

# Patent Information Analysis Based on GXTI (Summary Version)

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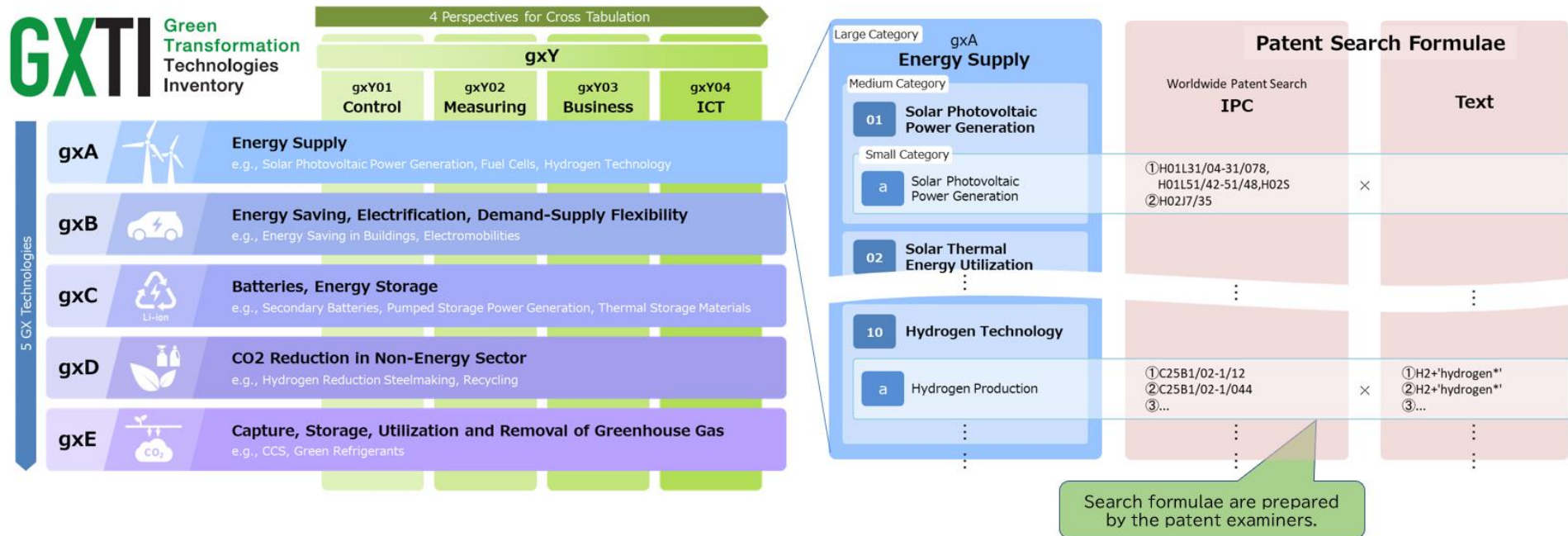
October 2023

Japan Patent Office



# 1. GXTI (Green Transformation Technologies Inventory)

- In June 2022, the Japan Patent Office (JPO) created and published the Green Transformation Technologies Inventory (GXTI), which provides a bird's-eye view of technologies related to Green Transformation (GX) in five large technology categories and four transversal perspectives.
- The JPO **also published patent search formulae specific** to search patent documents corresponding to each technology category, and **to figure out technological trends**.



# 1. GXTI (Hierarchical structure)

- It is possible to conduct a survey for every hierarchical structure in the Level 1, Level 2 and Level 3 categories according to the purpose.

Level 1	Level 2	Level 3
gxA	Energy Supply	
01	Solar Photovoltaic Power Generation	a Solar Photovoltaic Power Generation
02	Solar Thermal Energy Utilization	a Solar Thermal Power Generation b Solar Thermal Collectors, Solar Thermal Systems
03	Wind Power Generation	a Wind Power Generation
04	Geothermal Utilization	a Geothermal Power Generation b Geothermal Collectors, Geothermal Systems
05	Hydro-Power Generation	a Hydro-Power Generation
06	Ocean Energy Power Generation	a Wave Power Generation, Tidal Power Generation b Ocean Thermal Energy Conversion, Ocean Salinity Gradient Power Generation
07	Biomass	a Solid Biofuels b Liquid Biofuels c Biogas
08	Nuclear Power Generation	a Fusion Reactors, Nuclear Reactors, Nuclear Power Plant
09	Fuel Cells	a Fuel Cells, Fuel Cell Systems (Stationary, Mobility)
10	Hydrogen Technology	a Hydrogen Production b Hydrogen Storage, Transportation, Supply, Hydrogen Stations c Use of Hydrogen in Combustion (Hydrogen Engine Vehicles, etc.)
11	Ammonia Technology	a Ammonia Production b Ammonia Storage, Transportation c Use of Ammonia in Combustion

Level 1	Level 2	Level 3
gxB	Energy Saving, Electrification, Demand-Supply Flexibility	
01	Energy Saving in Buildings (ZEB, ZEH, etc.)	a Building Insulation b High-Efficiency Air Conditioner c High-Efficiency Water Heaters d High-Efficiency Lighting (LEDs, OLEDs)
02	High-Efficiency Motors and Inverters	a High-Efficiency Motors and Inverters
03	Combined Heat and Power (CHP)	a Combined Heat and Power (CHP)
04	Energy Saving and Supply/Demand Flexibility in Treatment of Water, Wastewater, Sewage, and Sludge	a Energy Saving and Supply/Demand Flexibility in Treatment of Water, Wastewater, Sewage, and Sludge
05	Electromobilities	a Electric Vehicles, Hybrid Vehicles b Others (Aircraft, Ships, etc.)
06	Electrification of Industrial Heat	a Resistance Heating, Infrared Heating b Induction Heating c Electromagnetic Heating (Microwave Heating, Dielectric Heating) d Electric Discharge Heating
07	Power Transmission and Distribution, Smart Grids	a Direct Current Transmission and Distribution (HVDC, etc.) b Smart Grids
08	Demand-Supply Flexibility of Power Systems	a VPP, Negawatt, Resource Aggregation
gxC	Batteries, Energy Storage	
01	Secondary Batteries	a Secondary Batteries b Module-Related Technology for Secondary Batteries
02	Mechanical Energy Storage	a Pumped Storage Power Generation, Flywheels, Compressed Air Energy Storage
03	Thermal Energy Storage	a Thermal Storage Devices, Thermal Storage Materials (Including Carnot Batteries)
04	Electric Double Layer Capacitors, Hybrid Capacitors	a Electric Double Layer Capacitors, Hybrid Capacitors

Level 1	Level 2	Level 3
gxD	CO2 Reduction in Non-Energy Sector	
01	Chemical Production from Biomass	a Biomass Plastic b Cellulose Nanofibers c Production of Chemicals from Biomass
02	Reduction of CO2 Emission in Steelmaking Process	a Hydrogen Reduction Steelmaking b Direct Reduced Iron (DRI) c Highly Reactive Coke d Electrolytic Reduction Method
03	Recycling	a Plastic Recycling b Iron Recycling c Aluminum Recycling d Copper Recycling
gxE	Capture, Storage, Utilization and Removal of Greenhouse Gas	
01	CCS, CCUS, Negative Emission	a CO2 Separation by Absorption b CO2 Separation by Adsorption c CO2 Separation by Membranes d DAC (Direct Air Capture) e Oxyfuel Combustion, Chemical Looping f Underground Storage of CO2, Effective Use of Underground CO2 Injection g CO2 Fixation as Carbonates (Concrete, etc. and Blast Furnace Slag) h CO2 Absorption and Fixation by Organisms (Forest, Agricultural Soil Carbon, Urban Greening, Marine Biological Systems) i CO2 Conversion into Hydrocarbons and Derivatives by Reduction (Methanation, Electrosynthesis, Carboxylation, Artificial Photosynthesis, etc.) j CO2 Conversion by Non-Reductive Methods k CO2 Transportation
02	Measures Against Non-CO2 Greenhouse Gases	a Recovery, Decomposition and Detoxification of Chlorofluorocarbon Gas b Green Refrigerants (Low GWP Refrigerant) c Reduction of Non-CO2 Greenhouse Gases from Livestock and Agricultural Land

## 2. Survey and Analysis Methodology

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- Technology Categories of Survey :

Overall GX Technology, GXTI Large Category, GXTI Medium Category, Notable Technologies outside GXTI.

(The search formulae are based on the GXTI version 1.03 published on September 2, 2022.)

- Countries/regions of Survey: Japan, USA, Europe, Germany, France, UK, China, Taiwan, South Korea, Canada, India, ASEAN, Australia (including PCT applications)

European applications in this survey include Ireland, Italy, Austria, Netherlands, Switzerland, Sweden, Spain, Slovakia, Czech Republic, Denmark, Germany, Turkey, Norway, Hungary, Finland, France, Belgium, Poland, Portugal, Romania, Luxembourg, UK, and European Patent Convention (EPC).

- Period of Survey: 2010-2021 (Filing Year (Priority year))

- Database: Derwent™ Innovation

- Survey implementation date (search date): October 24, 2022 - December 16, 2022

### 3. Utilization of GXTI

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- The International Patent Classification (IPC) search formulae make it possible for **anyone to conduct a global patent information analysis under the same conditions**. In addition, by conducting the analysis under the same conditions, **third parties can also compare and evaluate the search results**.
- The hierarchical structure enables analysis according to the purpose.
- Each applicant data can also be obtained by adding the applicant's name to the search formulae.



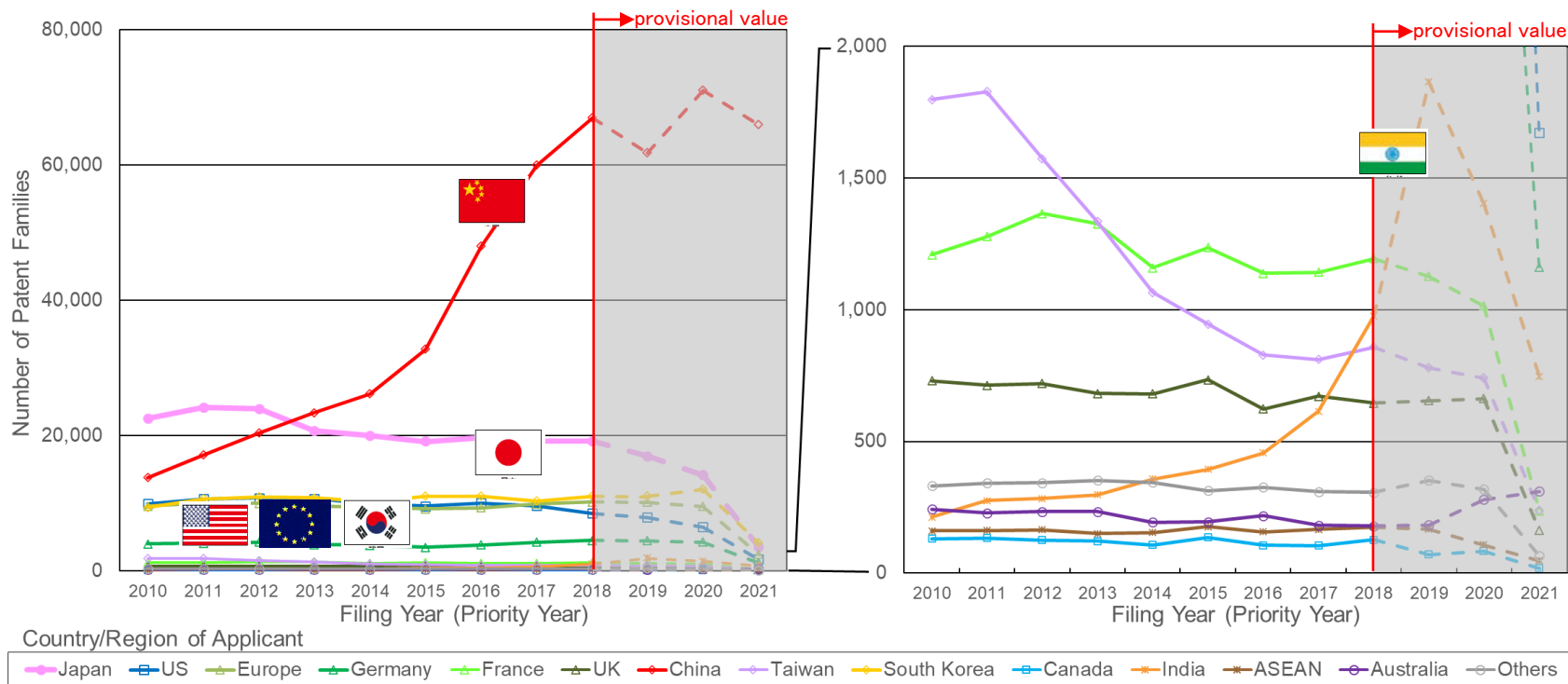
- For example, the results of patent information analysis using GXTI can be utilized as follows:
  - The results of patent information analysis help companies **figure out their strengths and weaknesses of their GX-related technologies** and companies can utilize them in the formulation of their own management strategy and Research and Development strategy on an evidence basis.
  - Based on the results of patent information analysis, companies can explain to investors the superiority of their R&D capabilities related to GX-related technologies on an evidence basis.
  - Government agencies and NPOs **can use the patent information to visualize trends in GX-related technologies in countries and regions around the world, including developing countries**, and to support GX initiatives in countries and regions around the world on an evidence basis.

