

Visualization of "Green Enablers"¹ with Patent Applications

~Analysis of Patents Issued by Major IP Offices in 2021~

2022.4 Japio AI Research Center

Summary:

Patents data of the PCT international applications, applications to the U.S., China, and Germany, published in 2021, were analyzed for visualizing decarbonization (Carbon Neutrality) technologies using AI models, and the results were compiled to company level in order to see who the "Green Enabler" is. A brief result is below.

➤ PCT international applications (WO)

Six of the top 20 were Japanese companies, including MITSUBISHI ELECTRIC CORP, PANASONIC IP MAN CO LTD, and NTT DOCOMO INC in the overall ranking.

We also provide "Green Enablers" rankings by "Japio-Decarbonization Patent Index", an index that can evaluate "Green Enablers", independent of the number of patent applications. APB CORP and SANDEN AUTOMOTIVE CLIMATE SYSTEMS CORP were among the top companies.

➤ Applications to USPTO (US)

Six of the top 20 were Japanese companies, including TOYOTA JIDOSHA KABUSHIKI KAISHA and HONDA MOTOR CO., LTD in the overall ranking. A large number of Japanese companies were ranked.

In the ranking of by "Japio-Decarbonization Patent Index", GE-HITACHI NUCLEAR ENERGY AMERICAS LLC and HAPSMOBILE INC showed relatively high index values.

➤ Applications to CNIPA (CN)

Although TOYOTA MOTOR CORP and HONDA MOTOR CO LTD were among the top 20 companies in the overall ranking, Chinese companies and universities dominated in the various rankings.

In the ranking of by "Japio-Decarbonization Patent Index", GS YUASA INT LTD, SANYO ELECTRIC CO, and KOKUSAI ELECTRIC CORP were among the top

¹ In this report, a company that files many patent applications for decarbonized technologies is defined as "Green Enabler".

companies.

➤ Applications to DPMA (DE)

TOYOTA JIDOSHA KABUSHIKI KAISHA, DENSO CORPORATION, and MITSUBISHI ELECTRIC CORPORATION were shown in the overall ranking. A large number of Japanese companies were ranked in the various rankings.

In the ranking of by “Japio-Decarbonization Patent Index”, SUBARU CORPORATION and GS YUASA INTERNATIONAL LTD were among the top-ranked companies, and other Japanese companies also showed relatively high index values.

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1. Background

The movement toward carbon neutrality is accelerating around the world. As of September 2021, 123 countries and regions have committed to virtually zero emissions of carbon dioxide or greenhouse gases by 2050. China, the world's largest emitter thereof, has also announced that it will achieve virtually zero emissions of greenhouse gases by 2060.

The challenge is not a cost to economic growth, but a growth opportunity for a transformation of industrial structure, economic and social reform, and investment. The world has entered a new game-changing era.

It is a great opportunity for many Japanese companies skilled at energy-saving technology to improve their presence in the world. In order for Japanese companies to take advantage of this opportunity, it is essential to understand patent information closely related to innovation.

On the other hand, Japanese companies are underweighting in ESG investment universe. The Government Pension Investment Fund (GPIF) has published a country ranking of ESG investment in its ESG Activity Report FY2020. Japan's ESG country ranking is lower than those of developed countries and the degree of improvement is not high in both the FTSE and MSCI methodologies of the report².

While there might be many reasons for the ESG discounting of Japanese companies, the following two points are the most important.

- Although it is essential for many Japanese companies, which have high reputation for manufacturing, to present their own technologies to investors, their information disclosures are not enough for the global investors.
- ESG evaluation organizations are mainly US or Europe ones and they gather invest information in English. Japanese companies, especially small and medium-sized enterprises (SMEs), do not disclose enough information in English³. Therefore, a language barrier works against Japanese companies.

The author believes that one of the factors to solve the above issues is to use patent information.

² https://www.gpif.go.jp/investment/GPIF_ESGReport_FY2020_J.pdf

³ <https://www.jpx.co.jp/english/equities/listed-co/disclosure-gate/survey-reports/index.html>

It is essential for companies as investment targets to disclose objective information about themselves (in English, if possible) to investment trustees and asset owners. In addition, ESG investments are characterized by a longer investment period than other types of investments. Then, ESG investments and patent information have a high affinity in the following respects.

- Because patents are valid for 20 years from date of filing application, a patent application suggests that a company can possess the particular technology for a long time.
- Because application formats of various IP Offices is standardized and the quality of machine translations in the patent field is high⁴, it is possible to analyze the technology level of companies as investment targets on a global level, checking even non-English patent information such as Japanese and Chinese.
- The AI model of "Visualization of decarbonization patent technologies" by Japan Patent Information Organization (Japio) can select and disclose only relevant patent applications of noteworthy decarbonization technologies from a vast amount of patent information.

Japan Patent Information Organization (Japio) has various activities based on its philosophy "contributing to the economy and society by providing high-quality patent information". In 2021, the Japio AI Research Center has successfully established an AI model to estimate patent applications related to decarbonization technologies from patent specifications.

In this report, Japio investigates trends in PCT, US, CN, and DE patent applications by Japanese companies for decarbonization-related technologies, using Japio's AI model of decarbonization technologies. **This report shows Japanese companies as "Green Enablers⁵" that can show their technical presence in major countries.** Moreover, it shows that there is a great potential for Japanese companies to contribute to environmental protection on a global scale.

⁴ For machine translation (AI translation) in the patent field, please refer to "Japio AI Translation"

<https://transtool.japio.or.jp/work/en/>

⁵ In this report, a company that files many patent applications for decarbonized technologies is defined as "Green Enabler".

2. Materials and Methods

2 – 1. Data

Data of patent gazettes published between January 1, 2021 and December 31, 2021 for PCT international applications (WO), applications to the USPTO (US), applications to the CNIPA (CN), and applications to the DPMA (DE) were extracted from Japio-GPG/FX⁶. The data were analyzed for decarbonization technologies using the Japio's AI models.

The search query in Japio-GPG/FX is as follows. (Data extraction date: March 3, 2022.)

• WO : 271,767 records

Query ((PD:[20210101 TO 20211231])) AND (CC:WO)

• US : 410,293 records

Query ((PD:[20210101 TO 20211231])) AND ((CC:US AND (KI:A1 OR KI:A2 OR KI:A9 OR KI:H OR KI:H1 OR KI:P1)))

• CN : 1,720,484 records

Query ((PD:[20210101 TO 20211231])) AND ((CC:CN AND (KI:A)))

• DE : 55,350 records

Query ((PD:[20210101 TO 20211231])) AND ((CC:DE AND (KI:A1 OR KI:A5 OR KI:A8 OR KI:A9 OR KI:D2 OR KI:I1 OR KI:T OR KI:T1 OR KI:T5 OR KI:T8 OR KI:T9)))

2 – 2. Rankings of “Green Enablers” in 2021

For an overview of the Japio's AI model⁷ used in the analysis, see the URL below. The model was used to estimate decarbonization-related patented technologies for

⁶ https://www.japio.or.jp/service/service05_11.html

⁷ For more detailed information, please refer to the following paper.

“Macro analysis of decarbonization-related patent technologies by patent domain-specific BERT”, World Patent Information, Vol.69, 2022,
<https://doi.org/10.1016/j.wpi.2022.102112>

the above-mentioned patent gazettes. The model estimates the technology type⁸ and calculates its estimated value. The estimated value ranges from 0 to 1. The closer the value is to 1, the higher the certainty of the estimate is. The values are compiled as a “score” for each company.

- What is Visualization of the Decarbonization-Tech?

https://transtool.japio.or.jp/work/data/carbon_neutral.pdf

2 – 3 . “Green Enablers” rankings by “Japio-Decarbonization Patent Index”

For the countries mentioned above, the top 2.5%⁹ of the applicants with the largest number of publications were analyzed. The number of all applicants in each country and the number of applicants to be analyzed are as follows.

	Number of all applicants ¹⁰	Number of applicants to be analyzed (% of total)
WO	78413	2022 (2.58%)
US	105876	2706 (2.56%)
CN	336508	8682 (2.58%)
DE	10034	259 (2.58%)

The estimation results were aggregated by applicant, and the "Japio-Decarbonization Patent Index" was calculated as the ratio of the number of patents estimated as decarbonization-related technologies to the total number of patents.

⁸ we compiled each estimated patent document into three fields of “Energy-related industries”, “Transportation/manufacturing-related industries,” and “Household/office work-related industries”. These fields are described as the important fields where growth is expected in the "Green Growth Strategy through Achieving Carbon Neutrality in 2050"*3 (June 18, 2021) released by the Cabinet Secretariat.

