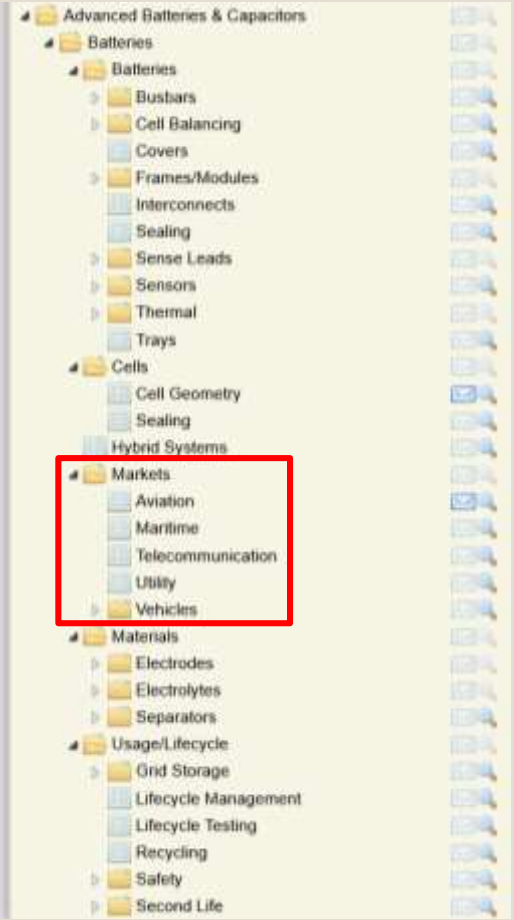
ABC PatentEdge Hierarchy



- Within the ABC PatentEdge™ database, there are six main high-level categories.
  - Battery Modules
  - Cells
  - Hybrid Systems
  - Markets
  - Materials
  - Usage/Lifecycle

- There is significant overlap between categories, particularly between Markets (i.e. End Use) and technical sectors such as Battery Modules, Materials, and Usage/Lifecycle.

- This year, IP Checkups inspects the Vehicles Market category, and in particular the overlap between Vehicles and Battery Modules, Materials, and Usage/Lifecycle.

- PatentCAM enables users to compare the overlap between multiple categories.

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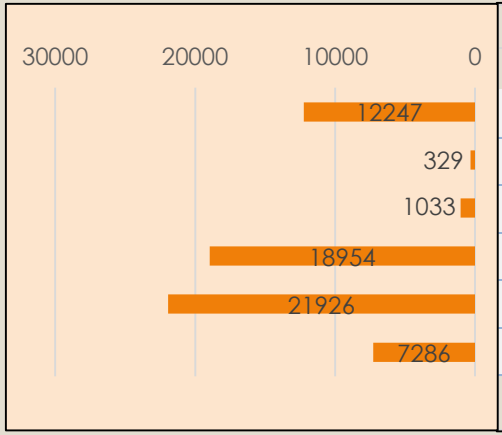
Worldwide Patent Publications in Battery Sectors: Full Year 2018

Overall Sector Activity



Sector Activity Change from 2017 to 2018

	US		EP		WO	
	App	Grant	App	Grant	App	
Battery Modules	▲196 (9%)	▼-192 (-8%)	▲105 (11%)	▲109 (15%)	▲225 (20%)	▲443 (6%)
Cells	▲30 (45%)	▼-17 (-21%)	▲24 (69%)	▲7 (14%)	▲15 (41%)	▲59 (22%)
Hybrid Systems	▼-92 (-26%)	▼-7 (-2%)	▼-35 (-19%)	▲37 (38%)	▲5 (3%)	▼-92 (-8%)
Markets	▲30 (1%)	▼-17 (%)	▼-48 (-3%)	▲190 (19%)	▲866 (80%)	▲1021 (9%)
Materials	▼-147 (-5%)	▼-218 (-10%)	▲134 (10%)	▲158 (17%)	▲207 (11%)	▲134 (1%)
Usage/ Lifecycle	▼-358 (-14%)	▼-478 (-22%)	▼-158 (-18%)	▲167 (30%)	▲70 (9%)	▼-757 (-11%)
	▲34 (%)	▼-288 (-4%)	▼-266 (-8%)	▲395 (17%)	▲1040 (26%)	▲915 (4%)

- In 2018, overall publication rates increased 4%, with the most notable sector increase in *Battery Cells, 26%.*
- While there was a net decrease in US publications, the volume of EP patents granted in 2018 increased 17% over 2017.
- The largest sector publication volume increase was in PCT (WO) applications relating to Battery Markets (up 80%).

*Note that many patents are categorized in multiple categories.

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Spotlight on Battery Innovation in the **Vehicles** Sector