The utilization of GXTI as a common asset in analyzing patent information on GX-related technologies is expected to contribute toward improving the economic and social value of companies, and promoting innovation to solve environmental problems.

## 4. Overall GX Technology Trends Research 1/2

### Number of patent families by Country / Region of Applicant Annual Trends

- In 2010, the number of patent families by Japanese applicants was the largest, but since 2013, the number has leveled off.
- The number of patent families by **Chinese applicants** increases rapidly, **surpassing the number of patent families by Japanese applicants in 2013**.
- The number of patent families by applicants of most countries/regions remained almost flat.
- The number of patent families by Indian applicants has been increasing since around 2015.

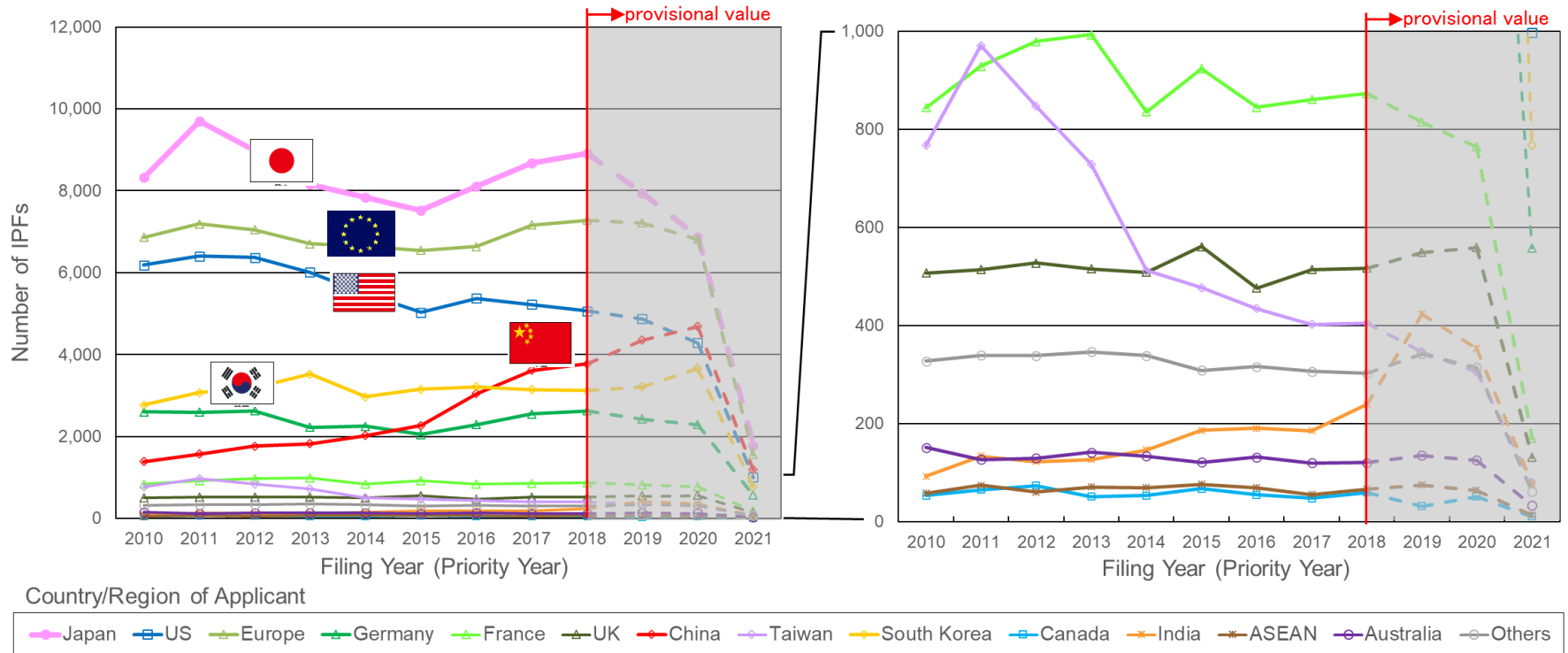


Note that at the time this study was conducted, Derwent™ Innovation may not have had sufficient data recorded after the priority claim year 2019. Therefore, data after 2019 are indicated by dotted lines.

## 4. Overall GX Technology Trends Research 2/2

### Number of IPFs by Country / Region of Applicant Annual Trends

- The number of IPFs by **Japanese applicants** remained the highest throughout the entire survey period, indicating **the significant presence of Japan in the GX technology field**.
  - The number of IPFs by **Chinese applicants** is gradually increasing, but **the growth is slower than the number of patent families, about half that of Japanese applicants as of 2019**.
- ➡ ■ The majority of applications filed by **Chinese applicants** are guessed to be filed **in only their country**.



Note that at the time this study was conducted, Derwent™ Innovation may not have had sufficient data recorded after the priority claim year 2019. Therefore, data after 2019 are indicated by dotted lines.

## 5. GXTI Level 1 Category Trends Research

### Number of IPFs by Year and by Country / Region of applicant

- **gxB and gxC are increasing**, gxD and gxE are flat, and gxA is decreasing.

Large Category		Filing Year (Priority Year)											
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
gxA	Energy Supply	10,067	10,102	9,018	7,857	7,224	6,919	6,957	7,088	7,096	6,894	6,889	1,604
gxB	Energy Saving, Electrification,	11,358	13,201	13,341	13,364	12,788	12,507	13,775	14,329	14,294	13,266	11,349	2,649
gxC	Batteries, Energy Storage	5,208	5,978	6,117	5,902	5,839	5,950	6,765	7,650	8,173	8,651	8,905	2,240
gxD	CO2 Reduction in Non-Energy Sector	1,351	1,382	1,424	1,398	1,234	1,262	1,255	1,199	1,317	1,541	1,507	332
gxE	Capture, Storage, Utilization and	779	812	826	751	740	714	708	753	733	758	690	136

- The number of IPFs by Japanese applicants is **the largest in gxB and gxC**.
- The number of IPFs by European applicants is the largest in **gxA**.
- The number of IPFs by US applicants is the largest in **gxD and gxE**.

Large Category		Country/Region of Applicant (Filing Year (Priority Year): 2010-2021)												
		Japan	US	Europe	Germany	France	UK	China	Taiwan	South Korea	Canada	India	ASEAN	Australia
gxA	Energy Supply	19,705	19,674	27,550	7,826	3,478	2,353	6,717	1,623	8,697	238	853	290	703
gxB	Energy Saving, Electrification,	48,009	26,090	35,286	14,443	4,224	2,350	15,573	3,658	14,758	260	664	233	462
gxC	Batteries, Energy Storage	28,065	12,185	13,079	6,062	1,992	938	8,618	954	13,154	82	522	119	212
gxD	CO2 Reduction in Non-Energy Sector	1,802	5,152	4,679	563	502	386	1,502	195	804	49	326	110	148
gxE	Capture, Storage, Utilization and	1,741	2,930	2,445	447	374	279	344	56	509	32	90	52	95

In the table, gray cells indicate the top three positions, red boxes indicate the first position, and blue boxes indicate the second position.



## 6. GXTI Level 2 Category Trends Research

### Ranking trends by country / region of IPFs

- Chinese applicants have significantly increased their presence in the overall GX technology field in recent years, especially in the gxA, where they have been among the top three in Ocean Energy / Wind / Hydro-Power Generation, Solar Thermal Energy Utilization, and Biomass.
- Japanese applicants maintain their position (except Power Transmission and Distribution, SmartGrids) for the technology fields in which they were ranked No. 1 in 2011-2013. However, the order for gxA reversed with Chinese applicants in a number of fields.

Energy Supply (gxA)	2011-2013				
	JP	US	EU	CN	KR
Solar Photovoltaic Power Generation	1	2	3	5	4
Solar Thermal Energy Utilization	3	2	1	4	5
Wind Power Generation	3	2	1	4	5
Geothermal Utilization	3	1	2	4	4
Hydro-Power Generation	3	2	1	4	5
Ocean Energy Power Generation	5	2	1	4	3
Biomass	3	1	2	5	4
Nuclear Power Generation	3	1	2	5	4
Fuel Cells	1	2	3	5	4
Hydrogen Technology	3	2	1	5	4
Ammonia Technology	3	2	1	5	4

2017-2019					
JP	US	EU	CN	KR	
1	3	2	4	5	
4	2	1	3	5	
4	2	1	3	5	
3	2	1	4	5	
4	2	1	3	5	
4	3	1	2	5	
4	2	1	3	5	
4	1	2	5	3	
1	3	2	5	4	
2	3	1	5	4	
3	2	1	4	5	

Batteries, Energy Storage (gxC)	2011-2013				
	JP	US	EU	CN	KR
Secondary Batteries	1	2	4	5	3
Mechanical Energy Storage	3	2	1	5	4
Thermal Energy Storage	3	2	1	4	5
Electric Double Layer Capacitors, Hybrid Capacitors	1	2	3	5	4

2017-2019					
JP	US	EU	CN	KR	
1	5	3	4	2	
3	2	1	4	5	
2	3	1	4	5	
1	2	3	4	5	

CO2 Reduction in Non-Energy Sector (gxD)	2011-2013				
	JP	US	EU	CN	KR
Chemical Production from Biomass	3	1	2	4	5
Reduction of CO2 Emission in Steelmaking Process	3	2	1	5	4
Recycling	3	2	1	4	5

2017-2019					
JP	US	EU	CN	KR	
4	1	2	3	5	
3	2	1	4	5	
3	2	1	4	5	

Energy Saving, Electrification, Demand-Supply Flexibility (gxB)	2011-2013				
	JP	US	EU	CN	KR
Energy Saving in Buildings (ZEB, ZEH, etc.)	1	3	2	5	4
High-Efficiency Motors and Inverters	1	3	2	5	4
Combined Heat and Power (CHP)	2	3	1	5	4
Energy Saving and Supply/Demand Flexibility in Treatment of Water, Wastewater, Sewage, and Sludge	4	1	2	3	5
Electromobilities	1	3	2	5	4
Electrification of Industrial Heat	2	3	1	5	4
Power Transmission and Distribution, Smart Grids	1	2	3	5	4
Demand-Supply Flexibility of Power Systems	2	1	2	5	2

2017-2019					
JP	US	EU	CN	KR	
1	4	3	2	5	
1	3	2	4	5	
2	3	1	4	5	
4	3	2	1	5	
1	3	2	5	4	
2	3	1	4	5	
2	3	1	4	5	
1	2	4	4	2	

Capture, Storage, Utilization and Removal of Greenhouse Gas (gxE)	2011-2013				
	JP	US	EU	CN	KR
CCS, CCUS, Negative Emission	3	1	2	5	4
Measures Against Non-CO2 Greenhouse Gases	2	1	3	4	5