<https://www.meti.go.jp/press/2021/06/20210618005/20210618005-3.pdf>

⁹ Since there are multiple applicants with the same number of patent applications, the number of applicants to be analyzed is slightly higher than 2.5% of the total.

¹⁰ Since the applicant's name cannot be fully corrected, the actual number of applicants is expected to be less than these figures.

$$\text{INDEX} = \frac{\text{The number of patents estimated as decarbonization-related technologies (※)}}{\text{The number of patents published in 2021}}$$

(※) patents whose estimated value is above 0.5

The closer the index is to 1, the more decarbonization-oriented patent applications are filed by this applicant. In this report, we have selected Japanese companies with a high index. For more information on the "Japio-Decarbonization Patent Index", please see the URL below.

- "Green Enablers" rankings by "Japio-Decarbonization Patent Index"
https://transtool.japio.or.jp/work/data/carbon_index_ranking.pdf
 (Available only in Japanese)

3. Rankings of "Green Enablers" in 2021

Various rankings are shown below. In these rankings, **Japanese companies are shown in red**. In addition, only Japanese companies with a high index are shown in "Green Enablers" rankings by "Japio-Decarbonization Patent Index".

The "applicant name" shown in the table below is the name of the applicant described in each patent publication. Applicant names that are considered to be the same but whose characters do not match due to abbreviations or misspellings are corrected. (Did not correct names of companies belonging to the same corporation group.)

The results of PCT international application (WO)

In general, companies tend to file PCT international applications for technologies that they plan to use in many countries. There are also many studies showing that the size of the number of patent families and the geographic scope of patent protection are related to the patent value. Thus, PCT international applications can

be an indicator of patent technologies that a company considers important and valuable.

Rankings of “Green Enablers” in 2021 (WO)

In terms of the number of patents published in 2021, 31 of the top 100 are Japanese companies. Seven of the top 20 are Japanese companies.

In the ranking of “Green Enablers”, 6 of the top 20 are Japanese companies in the overall, 7 of 20 in energy-related industry, 4 of 20 in transportation/manufacturing-related industry, and 5 of 20 in household/office-related industry.

➤ WO : Ranking overall (2021)

	Applicant Name	Score	No. of App
1	HUAWEI TECH CO LTD	2521.22	7054
2	QUALCOMM INC	2074.15	4043
3	LG ELECTRONICS INC	1178.94	2922
4	<u>MITSUBISHI ELECTRIC CORP</u>	1001.15	2701
5	<u>PANASONIC IP MAN CO LTD</u>	798.25	1840
6	GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP LTD	751.89	2511
7	SAMSUNG ELECTRONICS CO LTD	605.99	3059
8	BOSCH GMBH ROBERT	594.61	1248
9	LG CHEMICAL LTD	536.24	832
1 0	ERICSSON TELEFON AB L M	524.25	1908
1 1	LG ENERGY SOLUTION LTD	505.25	552
1 2	<u>NTT DOCOMO INC</u>	499.07	721
1 3	<u>DENSO CORP</u>	438.08	963
1 4	ZTE CORP	401.73	1499
1 5	BOE TECHNOLOGY GROUP CO LTD	400.24	2005
1 6	SZ DJI TECHNOLOGY CO LTD	394.11	1057
1 7	<u>FUJIFILM CORP</u>	330.31	1109
1 8	SAUDI ARABIAN OIL CO	323.56	872
1 9	APPLIED MATERIALS INC	315.18	592
2 0	<u>NIPPON TELEGRAPH & TELEPHONE</u>	312.93	1515

➤ **WO : Ranking in energy-related industry (2021)**

	Applicant Name	Score	No. of App
1	LG ENERGY SOLUTION LTD	472.10	552
2	<u>PANASONIC IP MAN CO LTD</u>	390.14	1840
3	LG CHEMICAL LTD	273.73	832
4	CONTEMPORARY AMPEREX TECHNOLOGY CO LTD	250.46	292
5	NINGDE AMPEREX TECHNOLOGY LTD	196.92	211
6	BOSCH GMBH ROBERT	186.84	1248
7	<u>MURATA MANUFACTURING CO</u>	162.34	895
8	<u>SANYO ELECTRIC CO</u>	135.72	156
9	VESTAS WIND SYS AS	128.68	163
1 0	HUAWEI TECH CO LTD	117.35	7054
1 1	SIEMENS GAMESA RENEWABLE ENERGY AS	105.49	137
1 2	<u>SONY SEMICONDUCTOR SOLUTIONS CORP</u>	102.30	760
1 3	<u>GS YUASA INT LTD</u>	99.26	124
1 4	SAMSUNG ELECTRONICS CO LTD	74.68	3059
1 5	<u>MITSUBISHI ELECTRIC CORP</u>	61.33	2701
1 6	GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP LTD	53.99	2511
1 7	SAUDI ARABIAN OIL CO	53.05	872
1 8	SAMSUNG SDI CO LTD	52.33	99
1 9	BYD CO LTD	51.53	175
2 0	<u>FUJIFILM CORP</u>	50.88	1109

➤ **WO : Ranking in transportation/manufacturing-related industry (2021)**

	Applicant Name	Score	No. of App
1	HUAWEI TECH CO LTD	2441.92	7054
2	QUALCOMM INC	2071.56	4043
3	LG ELECTRONICS INC	1023.20	2922
4	GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP LTD	739.48	2511
5	<u>PANASONIC IP MAN CO LTD</u>	610.79	1840

6	BOSCH GMBH ROBERT	574.48	1248
7	<u>MITSUBISHI ELECTRIC CORP</u>	561.65	2701
8	SAMSUNG ELECTRONICS CO LTD	536.14	3059
9	ERICSSON TELEFON AB L M	520.88	1908
1 0	LG ENERGY SOLUTION LTD	504.43	552
1 1	<u>NTT DOCOMO INC</u>	497.28	721
1 2	LG CHEMICAL LTD	427.46	832
1 3	<u>DENSO CORP</u>	403.31	963
1 4	ZTE CORP	394.48	1499
1 5	SZ DJI TECHNOLOGY CO LTD	381.11	1057
1 6	BAYERISCHE MOTOREN WERKE AG	305.11	380
1 7	VIVO MOBILE COMMUNICATION CO LTD	301.92	1342
1 8	APPLIED MATERIALS INC	296.48	592
1 9	SAUDI ARABIAN OIL CO	293.81	872
2 0	BOE TECHNOLOGY GROUP CO LTD	292.77	2005

➤ **WO : Ranking in household/office-related industry (2021)**

	Applicant Name	Score	No. of App
1	<u>MITSUBISHI ELECTRIC CORP</u>	574.50	2701
2	HAIER SMART HOME CO LTD	287.32	835
3	<u>PANASONIC IP MAN CO LTD</u>	219.81	1840
4	LG ELECTRONICS INC	173.05	2922
5	LG CHEMICAL LTD	134.76	832
6	<u>DAIKIN IND LTD</u>	125.93	469
7	BOE TECHNOLOGY GROUP CO LTD	122.30	2005
8	HUAWEI TECH CO LTD	118.37	7054
9	<u>HITACHI LTD</u>	111.01	485
1 0	SIEMENS AG	110.23	633
1 1	SIGNIFY HOLDING BV	94.01	346
1 2	SAMSUNG ELECTRONICS CO LTD	93.00	3059
1 3	QINGDAO HAIER AIR CONDITIONING ELECTRONIC CO LTD	92.57	187
1 4	SHENZHEN CHINA STAR OPTOELECTRONICS SEMICONDUCTOR DISPLAY TECH CO LTD	88.56	633
1 5	HEWLETT PACKARD DEVELOPMENT CO	72.77	1489

1 6	QINGDAO HAIER AIR CONDITIONER GENERAL CORP LTD	68.76	199
1 7	MIDEA GROUP CO LTD	68.44	320
1 8	<u>SONY SEMICONDUCTOR SOLUTIONS CORP</u>	67.74	760
1 9	GD MIDEA AIR CONDITIONING EQUIPMENT CO LTD	63.71	201
2 0	QINGDAO HAIER WASHING MACH CO	62.24	120

“Green Enablers” rankings by “Japio-Decarbonization Patent Index” (WO)

The estimation based on PCT international application showed that the average of index was 0.297. It means that about 29.7% of all the PCT gazettes published in 2021 were estimated as decarbonization-related technologies (reference: For application to JPO, the average of index in the same year was 0.292).

848 out of 2022 applicants analyzed had an average index value (0.297) or higher, of which 165 were identified as Japanese companies. **Here are the applicants name, its indexes, and number of publications for up to the top 100 Japanese companies.**

Note that the numbers skipped in the rankings indicate the presence of applicants other than Japanese firms among them.

