patent varemerke design
Patentstyret

Carbon Capture Technology

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Turning ideas into assets

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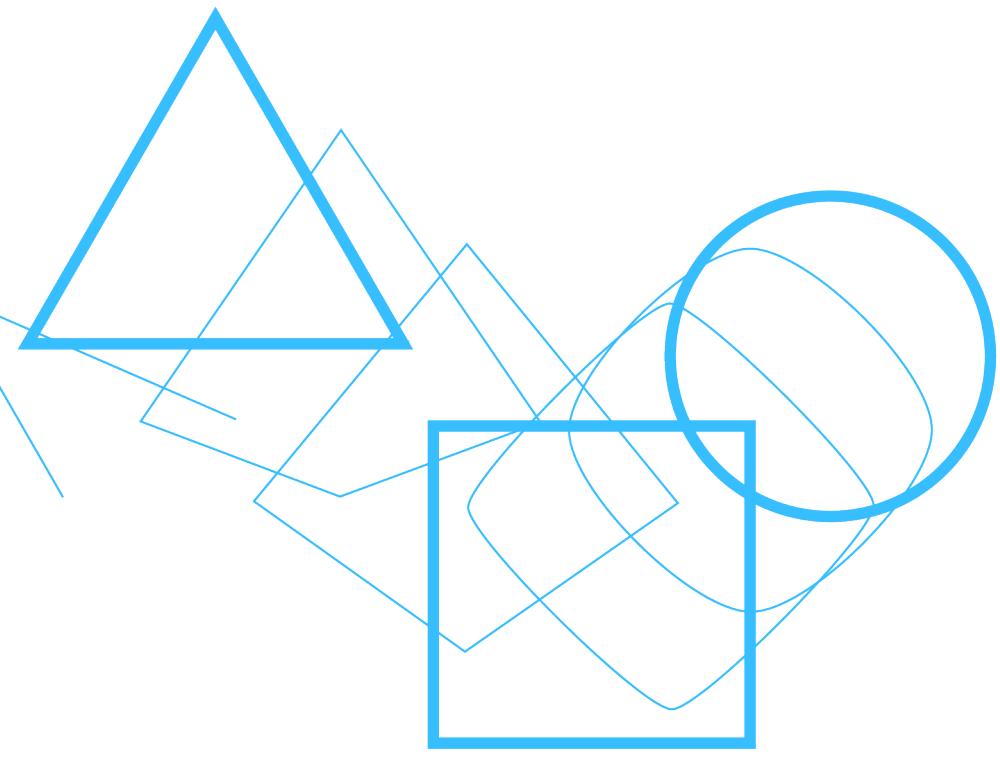
A national centre for intellectual property rights

The primary role of the Norwegian Industrial Property Office (NIPO) is to promote innovation and value creation, both as national intellectual property rights authority and as a guide and knowledge provider. NIPO contributes to competitiveness and helps to strengthen Norwegian trade and industry in various ways. We provide knowledge and expertise concerning intellectual property rights and values, enabling businesses to secure their investments, their competitive position and create economic growth in Norwegian society.

What are Intellectual Property Rights?

Intellectual Property Rights (IPR) are legal monopoly rights that protects inventions, names, logos, designs, and other innovations. Strategic use of these rights can make IPR to the most valuable assets of your business.



Executive Summary

The aim of this report is to provide an analysis of the existing patent data within the Carbon Capture Technology. This report is based on a collaboration between the Norwegian Industrial Property Office (NIPO) and the Norwegian state enterprise Gassnova, which ensures that technology for capture of CO_2 can be implemented and become an effective climate measure.

The report aims to uncover opportunities and challenges in IPR by mapping the patent landscape in the technical area related to Carbon Capture.

A patent dataset consisting of eight subareas of technologies adapted for the key research areas within Carbon Capture was retrieved and used for further analysis.

135 commercial Carbon Capture & Storage facilities in operation or in development were registered globally in 2021. A plurality of these is located in USA and Europe and a minor number in Asia and Australia. Norway has been successfully deploying Carbon Capture in the country's climate mitigation plans and actions for over 20 years with a continued commitment to reduce emissions[1].

When analysing the global patent environment for the present dataset, there is no doubt that USA is the world's largest provider of patent applications, followed by China, Japan, EPO and Germany. Norway is number ten on this list.

USA and Japan constitute most of the patent extensions and Norwegian applicants extend mostly to USA and Canada. The European countries, with Finland and Italy in front, are the most international focused nations, based on their high degree of patent extensions. China is on the other side of the list, extending less than 1 % of their patent applications. As expected, a considerable share of the patent applications is extended through the international PCT-system, organised by WIPO, and/or the regional European system, organised by EPO.

When looking at the historical patenting development (2001-2021), it is important to notice that China has an ever-increasing curve of granted patents in all the eight analysed technical areas, with an exception for the solid sorbent and oxy combustion technologies, while USA has a decreasing curve from 2015 despite of the cryogenic technology with a slight increment. One should also be aware of the other countries, which also have a decreasing trend in most areas. Norway is not represented in the graphs as the number of granted patents is low.

The solvent and membrane technologies are clearly the most patented areas within the Carbon Capture Technology internationally. Within these technological areas, USA, China, Korea and Japan have the largest patent force worldwide, when considering the number of granted patents.[1]

1 https://www.globalccsinstitute.com/wp-content/uploads/2021-/10/2021-Global-Status-of-CCS-Report_Global_CCS_Institute.pdf

1 Background

Future aspects of IPR within Carbon Capture Technology

Carbon Capture technology is a contribution to slowing global warming by capturing carbon dioxide (CO_2) from a gas stream and then storing it, for example in underground geological reservoirs, instead of releasing it into the atmosphere. This will enable the utilization of depleted Norwegian and international oil and gas reservoirs. Norwegian and foreign oil and production companies have therefore been at the forefront of developing carbon capture technology as well as transport and storage for CO_2.

However, new and innovative solutions are still required to be able to improve the technology and to reduce the costs and complexity of developing new Carbon Capture facilities.

IPR will become increasingly important for the Norwegian Carbon Capture technology when they seek to expand their technology internationally, or when they face competition from international companies that want to do the same.

Understanding the global patent environment is an important factor in making good strategic decisions. The aim of this report is to present available patent data in the different areas of Carbon Capture technology to form a knowledge platform as a tool to make the right decisions.

The nature of IPRs is complex and it is very important to have a thoroughly insight in the patent landscape you are working in to know where you have the freedom to operate and to avoid doing infringements into your competitors' IPR, which can be very expensive and cause a lot of trouble. In the ever-increasing complexity of the technical field, it is also important to protect your own unique knowledge and ideas, both to secure exclusive rights to your own invention, and to gain more advantages in negotiations with investors, partners, and potential rights holders.

Interpretation of patent data

When looking at a patenting environment, it is important to view it from the right perspective. A large number of patent applications from a competing nation in a competing field of technology may not always be of great concern, for example if it's not valid in your marked. However, it is important to note that these documents are a part of prior art, which might be a hinder if you want to protect your invention with a patent.

A patent application may have varying legal statuses in different countries. The legal status of an invention may range from declined to granted. A declined patent application is most useful in the sense that it adds to prior art and will not be eligible for legal enforcement. However, a granted patent can be legally enforced and is therefore a greater threat to competitors in the marked.