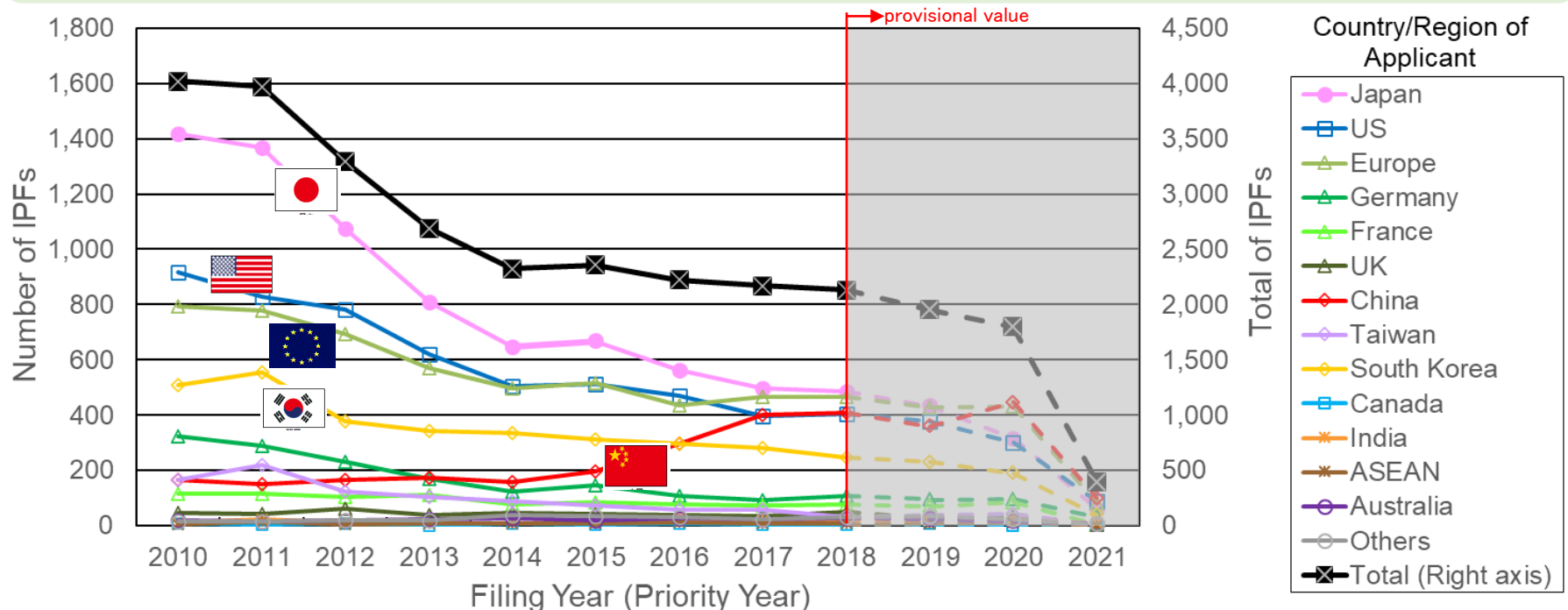
2017-2019					
JP	US	EU	CN	KR	
3	1	2	4	5	
1	2	3	4	5	

\*"Demand-Supply Flexibility of Power Systems" has a single-digit number of IPFs, and the ranking is for reference only.

## 7. GXTI Level 2 Category Trends Research

### 7-1. gxA01: Solar Photovoltaic Power Generation 1/3

- The total number of IPFs is on a **decreasing**, it implies that the industry may be moving from the development phase of new technologies to the dissemination phase of existing technologies.
- The number of IPFs by **Japanese applicants is the largest** in each year from 2010 to 2018 .
- While the number of IPFs by Japanese, US, European, and Korean applicants in recent years are decreasing, the number of IPFs by **Chinese applicants has increased to the same level** as those of Japanese, US, and European applicants.



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## 7. GXTI Level 2 Category Trends Research

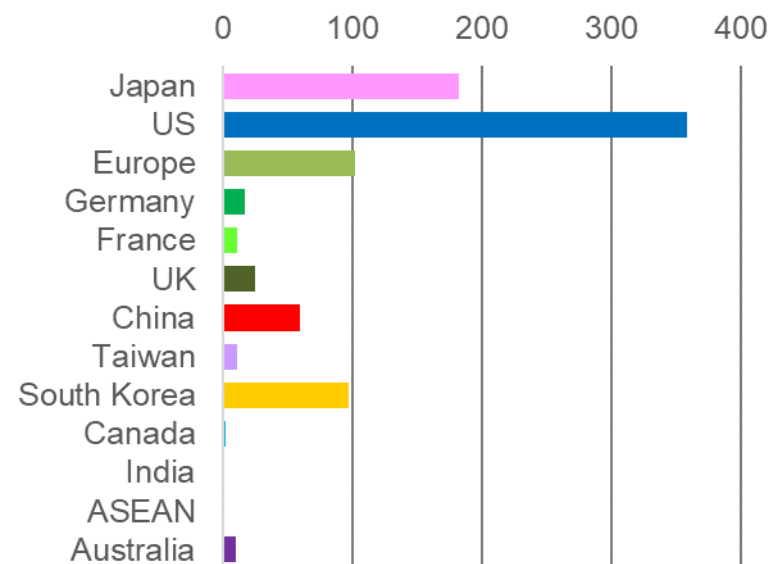
### 7-1. gxA01: Solar Photovoltaic Power Generation 2/3

- Japanese applicants account for 10 of the top 20 applicants by number of IPFs.
- “The number of highly cited IPFs” by US applicants is the largest at 359, that by Japanese applicants is the second largest at 182, that by European applicants is 102, that by Korean applicants is 97, that by Chinese applicants is 59.
- These results of the number of IPFs and the number of highly cited IPFs imply that Japanese applicants have strengths and US applicants and Europeans applicants also have presence in the Solar Photovoltaic Power Generation. The rise of the number of IPFs by Chinese applicants in recent years should also be noted.

Top 20 Applicants by number of IPFs  
Filing Year (Priority Year): 2010-2021

Order	Number	Name of Applicant	Country / Region
1	909	LG CORPORATION	Korea
2	808	PANASONIC CORP.	Japan
3	799	SAMSUNG GROUP	Korea
4	553	SHARP CORP.	Japan
5	482	FUJIFILM CORP.	Japan
6	476	SANYO ELECTRIC CO.,LTD.	Japan
7	402	SONY GROUP CORP.	Japan
8	380	FRENCH ALTERNATIVE ENERGIES AND ATOMIC ENERGY COMMISSION	France
9	352	TOTAL S.A.	France
10	322	TOSHIBA CORP.	Japan
11	263	mitsubishi electric corp.	Japan
12	247	KYOCERA CORP.	Japan
13	242	MERCK KGAA	Germany
14	228	KANEKA CORPORATION	Japan
15	213	SUMITOMO CHEMICAL CO., LTD.	Japan
16	199	HANERGY HOLDING GROUP LTD.	China
17	178	FIRST SOLAR, INC.	US
18	167	DUPONT DE NEMOURS, INC.	US
19	158	AU OPTRONICS CORP.	Taiwan
20	154	TAIWAN SEMICONDUCTOR MFG CO., LTD.	Taiwan

Number of highly cited IPFs  
Filing Year (Priority Year): 2010-2021



## 7. GXTI Level 2 Category Trends Research

### 7-1. gxA01: Solar Photovoltaic Power Generation 3/3

- Japanese applicants accounted for half of the top 20 in the number of IPFs during all periods.
- Focusing on Japanese applicants, KANEKA CORPORATION has increased its number of IPFs in recent years, while automobile manufacturers have also been ranked in the top 20.
- While U.S. applicants have fallen out of the rankings in recent years, the number of Chinese applicants in the top 20 has increased.

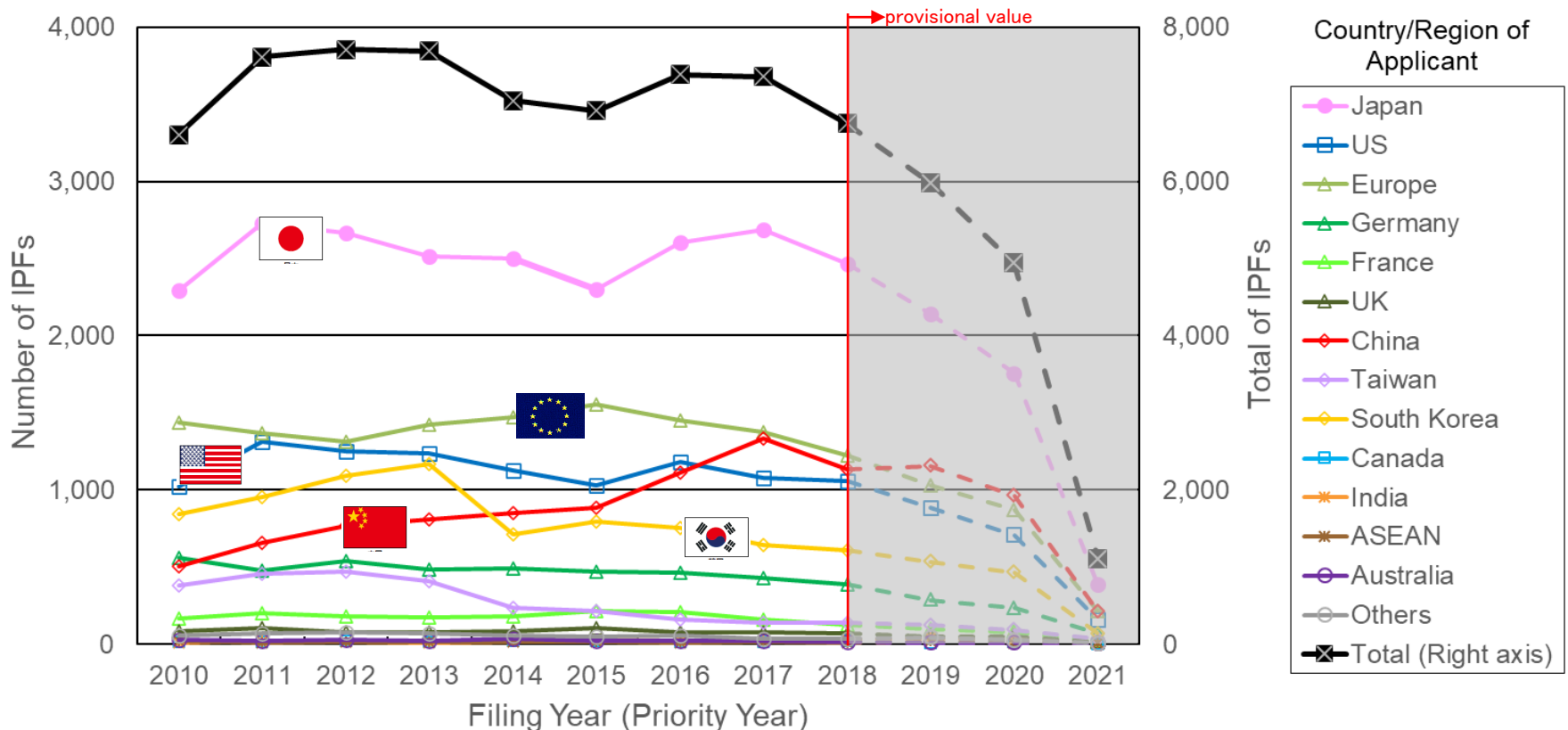
Trends of top 20 applicants by number of IPFs