	Applicant Name	Index	No. of App
1	APB CORP	1.000	20
3	SANDEN AUTOMOTIVE CLIMATE SYSTEMS CORP	1.000	21
17	SANYO ELECTRIC CO	0.949	156
29	TOYOTA TSUSHO CORP	0.909	22
30	AERONEXT INC	0.905	21
32	GS YUASA INT LTD	0.903	124
54	MITSUBISHI MOTORS CORP	0.865	37
68	NILEWORKS INC	0.838	37
71	HAPSMOBILE INC	0.833	24
72	TAKEDA KAZUKI	0.833	18
74	NIPPON ELECTRIC GLASS CO	0.831	142
90	NISSAN MOTOR	0.812	276
113	SHINETSU HANDOTAI KK	0.789	38

114	TOKYO ELECTRON US HOLDINGS INC	0.788	104
118	TOKYO ELECTRON LTD	0.775	334
119	KWANSEI GAKUIN EDUCATIONAL FOUND	0.773	22
120	NTT DOCOMO INC	0.770	721
127	MAZDA MOTOR	0.763	38
156	YOKOHAMA RUBBER CO LTD	0.734	109
162	MITSUI MINING & SMELTING CO	0.731	52
196	KOKUSAI ELECTRIC CORP	0.692	52
197	HONDA MOTOR CO LTD	0.692	331
206	YAMAHA MOTOR CO LTD	0.681	144
212	ISUZU MOTORS LTD	0.671	140
225	TORAY ENG CO LTD	0.667	27
227	KURARAY NORITAKE DENTAL INC	0.667	21
234	SENJU METAL INDUSTRY CO	0.654	26
235	ORGANO CORP	0.652	23
240	ADVICS CO LTD	0.650	40
243	GAO YUKAI	0.650	20
248	FUJIFILM ELECTRONIC MAT USA INC	0.647	17
254	HITACHI TRANSPORT SYSTEM	0.647	17
257	YANMAR POWER TECHNOLOGY CO LTD	0.647	51
258	OSAKA GAS CO LTD	0.647	17
260	KUBOTA KK	0.645	110
262	TOKYO OHKA KOGYO CO LTD	0.645	31
265	IDEMITSU KOSAN CO	0.642	148
270	EBARA CORP	0.638	47
273	NIPPON STEEL CHEMICAL & MAT CO LTD	0.636	55
286	CENTRAL GLASS CO LTD	0.625	40
292	SOFTBANK CORP	0.618	34
295	JSR CORP	0.614	88
296	AQUA CO LTD	0.613	62
297	FUJI CORP	0.613	240
305	UNIV SHIZUOKA NAT UNIV CORP	0.609	23
312	NIPPON SHEET GLASS CO LTD	0.600	35
315	JAPAN AEROSPACE EXPLORATION	0.600	25
321	JGC CORP	0.594	32

323	ICHIKOH INDUSTRIES LTD	0.593	27
331	KDDI CORP	0.587	46
337	SHOWA DENKO MAT CO LTD	0.583	216
338	KOITO MFG CO LTD	0.583	156
339	SEMICONDUCTOR ENERGY LAB	0.583	228
340	SUMITOMO METAL MINING CO	0.583	60
344	KURITA WATER IND LTD	0.579	57
347	TAIHEIYO KOGYO KK	0.579	19
348	NUFLARE TECHNOLOGY INC	0.579	19
355	JX NIPPON MINING & METALS CORP	0.576	33
365	TOYOTA MOTOR EUROPE	0.566	53
372	MAXELL HOLDINGS LTD	0.563	32
381	MITSUBISHI HEAVY IND THERMAL SYSTEMS LTD	0.560	25
383	KIOXIA CORP	0.559	34
384	BRIDGESTONE CORP	0.558	163
392	TOSHIBA ENERGY SYSTEMS & SOLUTIONS CORP	0.552	58
401	TOYOTA MOTOR CO LTD	0.545	99
407	MITSUBISHI POWER LTD	0.542	144
426	SCREEN HOLDINGS CO LTD	0.529	70
427	MITSUBISHI HEAVY IND LTD	0.528	199
429	DAIKIN EUROPE NV	0.526	19
434	YAZAKI CORP	0.524	21
441	SUMITOMO OSAKA CEMENT CO LTD	0.522	23
442	TOYOTA JIDOSHOKKI KK	0.521	48
446	STANLEY ELECTRIC CO LTD	0.519	27
450	HITACHI JOHNSON CONTROLS AIR CONDITIONING INC	0.512	43
452	NICHIA CORP	0.510	51
453	TOSOH CORP	0.510	51
454	AGC INC	0.509	271
457	KUREHA CORP	0.500	30
467	TOYODA GOSEI KK	0.500	28
479	NGK INSULATORS LTD	0.493	142
483	TOKUYAMA CORP	0.492	61

486	USHIO ELECTRIC INC	0.489	47
487	HITACHI AUTOMOTIVE SYSTEMS LTD	0.489	94
488	HITACHI INT ELECTRIC INC	0.489	45
492	NISSAN CHEMICAL CORP	0.486	142
493	SUMITOMO RUBBER IND	0.485	66
495	ENEOS CORP	0.485	66
498	SHOWA DENKO KK	0.485	163
506	SUMCO CORP	0.481	27
517	NAMICS CORP	0.476	21
530	UNIV NAT CORP KANAZAWA	0.471	17
531	DENSO CORP	0.470	963
537	HITACHI CONSTRUCTION MACH CO	0.465	101
549	JFE STEEL CORP	0.452	292
550	RAKUTEN INC	0.452	31
556	PANASONIC IP MAN CO LTD	0.448	1840
560	HITACHI LTD	0.445	485
566	DAIKIN IND LTD	0.441	469
574	HITACHI GLOBAL LIFE SOLUTIONS INC	0.432	37
577	TOSHIBA CARRIER CORP	0.432	37

The results of applications to USPTO (US)

The nominal GDP of the U.S. in 2020 was 20,893.750 (USD)¹¹, the highest in the world. According to the JPO's Annual Report 2021¹², the number of patent applications on a filing basis in 2019 was the second highest (621,451), after China (1,400,661).

Of the applications to USPTO, the largest number of applications from abroad came from Japan (14%¹³ of the 2019 application base). Although the number of applications from China has increased dramatically in recent years, Japanese industry currently possesses more patents, a powerful business resource, in the U.S. market than any other foreign country. Therefore, in order to survive and grow in the U.S. market, it is extremely important for Japanese industry to understand effective and strategical use of patent rights¹⁴.

Rankings of “Green Enablers” in 2021 (US)

In terms of the number of patents published in 2021, 18 of the top 100 are Japanese companies. Five of the top 20 are Japanese companies.

In the ranking of “Green Enablers”, 6 of the top 20 are Japanese companies in the overall, 7 of 20 in energy-related industry, 6 of 20 in transportation/manufacturing-related industry, and 6 of 20 in household/office-related industry.

➤ US : Ranking overall (2021)

	Applicant Name	Score	No. of App
1	SAMSUNG ELECTRONICS CO., LTD.	3204.79	9948
2	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	3042.78	4132
3	TAIWAN SEMICONDUCTOR MANUFACTURING CO., LTD.	2760.09	4972
4	HYUNDAI MOTOR COMPANY	2054.82	2730
5	QUALCOMM INCORPORATED	1872.40	3772
6	KIA MOTORS CORPORATION	1736.33	2281

¹¹ World Economic Outlook Database: October 2021

¹² <https://www.jpo.go.jp/resources/report/nenji/2021/index.html>

¹³ Figure 1-1-22 in the annual report.