The patent authorities may have different practices in handling of the applications, and the lifetime of a patent may vary, e.g. as a part of the assignee's IPR-strategy. Many applications from China are filed as utility models (see terminology) which is a simplified version of patent, with a reduced lifetime and less stringent patentability requirements.

2 Methodology

Dataset overview

In this report, there are eight technology areas linked to Carbon Capture. These eight areas constitute the eight sub datasets in this report, which together represents the entire patent dataset. The analysis of this report is limited to this patent dataset.

The eight different technology areas are listed in Table 1. These areas are referred to as sub datasets in this report.

SOLVENTS
MEMBRANES
SOLID SORBENTS
CRYOGENIC
OXYCOMBUSTION
CHEMICAL LOOPING
HYDROGEN SEPARATION
FUEL CELLS

Table 1: The different areas of technology.

Search strategy

The patent data for this report was retrieved in April 2022 from different patent literature databases and was restricted to the twenty-year period 2001-2021. A combination of classification and full text search has been conducted to get relevant search results. In addition, backward and forward citations from the description in the publications have been used to gather related prior art. Each search result has been filtered and later grouped into the different technical areas.
Full text search is conducted with both query search and classification search. The set of query and classification is mainly prepared and completed in collaboration with GASSNOVA.
PatSnap was used to analyze the retrieved patent documents.

Patent classification overview

The different sub datasets represent a large number of publications with several different classifications, according to the CPC and IPC classification system. The classification chart beneath (Table 2) illustrates the main relevant patent classifications for the technology area in subject.

- B01D2251/00 - Reactants
- B01D2252/00 - Absorbents, i.e. solvents and liquid materials for gas absorption
- B01D2253/00 - Adsorbents used in seperation treatment of gases and vapours
- B01D2255/00 - Catalysts
- B01D2256/00 - Main component in the product gas stream after treatment
- B01D2257/00 - Components to be removed (f.ex Organic, sulfur, halogens etc.)
- B01D2258/00 - Sources of waste gases
- B01D2259/00 - Type of treatment
- B01D2311/00 - Details relating to membrane separation process operations and control
- B01D2323/00 - Details relating to membrane preparation
- B01D2325/00 - Details relating to properties of membranes
- B01D3/00 - Distillation or related exchange processes in which liquids are contacted with gaseous media, e.g. stripping
- B01D15/00 - Separating processes involving the treatment of liquids with solid sorbents
- B01D19/00 - Degasification of liquids
- B01D53/00 - Separation of gases or vapours; Recovering vapours of volatile solvents from gases; Chemical or biological purification of waste gases, e.g. engine exhaust gases, smoke, fumes, flue gases, aerosols,
- B01D61/00 - Processes of separation using semi-permeable membranes, e.g. dialysis, osmosis, ultrafiltration; Apparatus, accessories or auxiliary operations specially adapted therefor
- B01D63/00 - Apparatus in general for separation processes using semi-permeable membranes
- B01D67/00 - Processes specially adapted for manufacturing semi-permeable membranes for separation processes or apparatus
- B01D69/00 - Semi-permeable membranes for separation processes or apparatus characterised by their form, structure or properties; Manufacturing processes specially adapted therefor
- B01D71/00 - Semi-permeable membranes for separation processes or apparatus characterised by the material; Manufacturing processes specially adapted therefor
- B01F3/00 - Mixing, e.g. dispersing, emulsifying, according to the phases to be mixed
- B01J8/00 - Chemical or physical processes in general, conducted in the presence of fluids and solid particles; Apparatus for such processes
- B01J19/00 - Chemical, physical or physico-chemical processes in general
- B01J20/00 - Solid sorbent compositions
- B82Y30/00 - Nanotechnology for materials or surface science, e.g. nanocomposites
- B82Y40/00 - Manufacture or treatment of nanostructures
- C01B3/00 - Hydrogen; Gaseous mixtures containing hydrogen; Separation of hydrogen from mixtures containing it ; Purification of hydrogen

Table 2: Patent classification

- C01B32/00 - Carbon, Compounds thereof
- C01B2203/00 - Integrated processes for the production of hydrogen or synthesis gas
- C01C1/00 - Ammonia
- C07C7/00 - Purification; Separation; Use of additives
- C10G2/00 - Production of liquid hydrocarbon mixtures of undefined composition from oxides of carbon
- C10J3/00 - Production of combustible gases containing carbon monoxide from solid carbonaceous fuels
- C10J2300/00 - Details of gasification processes
- C10K1/00 - Purifying combustible gases containing carbon monoxide
- C10K3/00 - Modifying the chemical composition of combustible gases containing carbon monoxide to produce an improved fuel, e.g. one of different calorific value, which may be free from carbon monoxide
- C10L3/00 - Gaseous fuels; Natural gas; Synthetic natural gas obtained by processes not covered by subclass C10G, C10K; Liquefied petroleum gas
- C10L2200/00 - Components of fuel compositions
- C10L2290/00 - Fuel preparation or upgrading, processes or apparatus therefore, comprising specific process steps or apparatus units
- C25B3/00 - Electrolytic production of organic compounds
- E21B43/00 - Methods or apparatus for obtaining oil, gas, water, soluble or meltable materials or a slurry of minerals from wells
- F01K17/00 - Using steam or condensate extracted or exhausted from steam engine plant
- F01K23/00 - Plants characterised by more than one engine delivering power external to the plant, the engines being driven by different fluids
- F01N3/00 - Exhaust or silencing apparatus having means for purifying, rendering innocuous, or otherwise treating exhaust
- F02C3/00 - Gas-turbine plants characterised by the use of combustion products as the working fluid
- F22B1/00 - Methods of steam generation characterised by form of heating method
- F23C9/00 - Combustion apparatus characterised by arrangements for returning combustion products or flue gases to the combustion chamber
- F23J15/00 - Arrangements of devices for treating smoke or fumes
- F23L7/00 - Supplying non-combustible liquids or gases, other than air, to the fire, e.g. oxygen, steam
- F25J1/00 - Processes or apparatus for liquefying or solidifying gases or gaseous mixtures
- F25J3/00 - Processes or apparatus for separating the constituents of gaseous or liquefied gaseous mixtures involving the use of liquefaction or solidification
- H01M8/00 - Fuel cells
- Y02A50/00 - TECHNOLOGIES FOR ADAPTATION TO CLIMATE CHANGE in human health protection
- Y02C10/00 - CO_2 capture or storage
- Y02C20/00 - Capture or disposal of greenhouse gases [GHG] other than CO_2 ture by chemical separation
- Y02E20/00 - Combustion technologies with mitigation potential
- Y02P20/00 - Technologies relating to chemical industry

Table 2: Patent classification

Search results

The size of the retrieved patent data in each sub dataset will to a certain degree reflect the magnitude of relevant prior art existing in global patent databases within these fields. The eight different subsets are all related to Carbon Capture Technology, but still they are quite different, as each of them are classified in different areas. Table 3 visualises the distribution of the major patent classes for each subset. There will always be some overlap between the different technical areas when looking at the classification system at a superior level as shown in Table 3. However, to solve this problem, we have searched in subgroups of these, as shown in Table 2, in combination with keywords.