2010–2013 (year)				2014–2017 (year)				2018–2021 (year)			
Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region
1	501	LG CORPORATION	Korea	1	299	LG CORPORATION	Korea	1	148	SAMSUNG GROUP	Korea
2	475	SANYO ELECTRIC CO.,LTD.	Japan	2	275	PANASONIC CORP.	Japan	2	130	PANASONIC CORP.	Japan
3	429	SAMSUNG GROUP	Korea	3	222	SAMSUNG GROUP	Korea	3	113	KANEKA CORPORATION	Japan
4	403	PANASONIC CORP.	Japan	4	148	SHARP CORP.	Japan	4	109	LG CORPORATION	Korea
5	379	SHARP CORP.	Japan	5	145	FRENCH ALTERNATIVE ENERGIES AND ATOMIC ENERGY COMMISSION	France	5	89	SONY GROUP CORP.	Japan
6	335	FUJIFILM CORP.	Japan	6	139	TOTAL S.A.	France	6	84	FRENCH ALTERNATIVE ENERGIES AND ATOMIC ENERGY COMMISSION	France
7	198	SONY GROUP CORP.	Japan	7	115	SONY GROUP CORP.	Japan	7	81	HANERGY HOLDING GROUP LTD.	China
8	151	FRENCH ALTERNATIVE ENERGIES AND ATOMIC ENERGY COMMISSION	France	7	115	TOSHIBA CORP.	Japan	8	75	TOSHIBA CORP.	Japan
9	149	TOTAL S.A.	France	9	105	MITSUBISHI ELECTRIC CORP.	Japan	9	69	HUAWEI TECHNOLOGIES CO., LTD.	China
10	143	FIRST SOLAR, INC.	US	10	101	FUJIFILM CORP.	Japan	10	64	TOTAL S.A.	France
11	142	MERCK KGAA	Germany	10	101	HANERGY HOLDING GROUP LTD.	China	11	57	SUMITOMO ELECTRIC INDUSTRIES, LTD.	Japan
12	133	DUPONT DE NEMOURS, INC.	US	12	86	KYOCERA CORP.	Japan	11	57	LONGI SOLAR TECHNOLOGY CO., LTD.	China
13	132	TOSHIBA CORP.	Japan	13	84	MERCK KGAA	Germany	13	53	SUMITOMO CHEMICAL CO., LTD.	Japan
14	131	KYOCERA CORP.	Japan	14	77	KANEKA CORPORATION	Japan	14	46	FUJIFILM CORP.	Japan
15	129	MITSUBISHI ELECTRIC CORP.	Japan	15	64	SEKISUI CHEMICAL CO., LTD.	Japan	15	43	Sungrow Power Supply Co., Ltd.	China
16	121	Showa Denko Materials co.,Ltd.	Japan	16	61	DAIKIN INDUSTRIES, LTD. BOE TECHNOLOGY GROUP CO., LTD.	China	15	43	Hanwha Group	Korea
17	113	AU OPTRONICS CORP.	Taiwan	17	58	SUMITOMO CHEMICAL CO., LTD.	Japan	17	39	TOYOTA MOTOR CORPORATION	Japan
18	111	KONICA MINOLTA, INC.	Japan	18	57	TOYOTA MOTOR CORPORATION	Japan	18	38	RICOH CO., LTD.	Japan
19	110	ROBERT BOSCH GMBH	Germany	19	56	SUMITOMO ELECTRIC INDUSTRIES, LTD.	Japan	19	36	JINKOSOLAR HOLDING CO., LTD.	China
20	102	SUMITOMO CHEMICAL CO., LTD.	Japan	19	56	OSRAM GMBH	Germany	20	34	HONDA MOTOR CO., LTD.	Japan
20	102	DOW INC.	US								

## 7. GXTI Level 2 Category Trends Research

### 7-2. gxB01: Energy Saving in Buildings (ZEB, ZEH, etc.) 1/3

- Total number of IPFs remained around 7,000.
- The number of IPFs by **Japanese applicants** in each year from 2010 to 2018 **is the largest** at approximately 2500, highly surpassing that by European applicants that is the second largest.



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## 7. GXTI Level 2 Category Trends Research

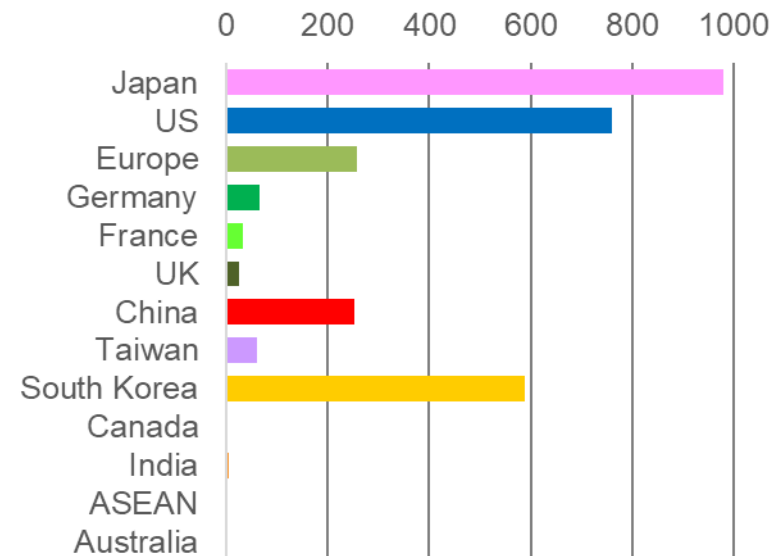
### 7-2. gxB01: Energy Saving in Buildings (ZEB, ZEH, etc.) 2/3

- Japanese applicants account for 12 of the top 20 IPF applicants by number of IPFs.
- “The number of highly cited IPFs” by Japanese applicants is the largest at approximately 1,000, that by US applicants is the second largest at approximately 800, that by Korean applicants is approximately 600, and that by European applicants and Chinese applicants are approximately 300 each.
- These results of the number of IPFs, highly cited IPFs, and the number of applicants in the top 20 IPFs, implying that **Japanese applicants have strength in this technology category.**

Top 20 Applicants by number of IPFs  
Filing Year (Priority Year): 2010-2021

Order	Number	Name of Applicant	Country / Region
1	3,106	SAMSUNG GROUP	Korea
2	2,827	PANASONIC CORP.	Japan
3	2,563	LG CORPORATION	Korea
4	2,342	MITSUBISHI ELECTRIC CORP.	Japan
5	1,969	KONINKLIJKE PHILIPS N.V.	Netherlands
6	1,953	SHARP CORP.	Japan
7	1,686	OSRAM GMBH	Germany
8	1,418	SIGNIFY N.V.	Netherlands
9	1,404	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	Japan
10	1,053	JAPAN DISPLAY INC.	Japan
11	1,005	TOSHIBA CORP.	Japan
12	945	DAIKIN INDUSTRIES, LTD.	Japan
13	833	ZUMTOBEL AG	Austria
14	799	KOITO MANUFACTURING CO., LTD.	Japan
15	793	VALEO S.A.	France
16	767	SUMITOMO CHEMICAL CO., LTD.	Japan
17	753	FUJIFILM CORP.	Japan
18	721	KONICA MINOLTA, INC.	Japan
19	674	SONY GROUP CORP.	Japan
20	663	BOE TECHNOLOGY GROUP CO., LTD.	China

Number of highly cited IPFs  
Filing Year (Priority Year): 2010-2021



## 7. GXTI Level 2 Category Trends Research

### 7-2. gxB01: Energy Saving in Buildings (ZEB, ZEH, etc.) 3/3

- Japanese applicants accounted for half of the top 20 in the number of IPFs during all periods.
- Focusing on Japanese applicants, MITSUBISHI ELECTRIC CORP. has maintained the top position since 2014, while DAIKIN INDUSTRIES, KOITO MANUFACTURING CO., LTD. and SUMITOMO CHEMICAL CO., LTD. have increased their numbers in recent years.
- In this technology field, there is little turnover among the companies in the rankings.

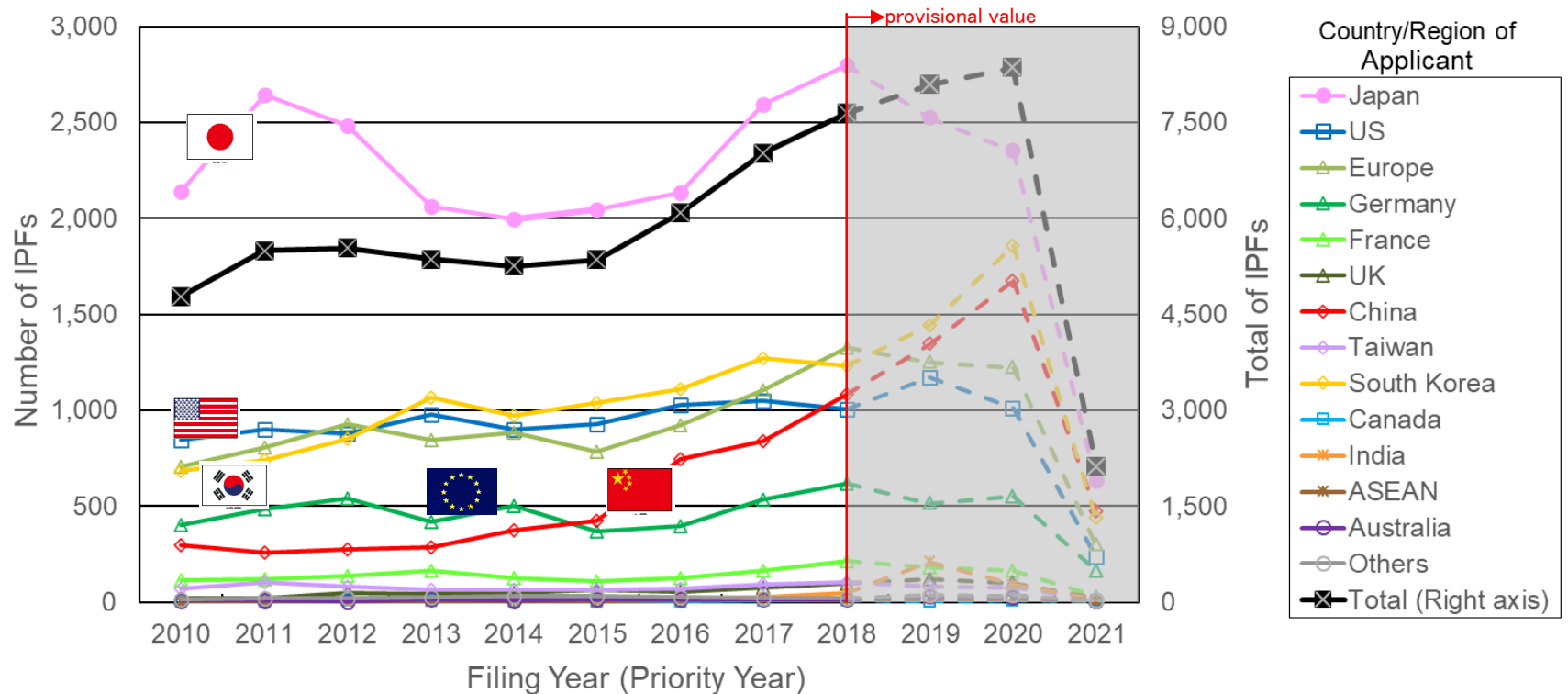
#### Trends of top 20 applicants by number of IPFs

2010-2013 (year)				2014-2017 (year)				2018-2021 (year)			
Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region
1	1,867	SAMSUNG GROUP	Korea	1	1,119	MITSUBISHI ELECTRIC CORP.	Japan	1	637	MITSUBISHI ELECTRIC CORP.	Japan
2	1,392	PANASONIC CORP.	Japan	2	1,017	PANASONIC CORP.	Japan	2	557	SHARP CORP.	Japan
3	1,019	LG CORPORATION	Korea	3	992	LG CORPORATION	Korea	3	552	LG CORPORATION	Korea
4	889	SHARP CORP.	Japan	4	895	KONINKLIJKE PHILIPS N.V.	Netherlands	4	526	SIGNIFY N.V.	Netherlands
5	888	KONINKLIJKE PHILIPS N.V.	Netherlands	5	806	SAMSUNG GROUP	Korea	5	433	SAMSUNG GROUP	Korea
6	863	OSRAM GMBH	Germany	6	630	OSRAM GMBH	Germany	6	418	PANASONIC CORP.	Japan
7	643	TOSHIBA CORP.	Japan	7	627	JAPAN DISPLAY INC.	Japan	7	349	DAIKIN INDUSTRIES, LTD.	Japan
8	586	MITSUBISHI ELECTRIC CORP.	Japan	8	583	SIGNIFY N.V.	Netherlands	8	321	KOITO MANUFACTURING CO., LTD.	Japan
9	579	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	Japan	9	527	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	Japan	9	298	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	Japan
10	428	HON HAI PRECISION IND CO., LTD.	Taiwan	10	507	SHARP CORP.	Japan	10	294	SUMITOMO CHEMICAL CO., LTD.	Japan
11	395	KONICA MINOLTA, INC.	Japan	11	398	VALEO S.A.	France	11	267	JAPAN DISPLAY INC.	Japan
12	362	ZUMTOBEL AG	Austria	12	375	DAIKIN INDUSTRIES, LTD. BOE TECHNOLOGY GROUP CO., LTD.	China	12	258	CANON INC.	Japan
13	323	AU OPTRONICS CORP.	Taiwan	13	352	DAIKIN INDUSTRIES, LTD.	Japan	13	248	Nitto Denko Corporation	Japan
14	309	SIGNIFY N.V.	Netherlands	14	299	ZUMTOBEL AG	Austria	14	229	Nichia Corporation	Japan
15	300	SONY GROUP CORP.	Japan	15	276	KONICA MINOLTA, INC.	Japan	15	222	FUJIFILM CORP.	Japan
16	289	TCL TECHNOLOGY	China	16	263	KOITO MANUFACTURING CO., LTD.	Japan	16	221	Leedarson IoT Technology Inc.	China
17	278	FUJIFILM CORP.	Japan	17	253	FUJIFILM CORP.	Japan	17	193	OSRAM GMBH	Germany
18	270	JOLED Inc.	Japan	17	253	SUMITOMO CHEMICAL CO., LTD.	Japan	18	190	DAIKIN INDUSTRIES, LTD. BOE TECHNOLOGY GROUP CO., LTD.	China
19	256	HITACHI, LTD.	Japan	19	244	TOSHIBA CORP.	Japan	19	186	KONINKLIJKE PHILIPS N.V.	Netherlands
20	245	CANON INC.	Japan	20	227	TCL TECHNOLOGY	China	20	182	VALEO S.A.	France