¹⁴ https://www.jetro.go.jp/ext_images/_Ipnews/us/2020/20200710.pdf

7	LG ELECTRONICS INC.	1680.68	4754
8	MICRON TECHNOLOGY, INC.	1414.27	2712
9	LG CHEM, LTD.	1395.20	2211
1 0	FORD GLOBAL TECHNOLOGIES, LLC	1289.11	1751
1 1	<u>HONDA MOTOR CO., LTD.</u>	1280.52	1855
1 2	INTEL CORPORATION	1248.48	3690
1 3	BOE TECHNOLOGY GROUP CO., LTD.	1199.06	4872
1 4	HUAWEI TECHNOLOGIES CO., LTD.	1073.98	3710
1 5	<u>PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.</u>	1019.27	2353
1 6	<u>MITSUBISHI ELECTRIC CORPORATION</u>	907.48	2691
1 7	SK HYNIX INC.	896.23	1690
1 8	<u>SONY CORPORATION</u>	836.91	2885
1 9	THE BOEING COMPANY	795.49	1688
2 0	<u>TOKYO ELECTRON LIMITED</u>	766.96	1070

➤ **US : Ranking in energy-related industry (2021)**

	Applicant Name	Score	No. of App
1	LG CHEM, LTD.	997.94	2211
2	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	560.34	4132
3	<u>PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.</u>	425.04	2353
4	CONTEMPORARY AMPEREX TECHNOLOGY CO., LIMITED	385.45	467
5	SAMSUNG ELECTRONICS CO., LTD.	278.87	9948
6	SAMSUNG SDI CO., LTD.	227.64	348
7	<u>HONDA MOTOR CO., LTD.</u>	216.86	1855
8	HYUNDAI MOTOR COMPANY	194.05	2730
9	KIA MOTORS CORPORATION	178.61	2281
1 0	GM GLOBAL TECHNOLOGY OPERATIONS LLC	178.48	1075
1 1	<u>SANYO ELECTRIC CO., LTD.</u>	161.03	174
1 2	<u>KABUSHIKI KAISHA TOSHIBA</u>	147.51	1590
1 3	<u>SONY SEMICONDUCTOR SOLUTIONS CORPORATION</u>	115.28	947
1 4	ROBERT BOSCH GMBH	113.84	1472

1 5	VESTAS WIND SYSTEMS A/S	113.20	143
1 6	<u>SUMITOMO ELECTRIC INDUSTRIES, LTD.</u>	95.53	1016
1 7	GENERAL ELECTRIC COMPANY	90.77	824
1 8	SIEMENS AKTIENGESELLSCHAFT	88.30	940
1 9	SAUDI ARABIAN OIL COMPANY	87.47	1375
2 0	LG ELECTRONICS INC.	79.94	4754

➤ **US : Ranking in transportation/manufacturing-related industry (2021)**

	Applicant Name	Score	No. of App
1	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	2990.27	4132
2	SAMSUNG ELECTRONICS CO., LTD.	2912.60	9948
3	TAIWAN SEMICONDUCTOR MANUFACTURING CO., LTD.	2736.70	4972
4	HYUNDAI MOTOR COMPANY	2031.05	2730
5	QUALCOMM INCORPORATED	1868.90	3772
6	KIA MOTORS CORPORATION	1717.58	2281
7	MICRON TECHNOLOGY, INC.	1404.74	2712
8	LG ELECTRONICS INC.	1368.63	4754
9	LG CHEM, LTD.	1318.22	2211
1 0	FORD GLOBAL TECHNOLOGIES, LLC	1280.89	1751
1 1	<u>HONDA MOTOR CO., LTD.</u>	1229.29	1855
1 2	INTEL CORPORATION	1201.73	3690
1 3	HUAWEI TECHNOLOGIES CO., LTD.	1042.69	3710
1 4	BOE TECHNOLOGY GROUP CO., LTD.	936.18	4872
1 5	<u>PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.</u>	905.69	2353
1 6	SK HYNIX INC.	880.17	1690
1 7	THE BOEING COMPANY	745.49	1688
1 8	<u>SONY CORPORATION</u>	742.95	2885
1 9	<u>TOKYO ELECTRON LIMITED</u>	736.64	1070
2 0	<u>MITSUBISHI ELECTRIC CORPORATION</u>	711.45	2691

➤ **US : Ranking in household/office-related industry (2021)**

	Applicant Name	Score	No. of App
1	SAMSUNG DISPLAY CO., LTD.	359.91	3152
2	SAMSUNG ELECTRONICS CO., LTD.	348.47	9948
3	LG ELECTRONICS INC.	347.65	4754
4	BOE TECHNOLOGY GROUP CO., LTD.	285.41	4872
5	<u>MITSUBISHI ELECTRIC CORPORATION</u>	250.70	2691
6	LG DISPLAY CO., LTD.	246.22	1217
7	HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.	166.97	3424
8	<u>NEC CORPORATION</u>	156.62	2353
9	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	154.48	843
1 0	SIEMENS AKTIENGESELLSCHAFT	152.83	940
1 1	JOHNSON CONTROLS TECHNOLOGY COMPANY	148.35	444
1 2	WUHAN CHINA STAR OPTOELECTRONICS SEMICONDUCTOR DISPLAY TECHNOLOGY CO., LTD.	145.50	1130
1 3	<u>DAIKIN INDUSTRIES, LTD.</u>	143.80	611
1 4	LUTRON TECHNOLOGY COMPANY LLC	132.73	314
1 5	INTERNATIONAL BUSINESS MACHINES CORPORATION	126.54	4891
1 6	<u>SEIKO EPSON CORPORATION</u>	124.55	1785
1 7	<u>HITACHI, LTD.</u>	122.62	807
1 8	LG CHEM, LTD.	121.74	2211
1 9	<u>PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.</u>	117.08	2353
2 0	SHENZHEN CHINA STAR OPTOELECTRONICS SEMICONDUCTOR DISPLAY TECHNOLOGY CO., LTD.	115.83	699

“Green Enablers” rankings by “Japio-Decarbonization Patent Index” (US)

The estimation based on application to USPTO showed that the average of index was 0.280. It means that about 28.0% of all the USPTO gazettes published in 2021 were estimated as decarbonization-related technologies (reference: For application

to JPO, the average of index in the same year was 0.292).

1071 out of 2706 applicants analyzed had an average index value (0.280) or higher, of which 225 were identified as Japanese companies. **Here are the applicants name, its indexes, and number of publications for up to the top 100 Japanese companies.**

Note that the numbers skipped in the rankings indicate the presence of applicants other than Japanese firms among them.

	Applicant Name	Index	No. of App
25	GE-HITACHI NUCLEAR ENERGY AMERICAS LLC	0.958	24
26	HAPSMOBILE INC.	0.957	23
27	SANYO ELECTRIC CO., LTD.	0.954	174
37	VEHICLE ENERGY JAPAN INC.	0.933	30
45	GS YUASA INTERNATIONAL LTD.	0.918	73
58	IBIDEN CO., LTD.	0.895	57
59	NISSAN NORTH AMERICA, INC.	0.894	142
63	JTEKT EUROPE	0.889	36
74	PANASONIC AUTOMOTIVE SYSTEMS COMPANY OF AMERICA, DIVISION OF PANASONIC CORPORATION OF NORTH AMERICA	0.879	33
84	MITSUI KINZOKU ACT CORPORATION	0.864	22
93	SUBARU CORPORATION	0.853	407
100	DISCO CORPORATION	0.840	200
106	SHINKAWA LTD.	0.833	24
120	MITSUBISHI HEAVY INDUSTRIES ENGINEERING, LTD.	0.821	39
130	TACHI-S CO., LTD.	0.818	22
135	MAZDA MOTOR CORPORATION	0.815	536
141	HINO MOTORS, LTD.	0.808	26
148	SUZUKI MOTOR CORPORATION	0.803	71
151	ISUZU MOTORS LIMITED	0.800	70
153	ORGANO CORPORATION	0.800	30
170	TOKYO ELECTRON LIMITED	0.778	1070
173	KOKUSAI ELECTRIC CORPORATION	0.774	164
179	NIPPON ELECTRIC GLASS CO., LTD.	0.764	55
180	FUJI CORPORATION	0.763	190
182	NTT DOCOMO, INC.	0.762	958