Table 2: Patent classification

	B01D53	B01D61	B01J20	C01B3	C07C7	C10J3	C10K1	C10L3	F23C9	F25J3	H01M8
SOLVENT	49%	7%	10%	18%	8%	0%	0%	8%	0%	0%	0%
MEMBRANE SOLID	37%	29%	0%	23%	3%	0%	4%	0%	4%	0%	0%
SORBENT	51%	0%	16%	21%	12%	0%	0%	0%	0%	0%	0%
CRYOGENIC OXY	43%	0%	6%	27%	0%	0%	5%	5%	0%	14%	0%
COMBUSTION	26%	0%	0%	26%	0%	0%	0%	0%	8%	40%	0%
CHEMICAL LOOPING	11%	0%	21%	31%	0%	14%	0%	0%	24%	0%	0%
HYDROGEN SEPERATION	10%	19%	3%	62%	0%	0%	0%	0%	0%	6%	0%
FUEL CELLS	7%	0%	8%	19%	0%	3%	0%	0%	3%	0%	60%

Table 3: Distribution of the major patent classes

3 Statistical Analysis

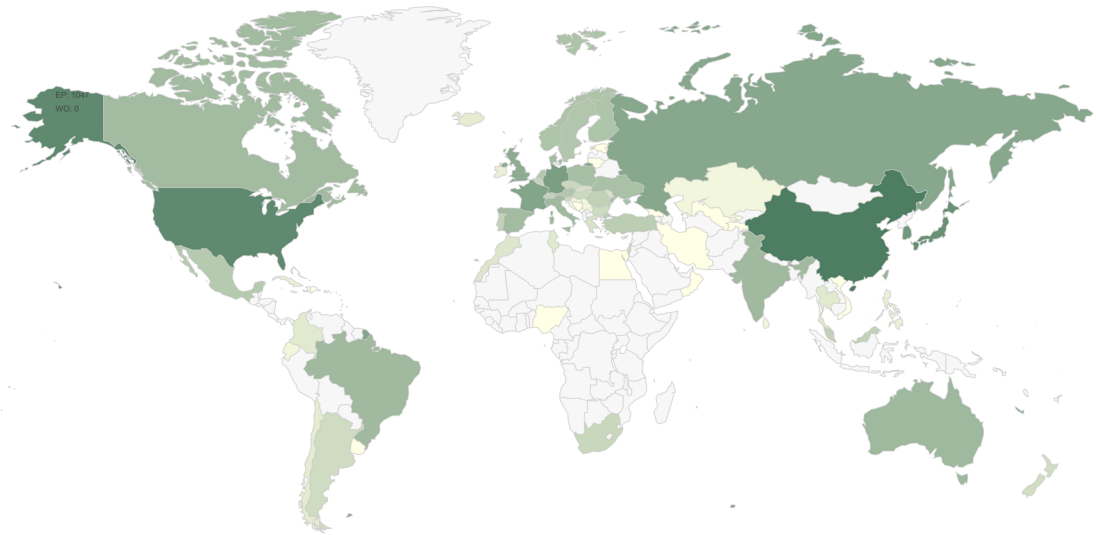
Geographical coverage of patents

In this chapter, we will enlighten the geographical coverage of patent applications and their originating countries.
This chapter is focused on the whole patent dataset in order to get a large-scale overview of the current patenting environment.

The worldwide patent coverage

Figure 1a gives an overview of the worldwide patenting activity within our patent dataset, excluding countries with less than 100 applications. Figure 1b shows the distribution of the patent dataset into the various technical areas (sub datasets), while Figure 1c shows the percentage of applications belonging to each sub dataset for each of the top filing countries.

Figure 1a shows where the major part of the patent applications is first filed, but it does not necessarily tell us in which countries the Carbon Capture technology is most active. Traditionally most applicants file their priority application in their native country, even though there is little activity within the Carbon Capture technology. Later, the applicants extend their applications to more active countries within the technical area to ensure IPR in these countries. However, the opposite is also quite normal, an applicant may file its priority application to a patent authority outside its home country, for example to the authority in an important market. There may be different reasons for this, of both strategic and/or practical reasons. In this analysis we look at the number of applications based on the priority data, which will give us a good overview of the patent situation and trends.



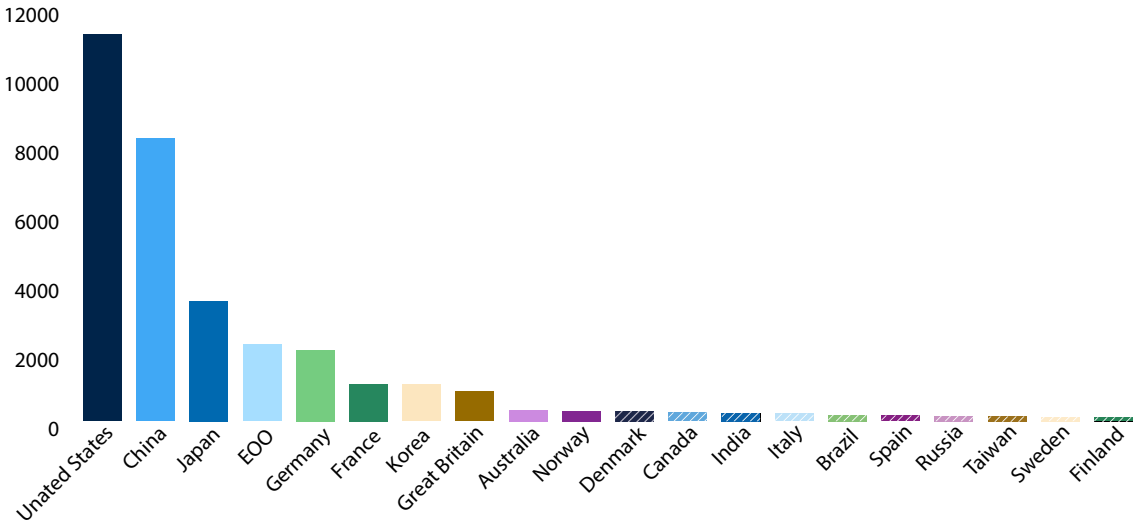


Figure 1a: Overview of the worldwide patenting activity (first filed) within the dataset

Figure 1a shows that most of the applications are filed in USA, China and Japan. China and Japan are not amongst the top countries of utilising Carbon Capture technologies in the world in 2021, but is still the second most active in developing technology related to the Carbon Capture technology[2].