## 7. GXTI Level 2 Category Trends Research

### 7-3. gxC01: Secondary Batteries 1/3

- The total number of IPFs has **increased significantly** from less than 5,000 in 2010 to more than 8,000 in 2019 and 2020, **implying that R&D has been active**.
- The number of IPFs by **Japanese applicants** in each year from 2010 to 2018 **is the largest** above 2,000, **highly surpassing** that by second largest country and region at approximately 1,000.



Note that at the time this study was conducted, Derwent™ Innovation may not have had sufficient data recorded after the priority claim year 2019. Therefore, data after 2019 is indicated by dotted lines.



## 7. GXTI Level 2 Category Trends Research

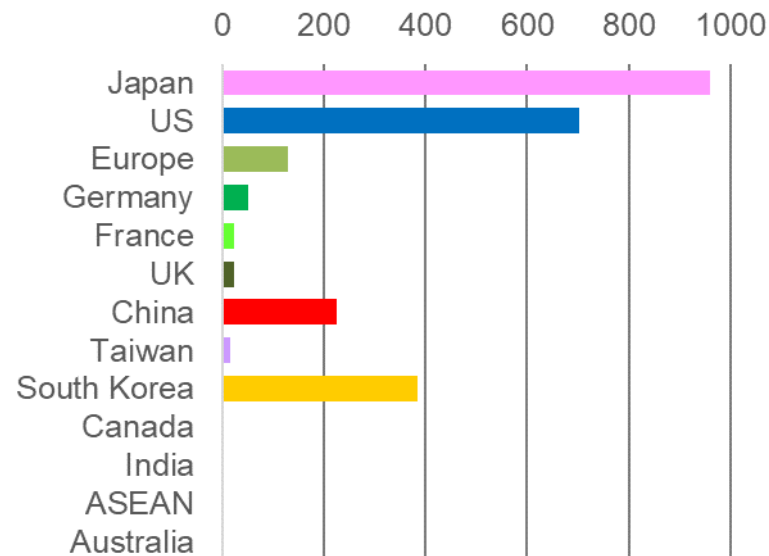
### 7-3. gxCO1: Secondary Batteries 2/3

- Japanese applicants account for 12 of the top 20 applicants by number of IPFs.
- “The number of highly cited IPFs” by **Japanese applicants is the largest** at 959, and that by **U.S. applicants is the second largest** at 703, **highly surpassing** that by Korean applicants in the third largest at 384.
- These result imply Japanese applicants have strength in the field of secondary batteries.**

Top 20 Applicants by number of IPFs  
Filing Year (Priority Year): 2010-2021

Order	Number	Name of Applicant	Country / Region
1	5,355	LG CORPORATION	Korea
2	4,976	SAMSUNG GROUP	Korea
3	3,064	TOYOTA MOTOR CORPORATION	Japan
4	2,376	ROBERT BOSCH GMBH	Germany
5	2,307	PANASONIC CORP.	Japan
6	1,500	SANYO ELECTRIC CO.,LTD.	Japan
7	1,306	CONTEMPORARY AMPEREX TECHNOLOGY CO., LTD.	China
8	1,181	HONDA MOTOR CO., LTD.	Japan
9	1,033	TDK CORP.	Japan
10	1,029	GS YUASA CORPORATION	Japan
11	1,007	MURATA MFG CO., LTD.	Japan
12	934	HITACHI, LTD.	Japan
13	916	HYUNDAI MOTOR CORP.	Korea
14	872	TOSHIBA CORP.	Japan
15	804	GENERAL MOTORS CORP.	US
16	794	FORD MOTOR CO.	US
17	732	SUMITOMO ELECTRIC INDUSTRIES, LTD.	Japan
18	696	NISSAN MOTOR CO., LTD.	Japan
19	688	NEC CORP.	Japan
20	628	KIA CORP.	Korea

Number of highly cited IPFs  
Filing Year (Priority Year): 2010-2021



## 7. GXTI Level 2 Category Trends Research

### 7-3. gxC01: Secondary Batteries 3/3

- Japanese applicants accounted for half of the top 20 in the number of inventions developed internationally during all periods.
- Focusing on Japanese applicants, TOYOTA MOTOR CORPORATION is increasing its presence, while PANASONIC CORP, TDK CORP, and HONDA MOTOR CO., LTD. have seen their numbers increase significantly in recent years.
- In terms of Korean applicants, LG CORPORATION has increased the number of IPFs, while SAMSUNG GROUP has decreased them.

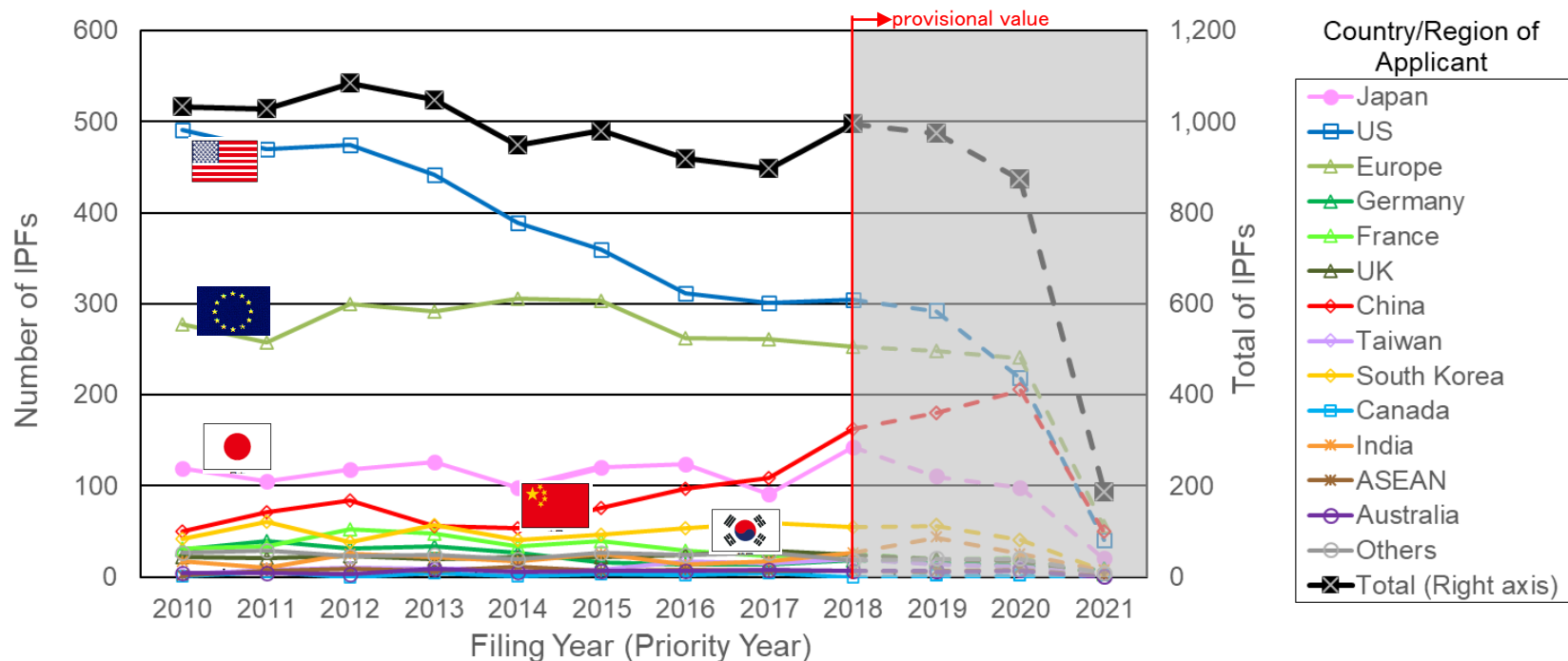
Trends of top 20 applicants by number of IPFs

2010-2013 (year)				2014-2017 (year)				2018-2021 (year)			
Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region
1	2,264	SAMSUNG GROUP	Korea	1	1,699	LG CORPORATION	Korea	1	2,675	LG CORPORATION	Korea
2	1,131	ROBERT BOSCH GMBH	Germany	2	1,683	SAMSUNG GROUP	Korea	2	1,080	TOYOTA MOTOR CORPORATION	Japan
3	981	LG CORPORATION	Korea	3	1,039	TOYOTA MOTOR CORPORATION	Japan	3	1,052	CONTEMPORARY AMPEREX TECHNOLOGY CO., LTD.	China
4	945	TOYOTA MOTOR CORPORATION	Japan	4	812	ROBERT BOSCH GMBH	Germany	4	1,029	SAMSUNG GROUP	Korea
5	761	SANYO ELECTRIC CO.,LTD.	Japan	5	665	PANASONIC CORP.	Japan	5	1,014	PANASONIC CORP.	Japan
6	628	PANASONIC CORP.	Japan	6	427	FORD MOTOR CO.	US	6	756	TDK CORP.	Japan
7	510	HITACHI, LTD.	Japan	7	398	GS YUASA CORPORATION	Japan	7	667	HONDA MOTOR CO., LTD.	Japan
8	468	NISSAN MOTOR CO., LTD.	Japan	8	377	MURATA MFG CO., LTD.	Japan	8	433	ROBERT BOSCH GMBH	Germany
9	386	SB LIMOTIVE CO. LTD.	Korea	9	351	TOSHIBA CORP.	Japan	9	424	HYUNDAI MOTOR CORP.	Korea
10	351	NEC CORP.	Japan	10	336	SANYO ELECTRIC CO.,LTD.	Japan	10	403	SANYO ELECTRIC CO.,LTD.	Japan
11	340	SONY GROUP CORP.	Japan	11	313	NEC CORP.	Japan	11	395	KIA CORP.	Korea
12	296	GENERAL MOTORS CORP.	US	12	303	HITACHI, LTD.	Japan	12	389	MURATA MFG CO., LTD.	Japan
13	284	TOSHIBA CORP.	Japan	12	303	SUMITOMO ELECTRIC INDUSTRIES, LTD.	Japan	13	352	GS YUASA CORPORATION	Japan
14	279	GS YUASA CORPORATION	Japan	14	300	HYUNDAI MOTOR CORP.	Korea	14	305	GENERAL MOTORS CORP.	US
15	266	TOYOTA INDUSTRIES CORP.	Japan	15	284	HONDA MOTOR CO., LTD.	Japan	15	302	SK Group	Korea
16	241	MURATA MFG CO., LTD.	Japan	16	249	CONTEMPORARY AMPEREX TECHNOLOGY CO., LTD.	China	16	253	FORD MOTOR CO.	US
17	230	HONDA MOTOR CO., LTD.	Japan	17	230	SUMITOMO CHEMICAL CO., LTD.	Japan	17	239	VOLKSWAGEN A.G.	Germany
18	211	SUMITOMO ELECTRIC INDUSTRIES, LTD.	Japan	18	226	TOYOTA INDUSTRIES CORP.	Japan	18	237	DENSO CORP.	Japan
19	205	HON HAI PRECISION IND CO., LTD.	Taiwan	19	203	TDK CORP.	Japan	18	237	TOSHIBA CORP.	Japan
20	196	DAIMLER A.G.	Germany	19	203	GENERAL MOTORS CORP.	US	20	218	SUMITOMO ELECTRIC INDUSTRIES, LTD.	Japan

## 7. GXTI Level 2 Category Trends Research

### 7-4. gxD01: Chemical Production from Biomass 1/3

- This technology category includes biomass plastics, cellulose nanofibers, etc.
- The total number of IPFs remains at around 1,000.
- The number of IPFs by **U.S. applicants was the largest at just under 500** until 2012, but since 2016 the number of IPFs has been around 300, with a smaller difference from the number of IPFs by European applicants.
- The number of IPFs by Japanese applicants is expected to remain at around 100, while that **by Chinese applicants is on the rise and is expected to equal that by European and U.S. applicants by around 2020.**



Note that at the time this study was conducted, Derwent™ Innovation may not have had sufficient data recorded after the priority claim year 2019. Therefore, data after 2019 are indicated by dotted lines.