183	MITSUI MINING & SMELTING CO., LTD.	0.760	50
186	MAXELL HOLDINGS, LTD.	0.760	25
191	THE YOKOHAMA RUBBER CO., LTD.	0.754	167
194	TOYOTA JIDOSHA KABUSHIKI KAISHA	0.753	4132
196	YAMAHA HATSUDOKI KABUSHIKI KAISHA	0.750	164
214	TOYOTA MOTOR EUROPE	0.737	38
217	ICHIKOH INDUSTRIES, LTD.	0.733	30
224	NIPPON MEKTRON, LTD.	0.727	22
232	FUJIFILM ELECTRONIC MATERIALS U.S.A., INC.	0.720	25
240	PANASONIC AVIONICS CORPORATION	0.711	45
242	SHIMANO INC.	0.710	131
243	KURARAY NORITAKE DENTAL INC.	0.710	31
244	HONDA MOTOR CO., LTD.	0.709	1855
245	CENTRAL GLASS COMPANY, LIMITED	0.708	48
252	TOSHIBA MEMORY CORPORATION	0.699	372
275	SUMITOMO ELECTRIC DEVICE INNOVATIONS, INC.	0.686	70
278	KOITO MANUFACTURING CO., LTD.	0.682	154
284	TOYOTA MOTOR ENGINEERING & MANUFACTURING NORTH AMERICA, INC.	0.671	644
293	ADVICS CO., LTD.	0.658	76
305	NIPPON SHEET GLASS COMPANY, LIMITED	0.647	51
310	AICHI STEEL CORPORATION	0.645	31
311	NIPPON SUISAN KAISHA, LTD.	0.643	28
313	SENJU METAL INDUSTRY CO., LTD.	0.641	39
320	TOYO TIRE CORPORATION	0.636	154
327	TAIYO YUDEN CO., LTD.	0.634	186
328	EBARA CORPORATION	0.633	120
332	BRIDGESTONE AMERICAS TIRE OPERATIONS, LLC	0.629	62
334	ENEOS CORPORATION	0.625	80
335	CATALER CORPORATION	0.625	40
338	NISSAN MOTOR CO., LTD.	0.623	400
341	JAPAN AEROSPACE EXPLORATION AGENCY	0.621	29
342	KIOXIA CORPORATION	0.621	1128
349	IDEMITSU KOSAN CO., LTD.	0.614	83
358	KOMATSU LTD.	0.605	205
360	MITSUBISHI HITACHI POWER SYSTEMS, LTD.	0.604	53
368	SUMITOMO RUBBER INDUSTRIES, LTD.	0.596	356

379	KURITA WATER INDUSTRIES LTD.	0.591	22
380	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	0.591	843
381	TOKYO OHKA KOGYO CO., LTD.	0.590	61
383	TOYOTA BOSHOKU KABUSHIKI KAISHA	0.588	85
384	JATCO LTD	0.588	51
387	TOSHIBA MATERIALS CO., LTD.	0.588	34
388	THE JAPAN STEEL WORKS, LTD.	0.588	34
397	NISHIKAWA RUBBER CO., LTD.	0.583	24
402	NIPPON LIGHT METAL COMPANY, LTD.	0.580	50
403	KUBOTA CORPORATION	0.580	207
406	KUREHA CORPORATION	0.579	38
412	SHINKO ELECTRIC INDUSTRIES CO., LTD.	0.574	54
413	SCREEN HOLDINGS CO., LTD.	0.573	143
414	SUMITOMO METAL MINING CO., LTD.	0.573	89
417	JX NIPPON MINING & METALS CORPORATION	0.569	72
418	SHELL OIL COMPANY	0.568	74
419	CLARION CO., LTD.	0.566	53
429	YANMAR POWER TECHNOLOGY CO., LTD.	0.560	109
430	NUVOTON TECHNOLOGY CORPORATION JAPAN	0.559	34
444	DENSO INTERNATIONAL AMERICA, INC.	0.550	120
449	TOYOTA MOTOR NORTH AMERICA, INC.	0.547	212
452	NIPPON KAYAKU KABUSHIKI KAISHA	0.545	22
460	SHOWA DENKO K.K.	0.540	161
462	BRIDGESTONE CORPORATION	0.539	269
467	AGC INC.	0.538	344
477	mitsubishi materials corporation	0.531	130
479	NIPPON SODA CO., LTD.	0.526	38
483	NIPPON STEEL CHEMICAL & MATERIAL CO., LTD.	0.525	40
484	HITACHI CONSTRUCTION MACHINERY CO., LTD.	0.524	82
486	IDEMITSU KOSAN CO.,LTD.	0.523	153
488	NUFLARE TECHNOLOGY, INC.	0.523	44
492	DAICEL CORPORATION	0.519	156
504	SAKAI DISPLAY PRODUCTS CORPORATION	0.514	109
508	TOKUYAMA CORPORATION	0.512	82
515	TOSHIBA ENERGY SYSTEMS & SOLUTIONS CORPORATION	0.506	166
516	SEKISUI CHEMICAL CO., LTD.	0.505	192
517	JTEKT CORPORATION	0.502	287

524	AGC FLAT GLASS NORTH AMERICA, INC.	0.500	28
529	NIPPON CHEMICAL INDUSTRIAL CO., LTD.	0.500	24

The results of application to CNIPA (CN)

China's nominal GDP in 2020 was 14,866.74 (USD)¹⁵, ranking second in the world after the United States. According to the JPO's Annual Report 2021¹⁶, the number of patent applications on a filing basis in 2019 was 1,400,661, the highest in the world.

Of applications to CNIPA, the largest number of applications from abroad came from Japan, accounting for only 3% of the total, although the number of applications from Japan is 48,867 on a filing basis in 2019. Most (89%) of the applications to CNIPA are from Chinese applicants¹⁷.

Rankings of “Green Enablers” in 2021 (CN)

In terms of the number of patents published in 2021, 4 of the top 100 are Japanese companies. No Japanese company is in the top 20¹⁸.

In the ranking of “Green Enablers”, 2 of the top 20 are Japanese companies in the overall, 1 of 20 in energy-related industry, 2 of 20 in transportation/manufacturing-related industry, and no Japanese company in household/office-related industry.

➤ CN : Ranking in overall (2021)

	Applicant Name (Original)	Applicant Name (English translation)	Score	No. of App
1	国家电网有限公司	STATE GRID CORP CHINA	5466.7	10060
2	华为技术有限公司	HUAWEI TECH CO LTD	3015.7	9169
3	中国石油化工股份有限公司	CHINA PETROLEUM & CHEM CORP	2993.1	5218
4	珠海格力电器股份有限公司	GREE ELECTRIC APPLIANCES INC ZHUHAI	2710.8	8767
5	海尔智家股份有限公司	HAIER SMART HOME CO LTD	1871.9	5838
6	<u>丰田自动车株式会社</u>	<u>TOYOTA MOTOR CORP</u>	1665.5	2200

¹⁵ World Economic Outlook Database: October 2021

¹⁶ <https://www.jpo.go.jp/resources/report/nenji/2021/index.html>

¹⁷ Figure 1-1-22 in the annual report.

¹⁸ In 2021, five out of the top 200 were identified as Japanese companies, and 10 out of the top 300 were Japanese companies.

7	浙江大学	UNIV ZHEJIANG	1663.8	4625
8	清华大学	UNIV TSINGHUA	1574.0	4309
9	西安交通大学	UNIV XI AN JIAOTONG	1497.1	3796
1 0	OPPO 广东移动通信有限公司	OPPO GUANGDONG MOBILE TELECOMMUNICATIONS CO LTD	1490.3	5336
1 1	华南理工大学	UNIV SOUTH CHINA TECH	1285.8	3452
1 2	东南大学	UNIV SOUTHEAST	1284.0	3327
1 3	西安热工研究院有限公司	XIAN THERMAL POWER RES INST CO	1266.8	2549
1 4	台湾积体电路制造股份有限公司	TAIWAN SEMICONDUCTOR MFG CO LTD	1254.6	2132
1 5	华中科技大学	UNIV HUAZHONG SCIENCE TECH	1251.9	2921
1 6	比亚迪股份有限公司	BYD CO LTD	1244.8	1546
1 7	南京航空航天大学	UNIV NANJING AERONAUTICS & ASTRONAUTICS	1205.2	2623
1 8	北京航空航天大学	UNIV BEIHANG	1149.4	2956
1 9	中国电力科学研究院有限公司	CHINA ELECTRIC POWER RES INST CO LTD	1127.0	1851
2 0	本田技研工业株式会社	HONDA MOTOR CO LTD	1126.5	1525

➤ **CN : Ranking in energy-related industry (2021)**

	Applicant Name (Original)	Applicant Name (English translation)	Score	No. of App
1	国家电网有限公司	STATE GRID CORP CHINA	2141.0	10060
2	西安热工研究院有限公司	XIAN THERMAL POWER RES INST CO	778.2	2549
3	中国华能集团清洁能源技术研究院有限公司	HUANENG CLEAN ENERGY RES INST	610.7	890
4	中国电力科学研究院有限公司	CHINA ELECTRIC POWER RES INST CO LTD	577.7	1851
5	西安交通大学	UNIV XI AN JIAOTONG	554.7	3796
6	浙江大学	UNIV ZHEJIANG	446.7	4625
7	清华大学	UNIV TSINGHUA	428.1	4309