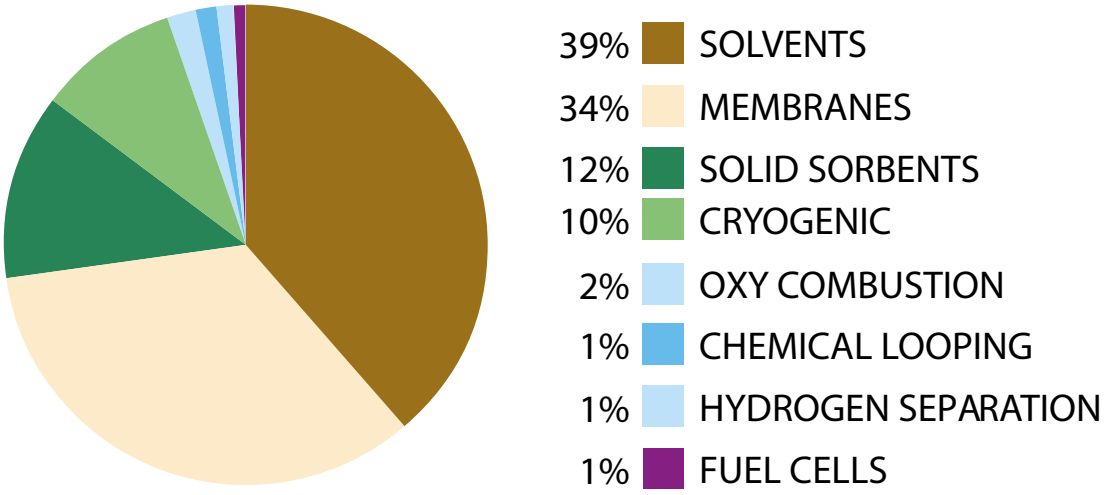
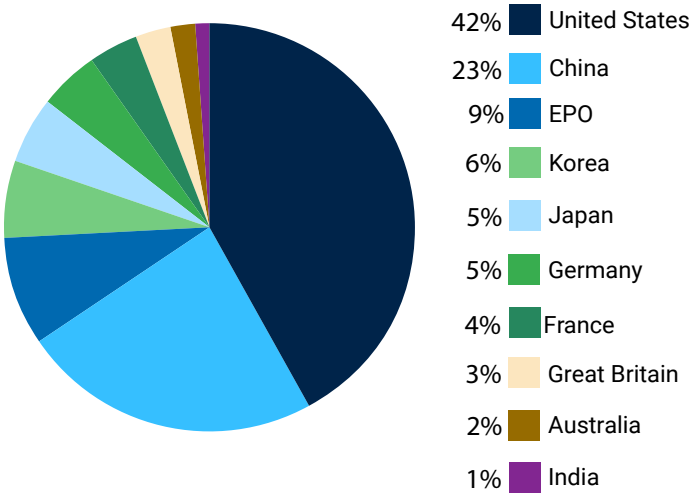


Figure 1b: Patent applications (patent dataset) divided in different areas (sub dataset)

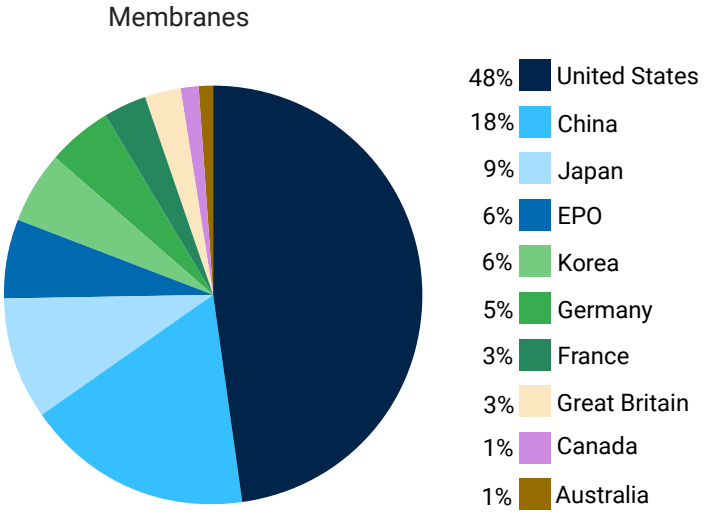
Figure 1b shows that the solvent and membrane technologies are the most innovative Carbon Capture technologies according to the number of filed patent applications. Almost 3 of 4 patent applications are filed within one of these two areas.
From Figure 1c we see that USA dominates in filing of patent applications for all areas except hydrogen separation technology where Japan is represented with an equal share.

2 https://www.globalccsinstitute.com/wp-content/uploads/2021/10/2021-Global-Status-of-CCS-Report_Global_CCS_Institute.pdf

Solvents



Membranes



Solid Sorbents

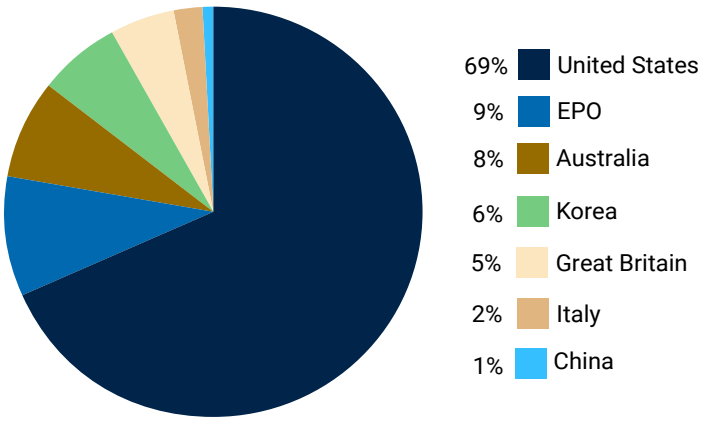
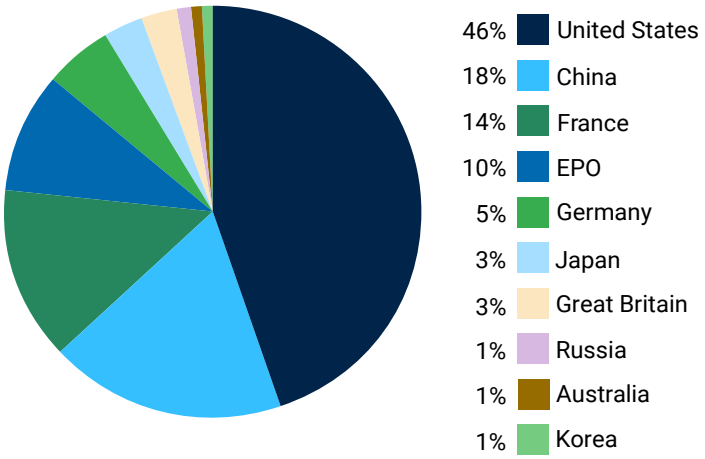
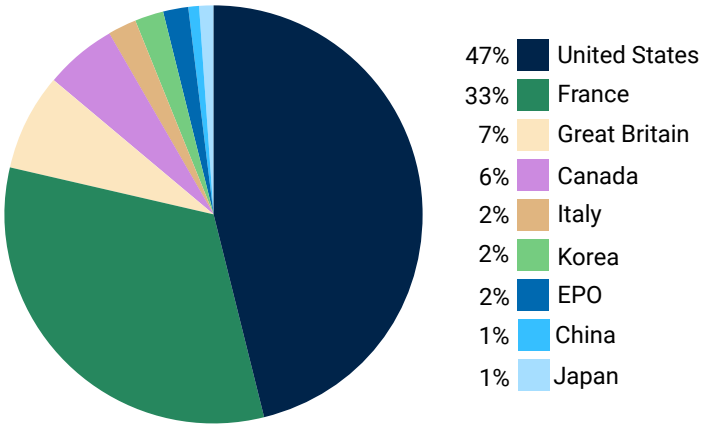


Figure 1c: Percentage of patent applications for each sub dataset.