## 7. GXTI Level 2 Category Trends Research

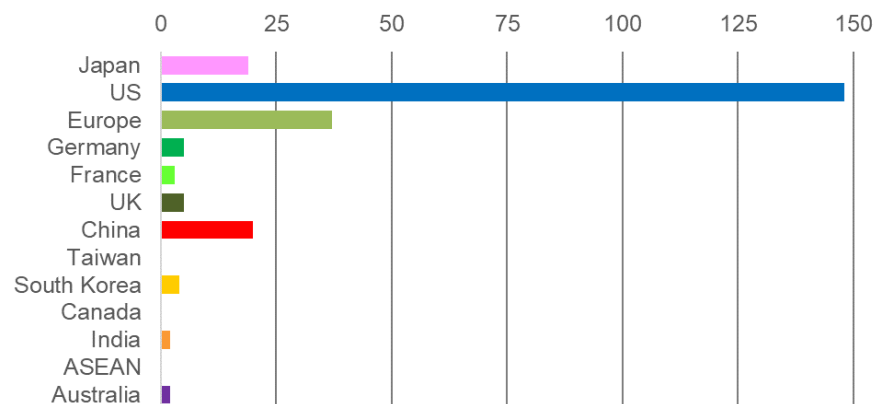
### 7-4. gxD01: Chemical Production from Biomass 2/3

- **U.S. applicants account for five of the top 20** in the number of IPFs.
- Materials and chemical manufacturers are making their presence felt in each country, while paper manufacturers are unique among Japanese applicants in that they are ranked among the top 20.
- Nordic applicants, universities and research institutes are also ranked in the top 20, such as JIANGNAN UNIVERSITY (China), UNIVERSITY OF CALIFORNIA (U.S.), and IFP ENERGIES NOUVELLES S.A.(France).

Top 20 applicants by number of IPFs  
Filing Year (Priority Year): 2010-2021

Order	Number	Country / Region	Country / Region
1	313	DUPONT DE NEMOURS, INC.	US
2	290	NOVO NORDISK AS	Denmark
3	226	KONINKLIJKE DSM N.V.	Netherlands
4	193	BASF SE	Germany
5	120	EVONIK IND A.G.	Germany
6	112	JIANGNAN UNIVERSITY	China
7	95	TORAY INDUSATRIES, INC.	Japan
8	83	UNIVERSITY OF CALIFORNIA	US
9	81	IFP ENERGIES NOUVELLES S.A.	France
10	80	MITSUBISHI CHEMICAL HOLDINGS CORP.	Japan
10	80	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	France
12	77	CJ CHEILJEDANG CORP.	Korea
13	75	INVISTA NORTH AMERICA S.A.R.L.	US
14	66	UPM KYMMENE CORP.	Finland
15	64	LANZATECH NEW ZEALAND LTD	New Zealand
16	57	NIPPON PAPER INDUSATRIES CO., LTD.	Japan
17	56	STORA ENSO OYJ	Finland
18	53	OJI HOLDINGS CORP.	Japan
18	53	CARGILL INCORPORATED	US
18	53	DOW INC.	US

Number of highly cited IPFs  
Filing Year (Priority year): 2010-2021



## 7. GXTI Level 2 Category Trends Research

### 7-4. gxD01: Chemical Production from Biomass 3/3

- In 2010-2013, **U.S. applicants** accounted for 6 of the top 20, but this number has **decreased** in recent years to two among the top 20. On the other hand, Chinese applicants have entered the rankings in recent years, which was not seen in 2010-2013.
- The presence of Nordic applicants, universities and research institutes have also been seen within the rankings, **which have accounted for 7 out of the top 21 in recent years.**

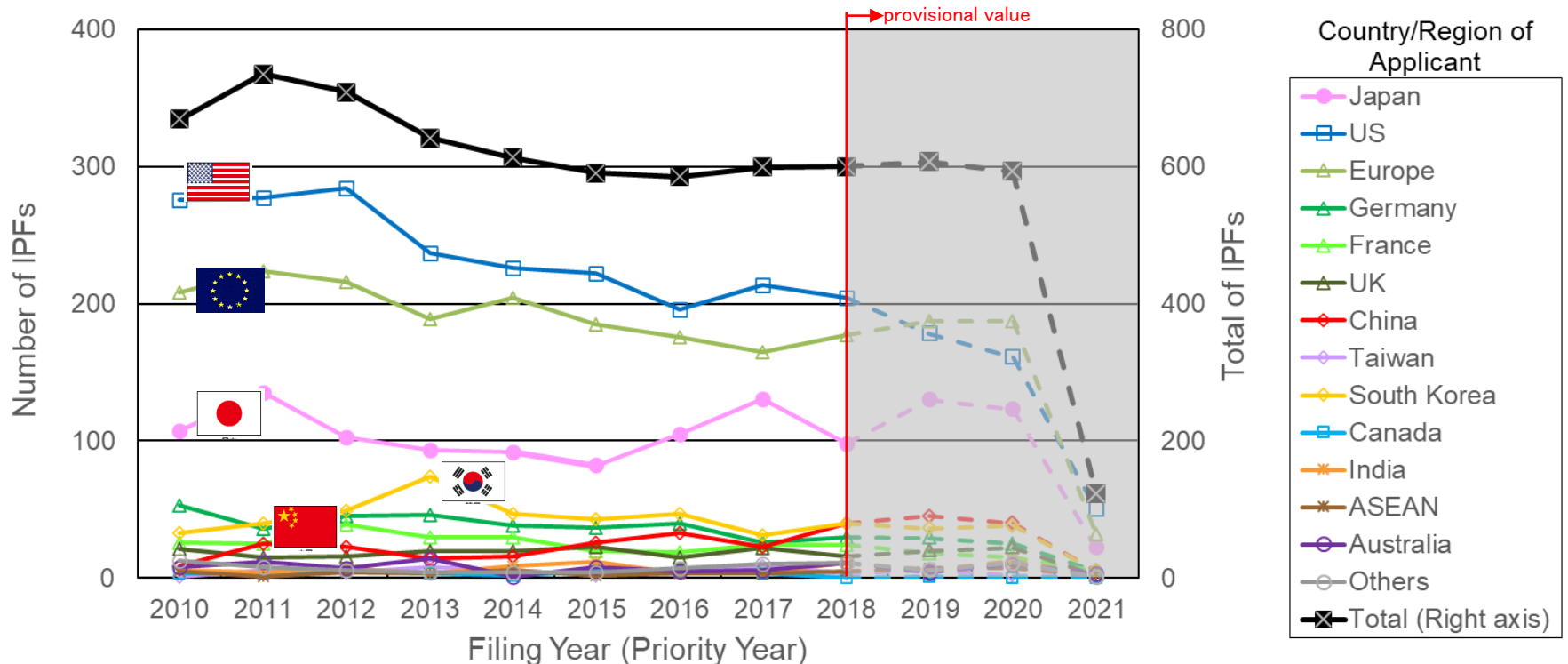
Trends of top 20 applicants by number of IPFs

2010–2013 (year)				2014–2017 (year)				2018–2021 (year)			
Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region
1	169	DUPONT DE NEMOURS, INC.	US	1	97	KONINKLIJKE DSM N.V.	Netherlands	1	68	JIANGNAN UNIVERSITY	China
2	166	NOVO NORDISK AS	Denmark	1	97	NOVO NORDISK AS	Denmark	2	58	BASF SE	Germany
3	83	KONINKLIJKE DSM N.V.	Netherlands	3	96	DUPONT DE NEMOURS, INC.	US	3	48	DUPONT DE NEMOURS, INC.	US
4	62	BASF SE	Germany	4	73	BASF SE	Germany	4	46	KONINKLIJKE DSM N.V.	Netherlands
5	51	TORAY INDUSATRIES, INC.	Japan	5	50	EVONIK IND A.G.	Germany	5	35	EVONIK IND A.G.	Germany
6	41	IFP ENERGIES NOUVELLES S.A.	France	6	37	mitsubishi chemical holdings corp.	Japan	6	28	OJI HOLDINGS CORP.	Japan
7	37	DOW INC.	US	6	37	INVISTA NORTH AMERICA S.A.R.L.	US	7	27	NOVO NORDISK AS	Denmark
8	35	EVONIK IND A.G.	Germany	6	37	JIANGNAN UNIVERSITY	China	7	27	Qilu University of Technology	China
9	33	MITSUBISHI CHEMICAL HOLDINGS CORP.	Japan	9	35	Evolva Holding SA	Switzerland	9	26	NIPPON PAPER INDUSTRIES CO., LTD.	Japan
9	33	UPM KYMMENE CORP.	Finland	10	33	UNIVERSITY OF CALIFORNIA	US	9	26	INBIOSE N.V.	Belgium
11	32	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	France	11	32	CJ CHEILJEDANG CORP.	Korea	11	24	Braskem S.A.	Brazil
11	32	Roquette Freres	France	12	31	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	France	12	22	TORAY INDUSATRIES, INC.	Japan
11	32	LANZATECH NEW ZEALAND LTD	New Zealand	13	26	UPM KYMMENE CORP.	Finland	13	20	UNIVERSITY OF CALIFORNIA	US
14	31	Genomatic, Inc	US	14	25	HONDA MOTOR CO., LTD.	Japan	13	20	IFP ENERGIES NOUVELLES S.A.	France
15	30	UNIVERSITY OF CALIFORNIA	US	15	23	Haldor Topsoe A/S	Denmark	13	20	CJ CHEILJEDANG CORP.	Korea
15	30	Stora Enso Oyj	Finland	15	23	PURAC BIOCHEM B.V.	Netherlands	13	20	Korea University	Korea
17	27	Codexis, Inc.	US	17	22	TORAY INDUSATRIES, INC.	Japan	17	18	Chr. Hansen Holding A/S	Denmark
18	25	CJ CHEILJEDANG CORP.	Korea	17	22	GARGILL INCORPORATED	US	18	17	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	France
19	24	Xerox Corporation	US	19	21	NIPPON PAPER INDUSTRIES CO., LTD.	Japan	18	17	Haldor Topsoe A/S	Denmark
19	24	PURAC BIOCHEM B.V.	Netherlands	20	20	IFP ENERGIES NOUVELLES S.A.	France	18	17	TIANJIN INSTITUTE OF INDUSTRIAL BIOTECHNOLOGY, China ACADEMY OF SCIENCES	China
								18	17	LANZATECH NEW ZEALAND LTD	New Zealand

## 7. GXTI Level 2 Category Trends Research

### 7-5. gxE01: CCS, CCUS, Negative Emission 1/3

- The total number of IPFs remained generally flat at around 600.
- The number of IPFs by **U.S. applicants** has decreased from less than 300 to around 200, and that by **European applicants** has also decreased from over 200 to less than 200.
- On the other hand, the number of IPFs by Japanese applicants has remained generally flat between 100 and 150. **The gap among the number of IPFs by U.S. applicant, that by European applicant, and that by Japanese applicants has narrowed.**



Note that at the time this study was conducted, Derwent™ Innovation may not have had sufficient data recorded after the priority claim year 2019. Therefore, data after 2019 are indicated by dotted lines.