8	宁德新能源科技有限公司	NINGDE AMPEREX TECHNOLOGY LTD	412.3	443
9	中国广核集团有限公司	CHINA GENERAL NUCLEAR POWER CORPORATION	406.8	808
1 0	中国广核电力股份有限公司	CGN POWER CO LTD	404.9	801
1 1	珠海冠宇电池股份有限公司	ZHUHAI COSMX BATTERY CO LTD	395.1	425
1 2	华中科技大学	UNIV HUAZHONG SCIENCE TECH	391.5	2921
1 3	广东电网有限责任公司	GUANGDONG POWER GRID CO	344.1	2357
1 4	蜂巢能源科技有限公司	SVOLT ENERGY TECH CO LTD	340.4	479
1 5	中国石油化工股份有限公司	CHINA PETROLEUM & CHEM CORP	335.9	5218
1 6	山东大学	UNIV SHANDONG	335.8	2934
1 7	华北电力大学	UNIV NORTH CHINA ELECTRIC POWER	314.9	1006
1 8	上海交通大学	UNIV SHANGHAI JIAOTONG	312.3	2932
1 9	<u>丰田自动车株式会社</u>	<u>TOYOTA MOTOR CORP</u>	298.9	2200
2 0	东南大学	UNIV SOUTHEAST	296.5	3327

➤ **CN : Ranking in transportation/manufacturing-related industry (2021)**

	Applicant Name (Original)	Applicant Name (English translation)	Score	No. of App
1	国家电网有限公司	STATE GRID CORP CHINA	4426.4	10060
2	华为技术有限公司	HUAWEI TECH CO LTD	2887.5	9169
3	中国石油化工股份有限公司	CHINA PETROLEUM & CHEM CORP	2849.6	5218
4	<u>丰田自动车株式会社</u>	<u>TOYOTA MOTOR CORP</u>	1641.0	2200
5	OPPO 广东移动通信有限公司	OPPO GUANGDONG MOBILE TELECOMMUNICATIONS CO LTD	1456.4	5336
6	浙江大学	UNIV ZHEJIANG	1298.1	4625
7	珠海格力电器股份有限	GREE ELECTRIC APPLIANCES	1263.6	8767

	公司	INC ZHUHAI		
8	清华大学	UNIV TSINGHUA	1251.6	4309
9	台湾积体电路制造股份有限公司	TAIWAN SEMICONDUCTOR MFG CO LTD	1242.9	2132
1 0	比亚迪股份有限公司	BYD CO LTD	1217.1	1546
1 1	<u>本田技研工业株式会社</u>	<u>HONDA MOTOR CO LTD</u>	1102.4	1525
1 2	南京航空航天大学	UNIV NANJING AERONAUTICS & ASTRONAUTICS	1067.5	2623
1 3	华南理工大学	UNIV SOUTH CHINA TECH	1052.9	3452
1 4	三星电子株式会社	SAMSUNG ELECTRONICS CO LTD	1041.6	3441
1 5	东南大学	UNIV SOUTHEAST	1029.7	3327
1 6	西安交通大学	UNIV XI AN JIAOTONG	1021.9	3796
1 7	中南大学	UNIV CENTRAL SOUTH	1015.6	2581
1 8	北京理工大学	BEIJING INSTITUTE TECH	997.2	2755
1 9	北京航空航天大学	UNIV BEIHANG	981.4	2956
2 0	西北工业大学	UNIV NORTHWESTERN POLYTECHNICAL	966.8	2560

➤ **CN : Ranking in household/office-related industry (2021)**

	Applicant Name (Original)	Applicant Name (English translation)	Score	No. of App
1	国家电网有限公司	STATE GRID CORP CHINA	3344.4	10060
2	珠海格力电器股份有限公司	GREE ELECTRIC APPLIANCES INC ZHUHAI	1837.0	8767
3	海尔智家股份有限公司	HAIER SMART HOME CO LTD	1701.6	5838
4	西安热工研究院有限公司	XIAN THERMAL POWER RES INST CO	713.1	2549
5	中国电力科学研究院有限公司	CHINA ELECTRIC POWER RES INST CO LTD	702.2	1851
6	广东电网有限责任公司	GUANGDONG POWER GRID CO	671.3	2357
7	浙江大学	UNIV ZHEJIANG	496.5	4625
8	青岛海尔空调电子有限公司	QINGDAO HAIER AIR CONDITIONER ELECTRIC CO	471.9	1606

		LTD		
9	青岛海尔空调器有限总公司	QINGDAO HAIER AIR CONDITIONER	465.7	1730
1 0	西安交通大学	UNIV XI AN JIAOTONG	465.4	3796
1 1	青岛海尔洗衣机有限公司	QINGDAO HAIER WASHING MACH CO	461.0	833
1 2	清华大学	UNIV TSINGHUA	419.4	4309
1 3	东南大学	UNIV SOUTHEAST	417.3	3327
1 4	华中科技大学	UNIV HUAZHONG SCIENCE TECH	402.1	2921
1 5	华北电力大学	UNIV NORTH CHINA ELECTRIC POWER	388.0	1006
1 6	国网江苏省电力有限公司	STATE GRID JIANGSU ELECTRIC POWER CO LTD	375.4	942
1 7	山东大学	UNIV SHANDONG	370.0	2934
1 8	深圳供电局有限公司	SHENZHEN POWER SUPPLY BUREAU	365.7	1083
1 9	京东方科技集团股份有限公司	BOE TECHNOLOGY GROUP CO LTD	350.0	4084
2 0	华南理工大学	UNIV SOUTH CHINA TECH	335.8	3452

“Green Enablers” rankings by “Japio-Decarbonization Patent Index” (CN)

The estimation based on application to CNIPA showed that the average of index was 0.356. It means that about 35.6% of all the CNIPA gazettes published in 2021 were estimated as decarbonization-related technologies (reference: For application to JPO, the average of index in the same year was 0.292).

3973 out of 8682 applicants analyzed had an average index value (0.356) or higher, of which 161 were identified as Japanese companies. **Here are the applicants name, its indexes, and number of publications for up to the top 100 Japanese companies.**

Note that the numbers skipped in the rankings indicate the presence of applicants other than Japanese firms among them.

	Applicant Name (Original)	Applicant Name (English translation)	Index	No. of App
46	株式会社杰士汤浅国际	GS YUASA INT LTD	0.987	79
90	三洋电机株式会社	SANYO ELECTRIC CO	0.965	114
175	株式会社国际电气	KOKUSAI ELECTRIC CORP	0.933	89
198	三电汽车空调系统株式会社	SANDEN AUTOMOTIVE CLIMATE SYSTEMS CORP	0.923	39
249	株式会社斯巴鲁	SUBARU CORP	0.911	168
290	广汽本田汽车研究开发有限公司	GUANGZHOU HONDA RES & DEVELOPMENT CO LTD	0.895	57
315	佳能特机株式会社	CANON TOKKI CORP	0.884	69
427	株式会社迪思科	DISCO CORP	0.847	262
464	东京毅力科创株式会社	TOKYO ELECTRON LTD	0.839	560
492	马自达汽车株式会社	MAZDA MOTOR	0.831	177
505	株式会社爱德克斯	ADVICS CO LTD	0.828	29
517	芝浦机械电子装置株式会社	SHIBAURA MECHATRONICS CORP	0.826	23
532	三井金属矿业株式会社	MITSUI MINING & SMELTING CO	0.822	45
594	住友金属矿山株式会社	SUMITOMO METAL MINING CO	0.810	58
674	江西五十铃汽车有限公司	JIANGXI ISUZU MOTORS CO LTD	0.793	29
712	日本电气硝子株式会社	NIPPON ELECTRIC GLASS CO	0.783	92
749	丰田自动车株式会社	TOYOTA MOTOR CORP	0.777	2200
758	株式会社久保田	KUBOTA KK	0.774	115
797	本田技研工业株式会社	HONDA MOTOR CO LTD	0.765	1525
798	日产自动车株式会社	NISSAN MOTOR	0.765	255
802	旭硝子欧洲玻璃公司	AGC GLASS EUROPE	0.765	34
839	东京应化工业株式会社	TOKYO OHKA KOGYO CO LTD	0.756	45
887	洋马动力科技有限公司	YANMAR CO LTD	0.746	67
931	松下电器产业株式会社	PANASONIC CORP	0.739	88
1011	株式会社 NTT 都科摩	NTT DOCOMO INC	0.723	458
1065	东风汽车有限公司 东风	DONGFENG MOTOR CO LTD	0.711	76