Cryogenic



Oxy Combustion



Chemical Looping

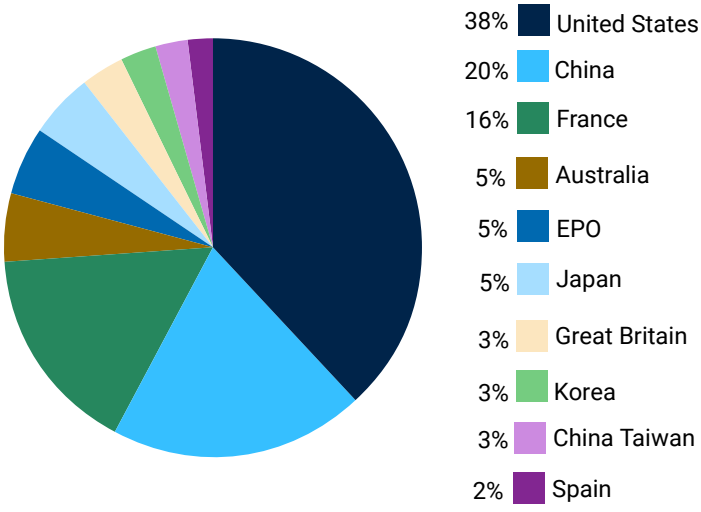
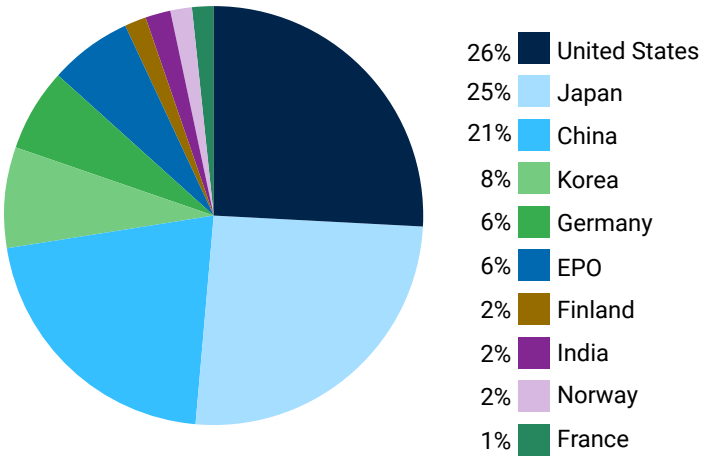


Figure 1c: Percentage of patent applications for each sub dataset.

Hydrogen Seperation



Fuel Cells

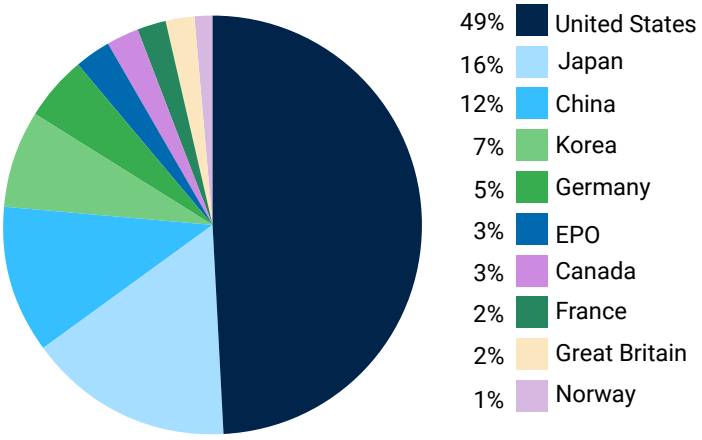


Figure 1c: Percentage of patent applications for each sub dataset continued

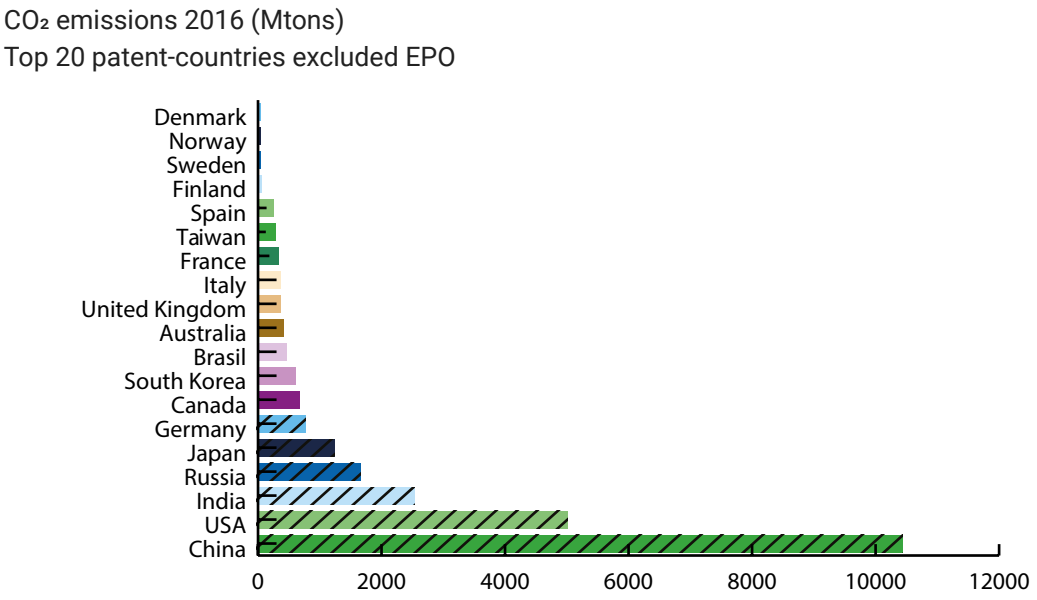


Figure 2: CO_2 emissions by the top 20 patent-countries[2].

According to Figure 2, China has the highest CO_2 emissions worldwide in 2016 followed by USA. However, Canada and Australia represent major emissions per capita, which is not reflected in the number of patent applications in our dataset.

International patent extensions

Figure 3 shows the extension rate for the top producing countries of patent applications. This extension rate is the ratio between the number of patent applications forwarded (extended) internationally from their respective originating country and the number of patent applications of origin.
We see that Finland, Italy and Denmark are the most internationally focused nations, as they have the highest share of applications extended. China is on the other side of the scale, with a very low focus on extensions of patent applications.