## 7. GXTI Level 2 Category Trends Research

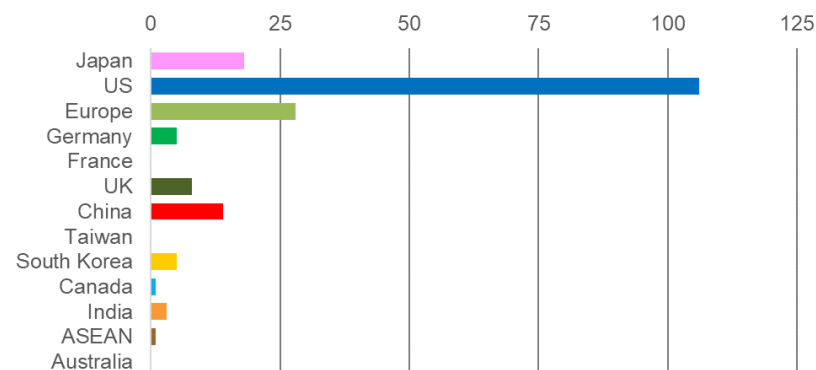
### 7-5. gxE01: CCS, CCUS, Negative Emission 2/3

- **Heavy electric machinery manufacturers** (MITSUBISHI HEAVY INDUSTRIES, LTD. 8k, TOSHIBA CORP., SIEMENS A.G., and GENERAL ELECTRIC CO., and **resource majors** such as EXXONMOBIL, SAUDI ARABIAN OIL CO. (Saudi Aramco), and ROYAL DUTCH SHELL PLC. **are ranked in the top 20.**
- Research institutes such as KOREA INSTITUTE OF ENERGY RESEARCH (Korea) and IFP ENERGIES NOUVELLES S.A. (France) are also ranked.

Top 20 applicants by number of IPFs  
Filing Year (Priority Year): 2010-2021

Order	Number	Country / Region	Country / Region
1	212	MITSUBISHI HEAVY INDUSATRIES, LTD.	Japan
2	203	AIR LIQUIDE S.A.	France
3	169	EXXONMOBIL CORP.	US
4	136	TOSHIBA CORP.	Japan
5	130	SIEMENS A.G.	Germany
6	123	GENERAL ELECTRIC CO.	US
7	122	LINDE A.G.	UK
8	112	ALSTOM S.A.	France
8	112	SAUDI ARABIAN OIL CO.	Saudi Arabia
10	110	BASF SE	Germany
11	93	UOP LLC	US
12	89	COVESTRO DEUTSCHLAND AG	Germany
13	88	ROYAL DUTCH SHELL PLC.	Netherlands
14	81	IFP ENERGIES NOUVELLES S.A.	France
15	78	FUJIFILM CORP.	Japan
16	74	KOREA INSTITUTE OF ENERGY RESEARCH	Korea
17	67	AIR PRODUCTS AND CHEMICALS, INC.	US
18	56	SAUDI BASIC IND CORP.	Saudi Arabia
19	50	PRAXAIR TECHNOLOGY INC.	US
19	50	BAYER A.G.	Germany

Number of highly cited IPFs  
Filing Year (Priority year): 2010-2021



## 7. GXTI Level 2 Category Trends Research

### 7-5. gxE01: CCS, CCUS, Negative Emission 3/3

- From 2010 to 2013, Japanese applicants accounted for 4 of the top 20, but this number has increased to 7 in recent years. Notably, automobile manufacturers have ranked among the top 20 in recent years.
- Japan, USA, Europe, and Saudi Arabia have been leading the creation of inventions within this technology field in recent years, while Chinese and Korean applicants have been excluded from the rankings.

Trends of top 20 applicants by number of IPFs

2010-2013 (year)				2014-2017 (year)				2018-2021 (year)			
Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region
1	108	MITSUBISHI HEAVY INDUSTRIES, LTD.	Japan	1	62	EXXONMOBIL CORP.	US	1	60	MITSUBISHI HEAVY INDUSTRIES, LTD.	Japan
2	100	ALSTOM S.A.	France	2	60	TOSHIBA CORP.	Japan	2	58	AIR LIQUIDE S.A.	France
3	91	GENERAL ELECTRIC CO.	US	2	60	AIR LIQUIDE S.A.	France	3	45	SAUDI ARABIAN OIL CO.	Saudi Arabia
4	85	AIR LIQUIDE S.A.	France	4	56	BASF SE	Germany	4	40	TOSHIBA CORP.	Japan
5	75	EXXONMOBIL CORP.	US	5	48	LINDE A.G.	UK	5	32	EXXONMOBIL CORP.	US
6	59	SIEMENS A.G.	Germany	6	44	MITSUBISHI HEAVY INDUSTRIES, LTD.	Japan	6	27	SIEMENS A.G.	Germany
7	52	ROYAL DUTCH SHELL PLC.	Netherlands	6	44	SIEMENS A.G.	Germany	7	26	COVESTRO DEUTSCHLAND AG	Germany
8	48	LINDE A.G.	UK	8	38	SABIC	Saudi Arabia	7	26	LINDE A.G.	UK
8	48	KOREA INSTITUTE OF ENERGY RESEARCH	Korea	9	37	SAUDI ARABIAN OIL CO.	Saudi Arabia	9	20	Nitto Denko Corporation	Japan
10	45	UOP LLC	US	10	34	COVESTRO DEUTSCHLAND AG	Germany	10	18	TOYOTA MOTOR CORPORATION	Japan
10	45	IFP ENERGIES NOUVELLES S.A.	France	11	33	UOP LLC	US	10	18	BASF SE	Germany
12	44	BAYER A.G.	Germany	12	32	FUJIFILM CORP.	Japan	10	18	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	France
13	41	AIR PRODUCTS AND CHEMICALS, INC.	US	13	27	GENERAL ELECTRIC CO.	US	10	18	TOTAL S.A.	France
14	37	FUJIFILM CORP.	Japan	13	27	CAS.ALE S.A.	Switzerland	14	17	HONDA MOTOR CO., LTD.	Japan
15	36	TOSHIBA CORP.	Japan	13	27	IFP ENERGIES NOUVELLES S.A.	France	14	17	Praxair Technology Incorporated	US
15	36	BASF SE	Germany	16	25	ROYAL DUTCH SHELL PLC.	Netherlands	16	16	Sumitomo Seika Chemicals Company, Limited.	Japan
17	31	SK Group	Korea	17	24	King Abdullah University of Science and Technology	Saudi Arabia	16	16	Arizona State University	US
18	30	SAUDI ARABIAN OIL CO.	Saudi Arabia	18	21	DOW INC.	US	18	15	NGK INSULATORS, LTD.	Japan
19	29	PANASONIC CORP.	Japan	18	21	University of California	US	18	15	UOP LLC	US
19	29	COVESTRO DEUTSCHLAND AG	Germany	20	20	LG CORPORATION	Korea	18	15	EVONIK IND A.G.	Germany
								18	15	Haldor Topsoe A/S	Denmark



## 8. Notable Technologies outside GXTI Trends Research

### Number of IPFs by Year

- The number of IPFs for “**Perovskite Solar Cell**” increased rapidly from 2010 to 2015 and remained constant since then.
- “**Optimization of Delivery Routes**” increased rapidly from 2010 to 2020.
- The “**sharing of goods**” (car sharing, etc.) and “**preservation of food at room temperature**” (canned food, dried food, etc.) **increasing**.
- “**Photonics Convergence Technology**” has decreased.

Notable Technologies Outside GXTI		Filing Year (Priority Year)											Total	
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		2021
Perovskite Solar Cell		1	2	12	38	105	143	131	149	148	148	163	30	1,070
Data Center Energy Saving	Photonics Convergence Technology	393	414	292	247	222	241	191	226	184	182	150	41	2,783
	Power Semiconductor	7	30	20	22	26	41	42	33	32	37	30	0	320
	Energy Saving for Entire Facility	176	182	223	195	154	166	161	157	136	144	129	35	1,858
Optimization of Delivery Routes		18	30	43	48	48	63	114	154	157	171	206	37	1,089
Sharing of Goods		286	409	529	507	451	401	404	577	642	564	628	133	5,531
Room Temperature Storage of Food		306	299	304	340	326	347	399	444	470	458	558	118	4,369
CO2 Emission Trading		2	3	2	3	0	0	0	1	2	2	3	0	18

## 8. Notable Technologies outside GXTI Trends Research

### Number of IPFs by Country / Region of applicants

- The number of IPFs by **Japanese applicants** is the largest for “**Perovskite Solar Cell**” and “**Photonics Convergence Technology**” and is the second or third largest for others.
- The number of IPFs by **U.S. applicants** is the largest for the five surveyed technologies and the third largest for the other two technologies.
- The number of IPFs by **European applicants** is the largest for “Room Temperature Storage of Food” and is the second largest for the other two technologies.
- The number of IPFs by Chinese and Korean applicants is the second or third largest for three surveyed technologies.

Notable Technologies Outside GXTI		Country/Region of Applicant (Filing Year (Priority Year): 2010-2021)							
		Japan	US	Europe	Germany	France	UK	China	South Korea
Perovskite Solar Cell		273	217	245	18	27	46	111	166
Data Center Energy Saving	Photonics Convergence Technology	2,039	61	17	0	1	6	201	332
	Power Semiconductor	24	245	1	0	0	0	14	35
	Energy Saving for Entire Facility	326	829	109	19	14	25	257	173
Optimization of Delivery Routes		155	424	221	42	32	20	146	67
Sharing of Goods		808	2,529	355	37	50	43	517	905
Room Temperature Storage of Food		726	897	1,371	57	134	73	474	549
CO2 Emission Trading		3	7	2	1	0	0	4	1

In the table, gray cells indicate the top three positions, red boxes indicate the first position, and blue boxes indicate the second position.

## 8. Notable Technologies Outside GXTI Trends Research

Top 20 Applicants by number of IPFs Filing Year (Priority Year): 2010-2021 1/3

- The ranking of the top 20 IPFs within the notable technologies is as follows:

Order	Number	Name of Applicant	Country / Region	Order	Number	Name of Applicant	Country / Region
1	46	PANASONIC CORP.	Japan	1	89	HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY	China
2	44	MERCK KGAA	Germany	2	86	SEKISUI CHEMICAL CO., LTD.	Japan
3	32	SEKISUI CHEMICAL CO., LTD.	Japan	3	75	CHINA HUANENG GROUP CO., LTD.	China
4	30	LG CORPORATION	Korea	3	75	SOOCHOW UNIVERSITY	China
5	29	FUJIFILM CORP.	Japan	5	71	UNIVERSITY OF ELECTRONIC SCIENCE AND TECHNOLOGY OF CHINA	China
6	26	SWISS FEDERAL INSTITUTE OF TECHNOLOGY IN LAUSANNE	Switzerland	6	65	HANGZHOU XIANNA OPTOELECTRONIC TECHNOLOGY CO. LTD.	China
7	25	TOSHIBA CORP.	Japan	7	64	NANJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS	China
8	23	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	US	8	62	WUHAN UNIVERSITY OF TECHNOLOGY	China
9	22	KOREA RESEARCH INSTITUTE OF CHEMICAL TECHNOLOGY	Korea	8	62	XI'AN JIAOTONG UNIVERSITY	China
10	20	FRENCH ALTERNATIVE ENERGIES AND ATOMIC ENERGY COMMISSION	France	10	61	LG CORPORATION	Korea
10	20	OXFORD UNIVERSITY INNOVATION LIMITED	UK	11	54	PEKING UNIVERSITY	China
10	20	GLOBAL FRONTIER CENTER FOR MULTISCALE ENERGY SYSTEMS	Korea	12	53	HANERGY HOLDING GROUP LTD.	China
13	19	SUMITOMO CHEMICAL CO., LTD.	Japan	13	52	PANASONIC CORP.	Japan
14	17	TCL TECHNOLOGY	China	14	50	DALIAN INSTITUTE OF CHEMICAL PHYSICS, CHINESE ACADEMY OF SCIENCES	China
15	16	HANGZHOU MICROQUANTA SEMICONDUCTOR CO. LTD	China	15	47	NANJING TECH UNIVERSITY	China
15	16	SUNGKYUNKWAN UNIVERSITY	Korea	15	47	KOREA RESEARCH INSTITUTE OF CHEMICAL TECHNOLOGY	Korea
17	13	KAO CORP.	Japan	17	46	NANKAI UNIVERSITY	China
17	13	SHARP CORP.	Japan	18	45	SHANGHAI INSTITUTE OF CERAMICS, CHINESE ACADEMY OF SCIENCES	China
19	12	NISSAN CHEMICAL CORPORATION	Japan	19	44	MERCK KGAA	Germany
19	12	UNIVERSITY OF NORTH CAROLINA	US	19	44	SHAANXI NORMAL UNIVERSITY	China
19	12	SIEMENS A.G.	Germany				