	日产乘用车公司	DONGFENG NISSAN PASSENGER CAR CO LTD		
1085	株式会社斯库林集团	SCREEN HOLDINGS CO LTD	0.709	158
1106	信越半导体株式会社	SHINETSU HANDOTAI KK	0.704	27
1107	日本板硝子株式会社	NIPPON SHEET GLASS CO LTD	0.704	27
1122	横滨橡胶株式会社	YOKOHAMA RUBBER CO LTD	0.701	144
1126	东芝电梯株式会社	TOSHIBA ELEVATOR KK	0.700	50
1180	三星钻石工业股份有限公司	MITSUBOSHI DIAMOND IND CO LTD	0.690	42
1197	太阳诱电株式会社	TAIYO YUDEN KK	0.688	64
1200	株式会社爱发科	ULVAC INC	0.688	48
1205	株式会社富士	FUJI CO LTD	0.686	156
1209	住友橡胶工业株式会社	SUMITOMO RUBBER IND	0.684	174
1212	株式会社德山	TOKUYAMA CORP	0.683	41
1229	杭州松下家用电器有限公司	PANASONIC HOME APPLIANCES WASHING MACHINE HANGZHOU CO LTD	0.680	25
1238	广汽本田汽车有限公司	GUANGQI HONDA AUTOMOBILE CO	0.679	112
1299	株式会社荏原制作所	EBARA CORP	0.667	81
1308	株式会社能率	NORITZ CORP	0.667	33
1323	奥加诺株式会社	ORGANO CORP	0.667	24
1332	五十铃自动车株式会社	ISUZU MOTORS LTD	0.664	125
1381	AQUA 株式会社	AQUA CO LTD	0.653	75
1387	株式会社半导体能源研究所	SEMICONDUCTOR ENERGY LAB	0.653	288
1449	通伊欧轮胎株式会社	TOYO TIRES KK	0.645	31
1537	爱信精机株式会社	AISIN SEIKI	0.631	84
1538	雅马哈发动机株式会社	YAMAHA MOTOR CO LTD	0.630	46
1568	上海中船三井造船柴油机有限公司	CSSC MES DIESEL CO LTD	0.625	48
1579	东风本田汽车有限公司	HONDA AUTOMOBILE CO LTD	0.625	24
1602	广汽丰田汽车有限公司	GAC TOYOTA MOTOR CO LTD	0.622	45
1617	株式会社科特拉	CATALER CORP	0.621	29

1654	株式会社吴羽	KUREHA CORP	0.615	26
1696	株式会社小糸制作所	KOITO MFG CO LTD	0.608	148
1712	AGC 株式会社	AGC INC	0.605	256
1761	日立电梯(中国)有限公司	HITACHI ELEVATOR CHINA CO LTD	0.596	104
1774	三菱动力株式会社	MITSUBISHI HITACHI POWER SYS	0.593	135
1822	东芝能源系统株式会社	TOSHIBA SYSTEM TECH CORPORATION	0.585	53
1831	株式会社爱信	AISIN CORP	0.583	48
1836	新光电气工业株式会社	SHINKO ELECTRIC IND CO	0.583	24
1845	中央硝子株式会社	CENTRAL GLASS CO LTD	0.581	43
1857	日铁化学材料株式会社	NIPPON STEEL CHEMICAL & MAT CO LTD	0.579	57
1891	株式会社普利司通	BRIDGESTONE CORP	0.572	166
1908	斯坦雷电气株式会社	STANLEY ELECTRIC CO LTD	0.571	28
1919	三菱重工业株式会社	MITSUBISHI HEAVY IND LTD	0.568	81
1928	昭和电工材料株式会社	SHOWA DENKO ELECTRICIAN MAT CO LTD	0.567	180
1929	株式会社丰田自动织机	TOYOTA JIDOSHOKKI KK	0.567	90
1931	三菱重工制冷空调系统株式会社	MITSUBISHI HEAVY IND THERMAL SYSTEMS LTD	0.567	30
1968	千住金属工业株式会社	SENJU METAL IND CO	0.563	32
2013	引能仕株式会社	ENEOS CORP	0.557	61
2050	提爱思科技股份有限公司	TS TECH CO LTD	0.552	29
2058	丰田合成株式会社	TOYODA GOSEI KK	0.550	40
2123	竹本油脂株式会社	TAKEMOTO OIL & FAT CO LTD	0.542	24
2156	加特可株式会社	JATCO LTD	0.537	41
2159	株式会社小松制作所	KOMATSU MFG CO LTD	0.536	110
2203	东曹株式会社	TOSOH CORP	0.531	32
2208	郑州日产汽车有限公司	ZHENGZHOU NISSAN AUTOMOBILE CO	0.531	32
2216	日立江森自控空调有限	HITACHI JOHNSON	0.529	34

	公司	CONTROLS CONDITIONING INC	AIR		
2310	栗田工业株式会社	KURITA WATER IND LTD		0.519	27
2335	富士通将军股份有限公司	FUJITSU GENERAL LTD		0.516	31

The results of applications to DPMA (DE)

Germany's nominal GDP in 2020 was 3,843.34 (USD)¹⁹, ranking fourth in the world after the United States, China, and Japan. According to the JPO's Annual Report 2021, the number of patent applications on a filing basis in 2019 was 67,434.

According to the annual report, the largest number of applications from abroad came from Japan (14% of the 2019 application base, accounted for 7,956). The United States is ranked as the second (6,207)²⁰.

Rankings of “Green Enablers” in 2021 (DE)

In terms of the number of patents published in 2021, 15 of the top 100 are Japanese companies. One of the top 20 is a Japanese company.

In the ranking of “Green Enablers”, 3 of the top 20 are Japanese companies in the overall, 5 of 20 in energy-related industry, 3 of 20 in transportation/manufacturing-related industry, and 6 of 20 in household/office-related industry.

➤ DE : Ranking overall (2021)

	Applicant Name	Score	No. of App
1	ROBERT BOSCH GMBH	1770.97	4070
2	BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	1539.17	2085
3	VOLKSWAGEN AKTIENGESELLSCHAFT	1078.81	1502
4	DAIMLER AG	1045.06	1448
5	ZF FRIEDRICHSHAFEN AG	900.91	1432
6	FORD GLOBAL TECHNOLOGIES, LLC	895.28	1154
7	AUDI AKTIENGESELLSCHAFT	870.92	1136
8	SCHAEFFLER TECHNOLOGIES AG & CO KG	818.98	1852
9	HYUNDAI MOTOR COMPANY	530.56	715
10	KIA MOTORS CORPORATION	528.92	712
11	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	358.23	488
12	DR. ING. H.C. F. PORSCHE	319.25	456

¹⁹ World Economic Outlook Database: October 2021

²⁰ <https://www.jpo.go.jp/resources/report/nenji/2021/document/index/0402.pdf#page=5>

	AKTIENGESELLSCHAFT		
1 3	GM GLOBAL TECHNOLOGY OPERATIONS LLC	281.51	449
1 4	<u>DENSO CORPORATION</u>	199.85	540
1 5	TAIWAN SEMICONDUCTOR MANUFACTURING CO., LTD.	178.22	684
1 6	<u>MITSUBISHI ELECTRIC CORPORATION</u>	175.07	653
1 7	DEERE & COMPANY	155.11	266
1 8	INTEL CORPORATION	146.94	597
1 9	VALEO SCHALTER UND SENSOREN GMBH	142.35	208
2 0	CONTINENTAL REIFEN DEUTSCHLAND GMBH	142.32	257

➤ **DE : Ranking in energy-related industry (2021)**

	Applicant Name	Score	No. of App
1	ROBERT BOSCH GMBH	462.74	4070
2	AUDI AKTIENGESELLSCHAFT	154.66	1136
3	BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	102.72	2085
4	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	97.86	488
5	VOLKSWAGEN AKTIENGESELLSCHAFT	90.71	1502
6	DAIMLER AG	76.45	1448
7	GM GLOBAL TECHNOLOGY OPERATIONS LLC	61.47	449
8	HYUNDAI MOTOR COMPANY	58.45	715
9	KIA MOTORS CORPORATION	58.44	712
1 0	SIEMENS AKTIENGESELLSCHAFT	37.96	271
1 1	ELRINGKLINGER AG	36.72	74
1 2	FORD GLOBAL TECHNOLOGIES, LLC	27.47	1154
1 3	<u>HONDA MOTOR CO., LTD.</u>	27.07	198
1 4	<u>GS YUASA INTERNATIONAL LTD.</u>	26.61	35
1 5	<u>DENSO CORPORATION</u>	19.30	540
1 6	MAHLE INTERNATIONAL GMBH	18.92	253
1 7	DR. ING. H.C. F. PORSCHE AKTIENGESELLSCHAFT	18.33	456
1 8	DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT E.V.	17.29	175
1 9	<u>SONY SEMICONDUCTOR SOLUTIONS</u>	16.62	145