2 https://www.worldometers.info/co2-emissions/co2-emissions-by-country/

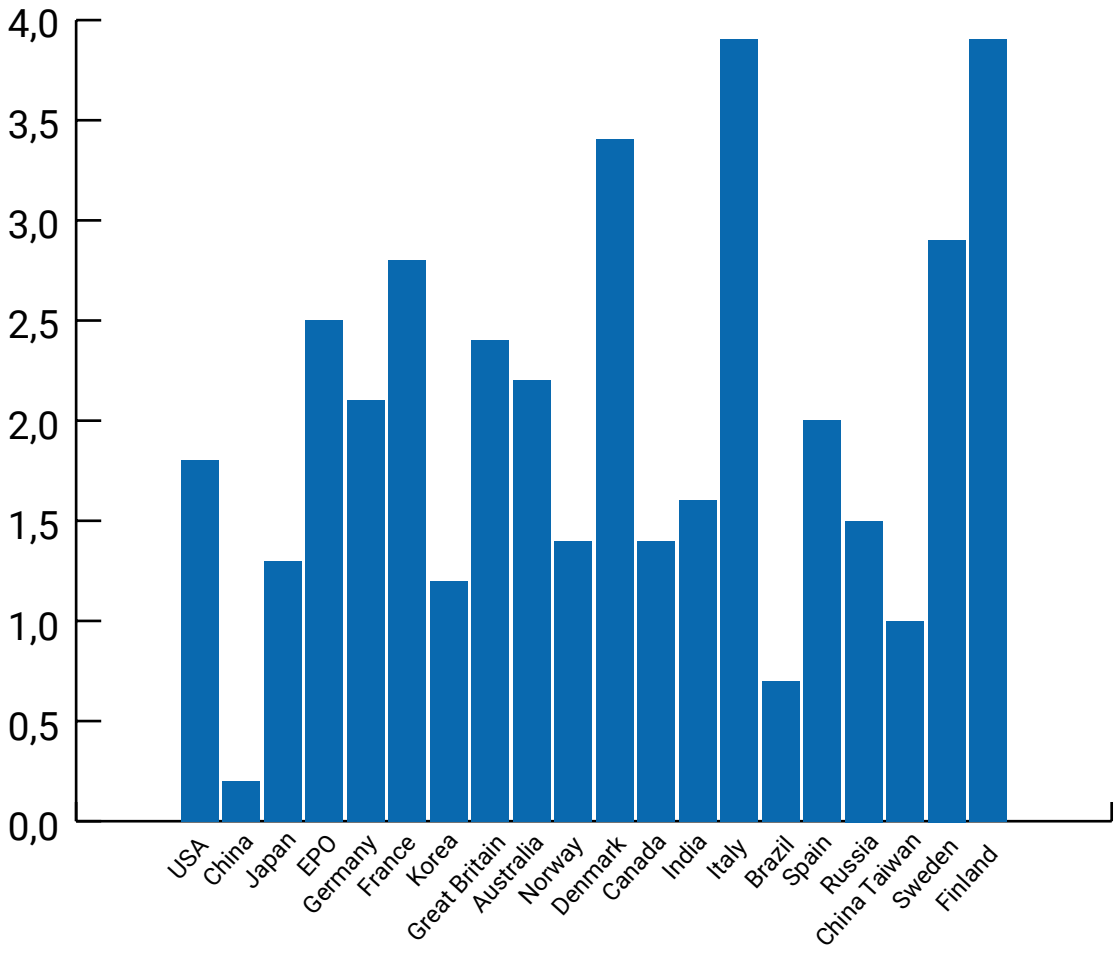


Figure 3: The rate of extended patent applications for the top 20 countries/regions

Table 4 provides an overview of where the patent applications in our patent dataset of the countries/ regions are extended to (Extension country) and where they are extended from (Priority country of the top filing nations/regions) showing the number of extended applications.

	Priority country/Region																				
Extension country/ region	USA	China	Japan	EPO	Germany	France	Korea	Great Britain	Australia	Norway	Denmark	Canada	India	Italy	Brazil	Spain	Russia	China Taiwan	Sweden	Finland	Total
WIPO	3 605	372	837	797	624	465	325	334	137	66	104	60	78	120	35	85	72	3	56	63	8 238
USA	-	220	840	660	494	416	369	247	98	46	87	58	55	78	16	43	21	60	41	50	3 899
EPO	2 428	99	591	-	587	450	121	236	76	49	85	38	41	116	14	52	19	11	44	53	5 110
Japan	1 460	90	-	297	241	203	129	102	48	15	45	20	21	39	4	18	7	15	22	18	2 794
India	1 025	60	131	314	200	102	19	99	55	22	51	16	-	37	6	7	9	1	15	18	2 187
Australia	1 339	50	288	265	175	120	18	115	-	27	53	29	16	22	3	12	7	3	16	15	2 573
Korea	975	50	241	233	171	80	-	57	32	8	44	13	19	25	1	5	2	6	10	12	1 984
Canada	1 800	44	257	379	207	177	24	112	56	38	63	-	18	40	1	11	11	2	18	33	3 291
Russia	450	41	85	223	158	73	12	41	10	11	23	4	6	31	-	6	-	-	10	15	1 199
Singapore	371	26	37	69	32	19	4	24	11	-	5	4	6	15	-	5	2	1	1	2	634
Brazil	752	25	47	231	118	68	6	62	15	21	39	14	11	23	-	11	6	2	15	18	1 484
South Africa	256	22	11	85	71	32	2	31	18	4	25	2	11	4	1	5	1	-	4	-	585
China Taiwan	369	20	151	86	69	19	25	11	3	-	7	1	2	7	-	1	-	-	7	1	779
Mexico	622	17	12	96	56	22	6	33	9	3	25	14	3	16	2	7	1	1	5	2	952
Spain	306	13	22	166	123	91	6	42	8	16	22	10	4	32	3	-	-	-	10	21	895
Denmark	114	13	17	81	67	39	1	36	4	11	-	2	3	16	2	4	-	-	6	10	426
EAPO	194	10	10	90	21	15	2	26	7	10	28	5	2	12	1	1	13	-	-	7	454
Poland	185	10	18	112	106	59	5	21	9	15	20	2	2	17	1	3	-	-	5	15	605
Germany	236	9	73	66	-	37	32	43	4	3	10	3	-	14	-	1	2	2	4	5	544
Great Britain	80	6	17	2	4	2	2	-	2	3	-	1	3	2	-	-	-	-	1	1	126
Argentina	150	3	3	55	23	17	3	11	3	-	7	3	2	8	6	4	3	-	2	1	304
Norway	88	1	17	22	17	20	-	17	2	-	5	3	-	5	-	1	1	-	2	2	203
France	12	1	7	2	10	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	34
Finland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Italy	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Sweden	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
China	1 934	-	536	551	368	245	169	137	69	28	72	22	24	58	5	16	16	33	25	34	4 342
Total	18 751	1 202	4 248	4 882	3 943	2 772	1 280	1 838	676	396	820	325	327	737	101	299	193	140	320	396	43 646

Table 4: Geographical coverage of extended patent applications

We see from Table 4 that a considerable fraction of the assignees files directly to WIPO, European Patent Office (EPO) or USA. Furthermore, we see that priority applications from USA and Japan constitute most of the extensions, followed by the European countries. As indicated earlier in this report, some patent applicants choose to file their priority application to a patent authority outside their native country. It is also possible to file a patent application directly to WIPO or EPO for a first examination of the application before further extension of the application to other relevant markets.

We see that US applicants often choose Canada and China for extension of their patent application to ensure IPR in these markets. Norwegian applicants extend mostly to USA and Canada. However, both US and Norwegian assignees extend a considerable share of their applications to EPO and WIPO. Most of the applications extended to Norway originate from USA while most of the applications extended to USA originates from Japan and European countries.

A considerable share of the applications with priority from EPO are extended either to WIPO, to enter international non-European phase, or directly to USA.

It is also interesting to notice that 26 % of the patent applications are extended to China, USA and Canada, while less than 1 % of the patent applications are extended to Norway.

Trend analysis

In this chapter, we look at some of the different trends within our patent dataset. We also look at the development in the patent sub datasets, compare development between nations and look at patent grant rates.