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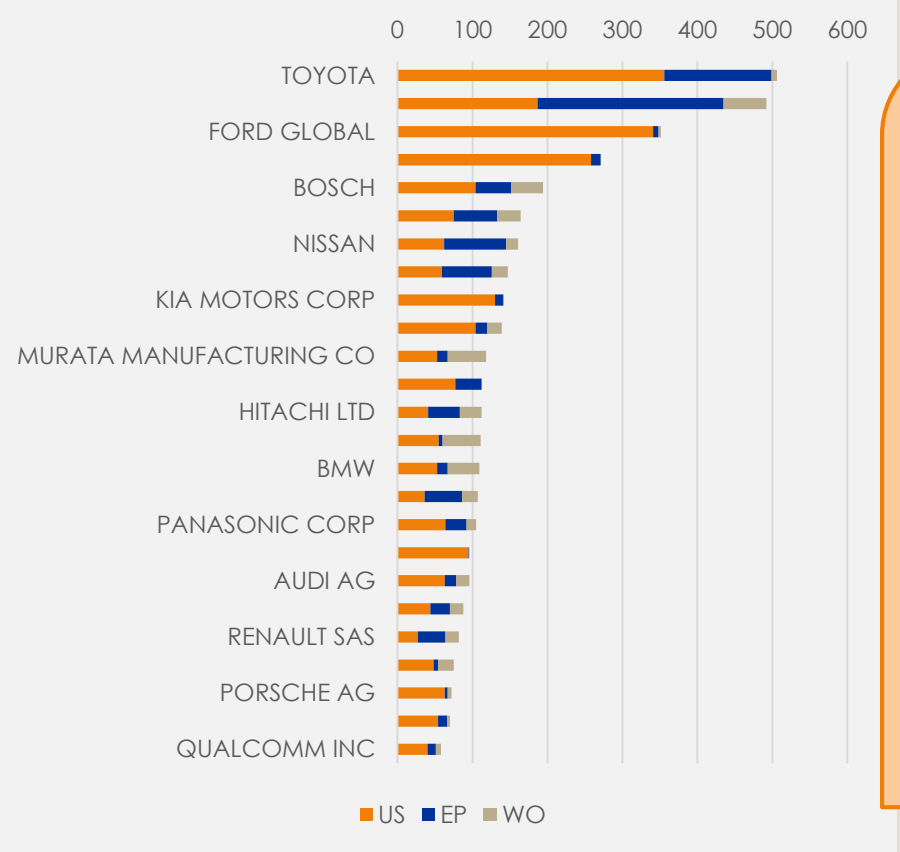
Top Assignees: **Vehicles** – 2018



Toyota, LG, Ford, and Hyundai lead the pack in IP related to Vehicle Battery technology.

LG, Nissan, Toshiba, BYD, Hitachi and Renault have budgeted heavily on IP protections in the European market.

Most other companies appear focused on US protection, including LG, Ford, Hyundai, and Kia.

The increase of innovation by multinational electronics manufacturers in the Vehicle sector may indicate a convergence of technology and business strategies.

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Top Assignees: **Vehicle** by Sector

- Top companies publishing patents in the Vehicle Battery sector are filing steadily in every sub-category (except Cells).
- Top companies are still innovating in the Hybrid Systems space, including Toyota, Ford, Hyundai, Nissan, Kia, and BYD.
- LG and Toshiba focus on IP related to battery materials in the vehicle space.
- LG is the only assignee focused on Battery Cells.

Assignee	Battery Modules	Cells	Hybrid Systems	Markets	Materials	Usage/Lifecycle
TOYOTA	158	2	35	506	42	43
LG CORP	335	35	2	492	104	91
FORD GLOBAL	147	3	41	351	8	15
HYUNDAI	104	1	45	271	5	17
BOSCH	71	3	12	194	22	17
SAMSUNG	85	0	8	164	15	19
NISSAN	36	1	23	161	4	1
TOSHIBA	19	0	2	147	78	44
KIA MOTORS CORP	49	0	20	141	1	7
HONDA	44	0	4	139	6	5
MURATA MANUFACTURING	18	0	0	118	52	26
THUNDER POWER	70	0	0	112	2	7
HITACHI LTD	61	0	9	112	8	14
SUMITOMO GROUP	27	0	1	111	2	10
BMW	37	1	8	109	8	2
BYD CO LTD	41	3	25	107	9	13
PANASONIC CORP	18	0	2	105	3	12
AUDI AG	35	0	3	96	8	9
GM GLOBAL	54	0	7	96	11	10
JOHNSON CONTROLS	57	3	5	88	11	40
RENAULT SAS	42	0	18	82	3	5
DENSO CORP	20	0	2	75	5	3
PORSCHE AG	28	1	2	72	11	2
LITHIUM ENERGY & POWER	28	2	1	48	18	18
VOLVO TRUCK CORP	27	0	2	39	0	7
JAGUAR LAND ROVER LTD	26	1	6	37	0	4

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2018 Vehicle Sector Patent Distribution

- This chart shows the distribution of 2018 Battery-related Vehicle publications within the category hierarchy.
  - Many of the Vehicle related publications fall into multiple categories.
- The inner circle shows each of the 5 technical battery sectors by volume, with sub-categories branching from the inner circle (the Markets sector is not shown here to reduce redundancy).
- Vehicle innovations were primarily focused on Battery Modules, Materials, and Usage/Lifecycle topics.

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2018 Advanced Battery Summary

- Battery-related patent filings increased last year, with more than 27,000 new publications in 2018 (there were about 25,000 in 2017).
- 2018 quarterly volume hovered around 7,000 combined US, EP, and WO publications.
- U.S. activity followed the quarterly trend, and again outpaced EP and WO filings.
- While there was a net decrease in US publications, the volume of EP patents granted in 2018 increased 17% over 2017.
- In 2018, **LG**, **Samsung**, and **Toyota** continued to be the top assignees, together accounting for 15% of worldwide battery-related patent publications.
- The increase of innovation by multinational electronics manufacturers in the Automotive sector may indicate a convergence of technology and business strategies.
- Automotive innovation was primarily focused on Battery Modules, followed by Materials and Usage/Lifecycle topics.
- Drill-downs on Assembly, Li-Oxide Cathodes, and Grid Storage reveal valuable insights, including investment details of multi-nationals, and the presence of new innovators.

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With ABC PatentEdge…

- Track worldwide patent filing, publication and issuance trends in more than 200 advanced battery related tech categories
- Identify which patents have been assigned to which companies
- Learn what trends within specific technologies are developing
- Identify key thought leaders in different technical areas
- Review patent activity coming from universities and research institutions filing patents in particular technology areas
- Find out where leading companies are really making their bets

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