	<u>CORPORATION</u>		
2 0	SCHAEFFLER TECHNOLOGIES AG & CO KG	16.61	1852

➤ **DE : Ranking in transportation/manufacturing-related industry (2021)**

	Applicant Name	Score	No. of App
1	ROBERT BOSCH GMBH	1724.81	4070
2	BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	1518.73	2085
3	VOLKSWAGEN AKTIENGESELLSCHAFT	1061.30	1502
4	DAIMLER AG	1031.64	1448
5	ZF FRIEDRICHSHAFEN AG	892.11	1432
6	FORD GLOBAL TECHNOLOGIES, LLC	887.66	1154
7	AUDI AKTIENGESELLSCHAFT	863.77	1136
8	SCHAEFFLER TECHNOLOGIES AG & CO KG	810.06	1852
9	HYUNDAI MOTOR COMPANY	523.83	715
1 0	KIA MOTORS CORPORATION	522.19	712
1 1	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	354.03	488
1 2	DR. ING. H.C. F. PORSCHE AKTIENGESELLSCHAFT	315.42	456
1 3	GM GLOBAL TECHNOLOGY OPERATIONS LLC	277.72	449
1 4	<u>DENSO CORPORATION</u>	193.34	540
1 5	TAIWAN SEMICONDUCTOR MANUFACTURING CO., LTD.	175.59	684
1 6	DEERE & COMPANY	150.64	266
1 7	INTEL CORPORATION	143.71	597
1 8	VALEO SCHALTER UND SENSOREN GMBH	142.35	208
1 9	CONTINENTAL REIFEN DEUTSCHLAND GMBH	142.32	257
2 0	<u>MITSUBISHI ELECTRIC CORPORATION</u>	131.66	653

➤ **DE : Ranking in household/office-related industry (2021)**

	Applicant Name	Score	No. of App
1	ROBERT BOSCH GMBH	77.69	4070
2	<u>MITSUBISHI ELECTRIC CORPORATION</u>	54.59	653

3	<u>FANUC CORPORATION</u>	43.14	326
4	BSH HAUSGERÄTE GMBH	42.30	421
5	MIELE & CIE. KG	40.19	308
6	ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.	40.08	43
7	SIEMENS AKTIENGESELLSCHAFT	39.80	271
8	BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT	30.80	2085
9	VOLKSWAGEN AKTIENGESELLSCHAFT	26.60	1502
1 0	HELLA GMBH & CO. KGAA	22.24	187
1 1	DAIMLER AG	21.16	1448
1 2	<u>TOYOTA JIDOSHA KABUSHIKI KAISHA</u>	15.36	488
1 3	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	14.52	54
1 4	<u>KOMATSU LTD.</u>	14.46	60
1 5	ZF FRIEDRICHSHAFEN AG	13.85	1432
1 6	CARL ZEISS SMT GMBH	13.72	184
1 7	AUDI AKTIENGESELLSCHAFT	13.66	1136
1 8	<u>SONY SEMICONDUCTOR SOLUTIONS CORPORATION</u>	10.96	145
1 9	<u>MITSUBISHI POWER, LTD.</u>	10.96	80
2 0	FISHER-ROSEMOUNT SYSTEMS, INC.	10.67	27

“Green Enablers” rankings by “Japio-Decarbonization Patent Index” (DE)

The estimation based on application to DPMA showed that the average of index was 0.402. It means that about 40.2% of all the DPMA gazettes published in 2021 were estimated as decarbonization-related technologies (reference: For application to JPO, the average of index in the same year was 0.292).

106 out of 259 applicants analyzed had an average index value (0.402) or higher, of which 19 were identified as Japanese companies. **Here are the applicants name, its indexes, and number of publications for Japanese companies.**

Note that the numbers skipped in the rankings indicate the presence of applicants other than Japanese firms among them.

	Applicant Name	Index	No. of App
3	SUBARU CORPORATION	0.941	34
7	GS YUASA INTERNATIONAL LTD.	0.886	35
20	SHIMANO INC.	0.800	115
33	TOYOTA JIDOSHA KABUSHIKI KAISHA	0.754	488
42	THE YOKOHAMA RUBBER CO., LTD.	0.722	90
47	HONDA MOTOR CO., LTD.	0.687	198
53	SUZUKI MOTOR CORPORATION	0.664	116
54	AISIN SEIKI KABUSHIKI KAISHA	0.659	41
62	ISUZU MOTORS LIMITED	0.612	49
68	AGC INC.	0.576	33
72	SEMICONDUCTOR ENERGY LABORATORY CO., LTD.	0.556	54
78	SUMCO CORPORATION	0.529	34
79	MITSUBISHI POWER, LTD.	0.500	80
82	DISCO CORPORATION	0.496	133
84	HITACHI AUTOMOTIVE SYSTEMS, LTD.	0.478	90
91	MITSUBISHI HEAVY INDUSTRIES, LTD.	0.455	44
96	KABUSHIKI KAISHA TOYOTA JIDOSHOKKI	0.439	66
99	YAMAHA HATSUDOKI KABUSHIKI KAISHA	0.424	33
103	KOMATSU LTD.	0.417	60

4. Discussion

Patents data of the PCT international applications, applications to the U.S., China, and Germany, published in 2021, were analyzed for visualizing decarbonization (Carbon Neutrality) technologies using Japio's AI models, and the results were compiled to company level in order to see who the "Green Enabler" is.

In the rankings of "Green Enablers", a company having decarbonization-related patents, in 2021, the number of Japanese companies in the top 20 was relatively high, comparing to the top 20 with the most applications. (See red number in Table 1)

Table 1: Number of Japanese companies in the rankings of "Green Enablers"

	Overall	Energy-related industry	transportation/manufacturing-related industry	household/office-related industry	(ref) top 20 with the most applications ²¹
WO	6	7	4	5	7
US	6	7	6	6	5
CN	2	1	2	0	0
DE	3	5	3	6	1

"Green Enablers" rankings by "Japio-Decarbonization Patent Index" shows a relatively high proportion of Japanese companies among those with above-average of the index. In particular, the values normalized by the ratio of the number of applications filed by Japanese entity in each country in 2019 or 2020 are generally above 1. (See red number in Table 2)

Table 2: The ratio of Japanese company in "Green Enablers" rankings by "Japio-Decarbonization Patent Index"

²¹ The number of Japanese companies in the top 20 with the most applications in 2021

	companies among those with above-average of the index(A)	Number of Japanese companies out of A (B)	Ratio of Japanese company (B/C, hereafter "C")	Normalized ²² (C/Z)
WO	848	165	0.195	0.980
				1.058 ²³
US	1071	225	0.210	1.546
CN	3973	161	0.041	1.162
DE	106	19	0.179	1.519

The ranking of "Green Enablers" is a quantitative indicator of their R&D capabilities in decarbonization technologies. On the other hand, "Green Enablers" ranking by "Japio-Decarbonization Patent Index" is an indicator of how a company's R&D is directed to decarbonization. From Tables 1 and 2 above, it is clear that Japanese companies are actively engaged in R&D and patent applications for decarbonization technologies in major countries, both in terms of quantity and directivity.

This is obvious evidence that many Japanese companies have the potential to develop technologies to solve the environmental changes that are becoming a social issue around the world, and the implementation of such technologies in society is eagerly awaited. For this purpose, they should present such evidence to global investors to alleviate the ESG discounting problem as described in "1. Background".

²² The number of applications filed in 2019 (or 2020) by each patent office, and the number and percentage of applications filed by Japanese company, are as follows. If the ratio (C/Z) in Table 2 is more than 1, it means more Japanese companies with high decarbonized patent index in the country. Please note that, because C is based on the number of patents and companies, and Z is based on the number of applications filed annually, it cannot be simply compared.

	Number of application (X)	Number of Japanese companies out of X (Y)	Ratio of Japanese company (Y/X, hereafter "Z")
WO (2019)	265382	52693	0.199
WO (2020)	274764	50527	0.184
US (2019)	621451	84435	0.136
CN (2019)	1400661	48867	0.035
DE (2019)	67434	7956	0.118

The figures were cited from the JPO's Annual Report 2021 and 2020.

²³ Normalized by Z (0.184) of PCT international applications.

In order to achieve the mid- and long-term goals of a decarbonized society, it is important for each government to create an environment, both institutional and financial, that encourages companies mentioned in this report, with the technological potential, to apply patents and implement these decarbonization-related technologies in its country.

For example, in terms of intellectual property, it is expected to research technological trends to identify which companies and universities have seeds that can contribute to decarbonization, and to establish a framework to promote cooperation among companies by utilizing these intellectual property rights.

5. Contact us

If you have any questions, comments or insights on this report, feel free to contact with us in the URL below. (Although the form is Japanese, you can contact us in English.)

➤ Contact us

<https://transtool.japio.or.jp/work/contact/>