Patent applications are made public 18 months after first filing. The numbers from 2020 and 2021 are therefore incomplete, which explain the dip we see for these years in Figures 4 and 5.

Historical patent development

Figure 4 shows the trend for first filing of patent applications in the field of Carbon Capture in the period from 2001 to 2021. The diagram shows an approximately linear annual increase of patent filing, where the number of patent filings is almost 5 times as high in 2020 as in 2001, even though the number of filings is not complete for 2020.

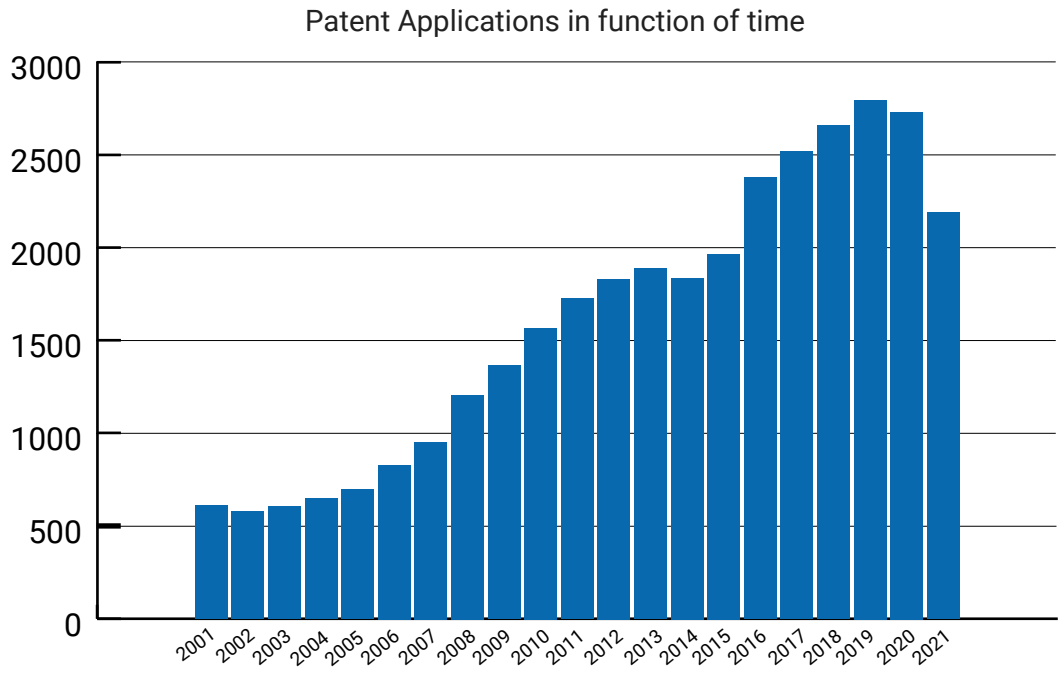


Figure 4: Number of first filed applications per year worldwide within Carbon Capture technology

Figure 5 illustrates the trends for granted patents from 2001 to 2021 for the different sub datasets. We see a linear growth in patents in the area of solvent, membrane and cryogenic from 2001 to 2015, which may indicate both an increasing technology development and/or an increasing awareness of protection of intellectual knowledge. After 2015, the growth has flattened out. The number of granted patents in the cryogenic area has doubled during the last decade, while the number of granted patents within the remaining technological areas have been quite stable since 2001.

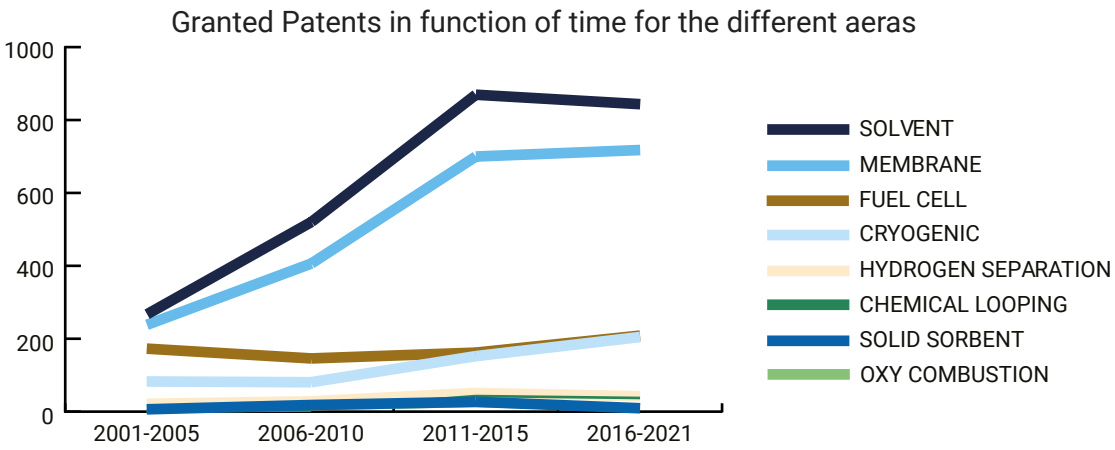


Figure 5: Historical patenting development for each patent data subset

International grant rates

Figure 6 illustrates the distribution of granted patents contra number of patent priority applications for the countries within the present dataset (see Figure 1a). The number of granted patents may exceed the number of applications. This is expected due to the extension rate of the patent priority application (see Table 4 and Figure 3). We see that Korea applications surpass EPO, Germany, and France in number of grants despite of a much lower number of priority applications (see Figure 1a), which can be explained by a high number of extensions from other nations (see Table 4) with a high rate of granted patents.

The main providers of patent applications, USA and China, clearly have the highest number of granted patents and almost all the countries have a larger number of priority applications than granted patents.

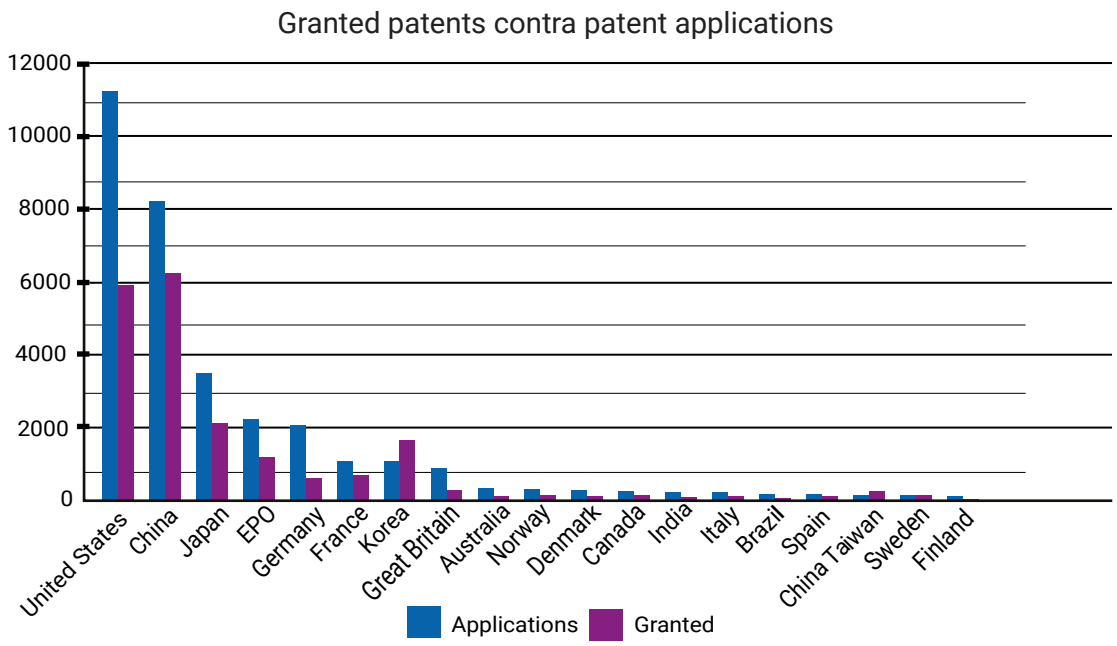


Figure 6: Number of granted patents contra applications for the top 20 countries

Figure 7 shows the same as Figure 6, but for each sub dataset, i.e. each technical area.