Perovskite Solar Cell (Number of IPFs)

Reference : Perovskite Solar Cell  
(Number of families)

## 8. Notable Technologies Outside GXTI Trends Research

Top 20 Applicants by number of IPFs Filing Year (Priority Year): 2010-2021 2/3

- The ranking of the top 20 IPFs within the notable technologies is as follows:

### Data Center Energy Saving

Order	Number	Name of Applicant	Country / Region
1	407	SONY GROUP CORP.	Japan
2	204	CANON INC.	Japan
3	184	PANASONIC CORP.	Japan
4	141	FUJIFILM CORP.	Japan
5	128	SHARP CORP.	Japan
6	125	SAMSUNG GROUP	Korea
7	123	TOSHIBA CORP.	Japan
8	106	LG CORPORATION	Korea
9	97	SANYO ELECTRIC CO.,LTD.	Japan
10	75	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	Japan
11	69	KANEKA CORPORATION	Japan
12	68	KYOCERA CORP.	Japan
13	47	mitsubishi electric corp.	Japan
14	45	SUMITOMO CHEMICAL CO., LTD.	Japan
15	25	SEIKO EPSON CORP.	Japan
15	25	SEKISUI CHEMICAL CO., LTD.	Japan
17	24	RICOH CO., LTD.	Japan
17	24	BOE TECHNOLOGY GROUP CO., LTD.	China
17	24	AU OPTRONICS CORP.	Taiwan
20	23	HON HAI PRECISION IND CO., LTD.	Taiwan
20	23	INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE	Taiwan

Order	Number	Name of Applicant	Country / Region
1	230	INTEL CORP.	US
2	22	SK GROUP	Korea
3	14	SAMSUNG GROUP	Korea
4	13	QUALCOMM INC.	US
5	7	FUJITSU LTD.	Japan
6	6	MICRON TECHNOLOGY, INC.	US
7	4	SONY GROUP CORP.	Japan
8	3	TOYOTA MOTOR CORPORATION	Japan
9	2	Hajime Watanabe (Individual applicant)	Japan
9	2	HIROSHI WATANABE (Individual applicant)	Japan
9	2	NIPPON TELEGRAPH AND TELEPHONE CORP.	Japan
9	2	RENESAS ELECTRONICS CORPORATION	Japan
9	2	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	Japan
9	2	TOSHIBA CORP.	Japan
9	2	MONOLITHIC POWER SYSTEMS, INC	US

### Power Semi Conductor

Order	Number	Name of Applicant	Country / Region
1	199	INTEL CORP.	US
2	151	SAMSUNG GROUP	Korea
3	103	FUJITSU LTD.	Japan
4	85	HON HAI PRECISION IND CO., LTD.	Taiwan
5	79	HEWLETT PACKARD ENTERPRISE CO.	US
6	71	MICROSOFT CORP.	US
7	54	INVENTEC CORP.	Taiwan
8	52	FOXCONN TECHNOLOGY GROUP	Taiwan
9	49	QUANTA GROUP LIMITED	Taiwan
10	41	HUAWEI TECHNOLOGIES CO., LTD.	China
11	40	NEC CORP.	Japan
12	39	INTERNATIONAL BUSINESS MACHINES CORP.	US
13	30	CANON INC.	Japan
14	29	QUALCOMM INC.	US
15	28	BAIDU, INC.	China
16	27	GOOGLE LLC	US
17	25	TOSHIBA CORP.	Japan
18	22	HITACHI, LTD.	Japan
19	18	WISTRON CORPORATION	Taiwan
20	17	APPLE INC.	US

### Energy Saving for Entire Facilities

### Photonics Convergence Technology

## 8. Notable Technologies Outside GXTI Trends Research

### Top 20 Applicants by Number of IPFs Filing Year (Priority Year): 2010-2021 3/3

- The ranking of the top 20 IPFs within the notable technologies is as follows:

Order	Number	Name of Applicant	Country / Region
1	41	DIDI GLOBAL	China
2	40	FORD MOTOR CO.	US
3	36	COUPANG CORP.	Korea
4	32	HITACHI, LTD.	Japan
5	31	TOYOTA MOTOR CORPORATION	Japan
6	28	UBER TECHNOLOGIES, INC.	US
7	22	SIEMENS A.G.	Germany
8	15	GENERAL ELECTRIC CO.	US
9	14	ACCENTURE GLOBAL SERVICES GMBH	Ireland
9	14	GRABTAXI HOLDINGS PTE. LTD	Singapore
11	12	NEC CORP.	Japan
11	12	PANASONIC CORP.	Japan
11	12	ROBERT BOSCH GMBH	Germany
11	12	BEIJING JINGDONG CENTURY TRADING CO., LTD.	China
15	11	FUJITSU LTD.	Japan
15	11	GOOGLE LLC	US
15	11	WALMART INC.	US
18	10	INTERNATIONAL BUSINESS MACHINES CORP.	US
18	10	HYUNDAI MOTOR CORP.	Korea
20	9	ALIBABA GROUP HOLDING, LTD.	China
20	9	KIA CORP.	Korea

Order	Number	Name of Applicant	Country / Region
1	198	SAMSUNG GROUP	Korea
2	197	TOYOTA MOTOR CORPORATION	Japan
3	154	MICROSOFT CORP.	US
4	151	GOOGLE LLC	US
5	84	HONDA MOTOR CO., LTD.	Japan
6	81	ALIBABA GROUP HOLDING, LTD.	China
7	77	META PLATFORMS, INC.	US
8	72	SONY GROUP CORP.	Japan
9	56	TENCENT HOLDINGS, LTD.	China
10	51	INTERNATIONAL BUSINESS MACHINES CORP.	US
11	50	KOREA ELECTRONICS & TELECOMMUNICATIONS RESEARCH INSTITUTE	Korea
12	46	FORD MOTOR CO.	US
13	41	HEWLETT PACKARD ENTERPRISE CO.	US
13	41	ANT GROUP	China
13	41	HYUNDAI MOTOR CORP.	Korea
16	39	KIA CORP.	Korea
17	38	LG CORPORATION	Korea
18	34	PANASONIC CORP.	Japan
19	33	INTEL CORP.	US
19	33	WALMART INC.	US

Order	Number	Name of Applicant	Country / Region
1	134	NESTLE S.A.	Switzerland
2	133	MEIJI HOLDINGS CO.,LTD.	Japan
3	128	CHR. HANSEN HOLDING A/S	Denmark
4	120	NUTRICIA NV	Netherlands
5	119	DUPONT DE NEMOURS, INC.	US
6	116	KONINKLIJKE DSM N.V.	Netherlands
7	79	ASAHI GROUP HOLDINGS, LTD	Japan
8	62	SUNTORY HOLDINGS LTD.	Japan
9	59	CJ CHEILJEDANG CORP.	Korea
10	54	JIANGNAN UNIVERSITY	China
11	42	NOVO NORDISK AS	Denmark
12	40	ROQUETTE FRERES	France
13	34	UNILEVER N.V.	UK
14	33	AT&T INC.	US
15	29	EVONIK IND A.G.	Germany
16	26	JENNEWAIN BIOTECHNOLOGIE GMBH	Germany
17	25	YAKULT HONSHA CO.,LTD.	Japan
17	25	AMOREPACIFIC CORP.	Korea
19	24	PURAC BIOCHEM B.V.	Netherlands
20	21	AJINOMOTO CO.,INC.	Japan

Sharing of Goods

Room Temperature  
Storage of Food

Optimization of Delivery Routes

\* "CO2 emissions trading" is omitted due to the lack of overall IPFs.

# 9. Summary 1/3

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## ■ Overall GX Technology

The number of IPFs by **Japanese applicants** is the largest in each year throughout the survey period for which definite data are available implies that inventions created in Japan are expected utilized in numerous countries/regions.

## ■ GXTI Level 1 Categories

- In terms of the total number of IPFs during the entire survey period, the category of **Energy Saving, Electrification and Demand-Supply Flexibility** (gxB) accounted for **the largest number**, followed by the categories of Energy Supply (gxA), Batteries/Energy Storage (gxC), CO2 Reduction in Non-Energy Sector (gxD), and Capture, Storage, Utilization and Removal of Greenhouse Gas (gxE).
- The annual trends in the number of IPFs during the survey period for which definite data are available show **increasing trends in the category of Energy Saving, Electrification and Demand-Supply Flexibility (gxB), and the category of Batteries/Energy Storage (gxC).**
- In terms of the total number of IPFs by applicant country and region during the entire survey period :
  - That by European applicants is the largest in the category of Energy Supply (gxA);
  - That by Japanese applicants is the largest in the category of Energy Saving, Electrification and Demand-Supply Flexibility (gxB), and also in the category of Batteries/Energy Storage (gxC)
  - That by U.S. applicants is the largest in the category of CO2 Reduction in the Non-Energy Sector (gxD), and also in the category of Capture, Storage, Utilization and Removal of Greenhouse Gas (gxE).

※ gxA is "Energy Supply;" gxB is "Energy Saving, Electrification, and Demand-Supply Flexibility";  
gxC is "Batteries, Energy Storage;" gxD is "CO2 Reduction in Non-Energy Sectors;"  
and gxE is "Capture, Storage, Utilization and Removal of Greenhouse Gas."

# 9. Summary 2/3

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## ■ GXTI Level 2 Categories

The annual trends in the number of IPFs during the survey period for which definite data are available shows the following:

- In the category of [gxA01] "Solar Photovoltaic Power Generation", the number of IPFs by **Japanese applicants is the largest in each year, but there are an overall downward trend, except for that by Chinese applicants.**
- In the category of [gxB01]"Energy Saving in Buildings (ZEB, ZEH, etc.) ", the number of IPFs by **Japanese applicants** (about 2,500 in each year) is the largest, and **much larger** than that by European applicants (about 1,500 in each year).
- In the category of [gxC01] "Secondary Batteries", **the number of IPFs by Japanese applicants is the largest in each year** at more than 2,000 throughout the period, **highly surpassing** that by U.S., European, and Korean applicants (around 1,000).
- In the category of [gxD01]"Chemical Production from Biomass", the number of IPFs by U.S. applicants was the largest at less than 500 until 2012, but since 2016 the number of IPFs has been around 300, with a smaller difference from the number of IPFs by European applicants. The number of IPFs by Japanese applicants is guessed to remain at around 100, while that by Chinese applicants is increasing and is expected to equal that by European and U.S. applicants by around 2020.
- In the category of [gxE01]"CCS, CCUS, Negative Emission", the number of IPFs by U.S. applicants is the largest and that by European applicants is the second largest **decreased** to about 200 between 2010 and 2018. On the other hand, the number of IPFs by Japanese applicants has remained generally unchanged between 100 and 150. **The gap among the number of IPFs by U.S. applicants, that by European applicants, and that by Japanese applicants has narrowed.**

- Focusing on universities and research institutes, such as universities in the United States, Europe, China, and South Korea are ranked in the top 20 in the number of IPFs in the category of **[gxE01]"CCS, CCUS, Negative Emission"** and in the category of **[gxD01]"Chemical Production from Biomass"**.

# 9. Summary 3/3

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## ■ Notable Technologies outside GXTI

In terms of the number of IPFs for the entire survey period for notable technologies outside GXTI:

- The number of IPFs by Japanese applicants is the largest for “Perovskite Solar Cell” and “Photonics Convergence Technology” and is the second or third largest for others.
- The number of IPFs by U.S. applicants is the largest for power semiconductors, facility-wide energy saving, delivery route optimization, goods sharing, and CO2 emissions trading and the third largest for the other two technologies.
- The number of IPFs by European applicants is the largest for “Room Temperature Storage of Food” and is the second largest for the other two technologies.