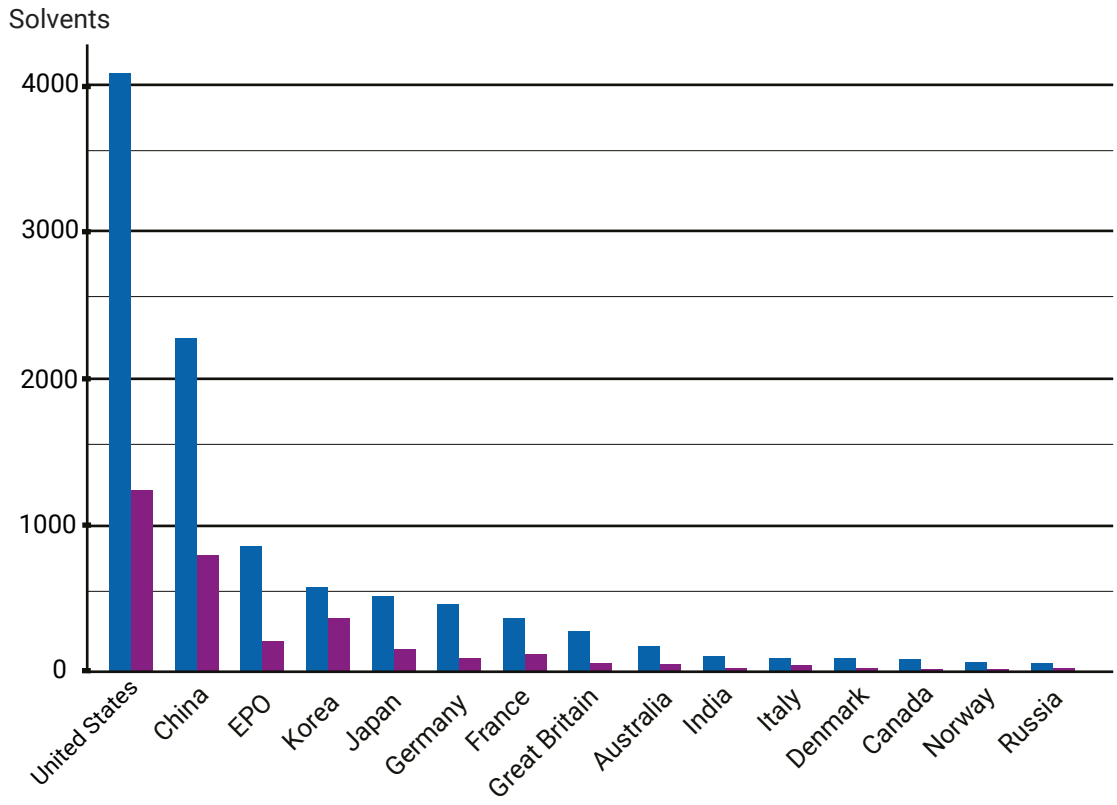
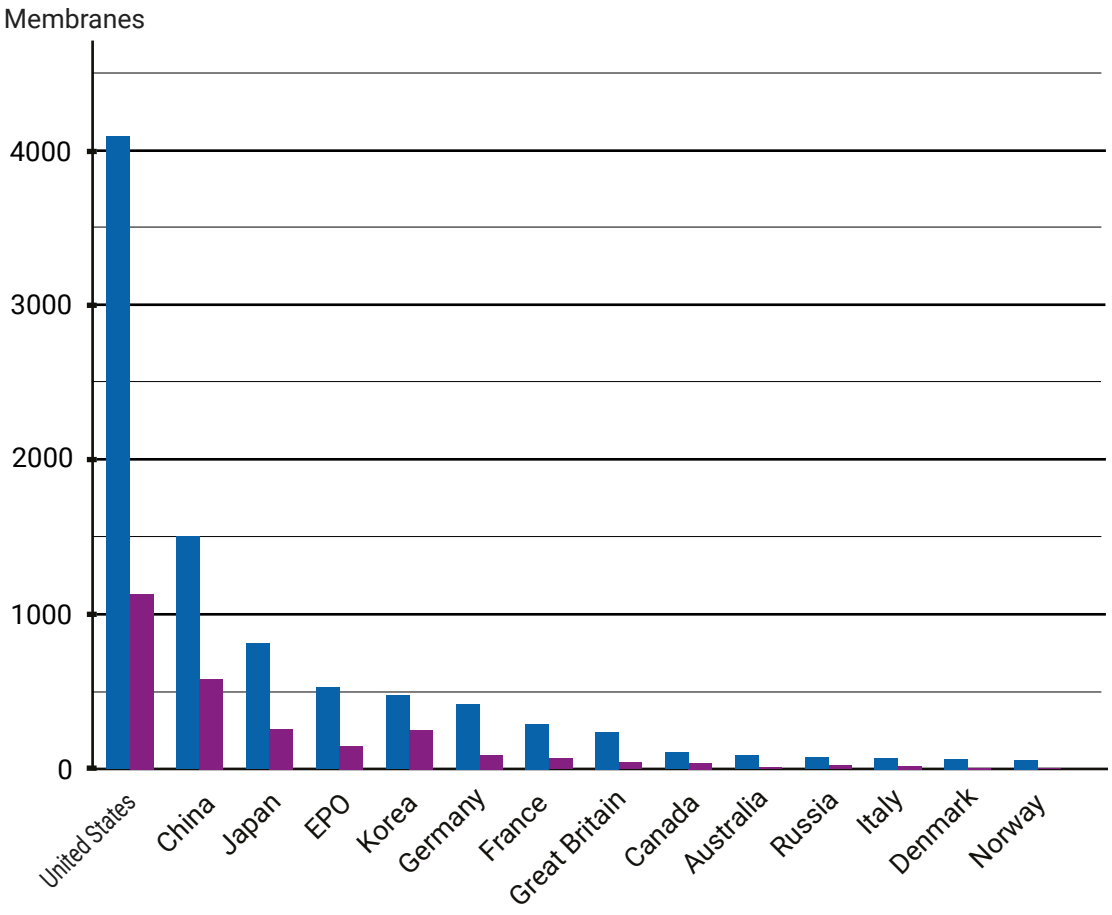


Figure 7: Number of granted patents contra applications for each sub dataset for the top countries



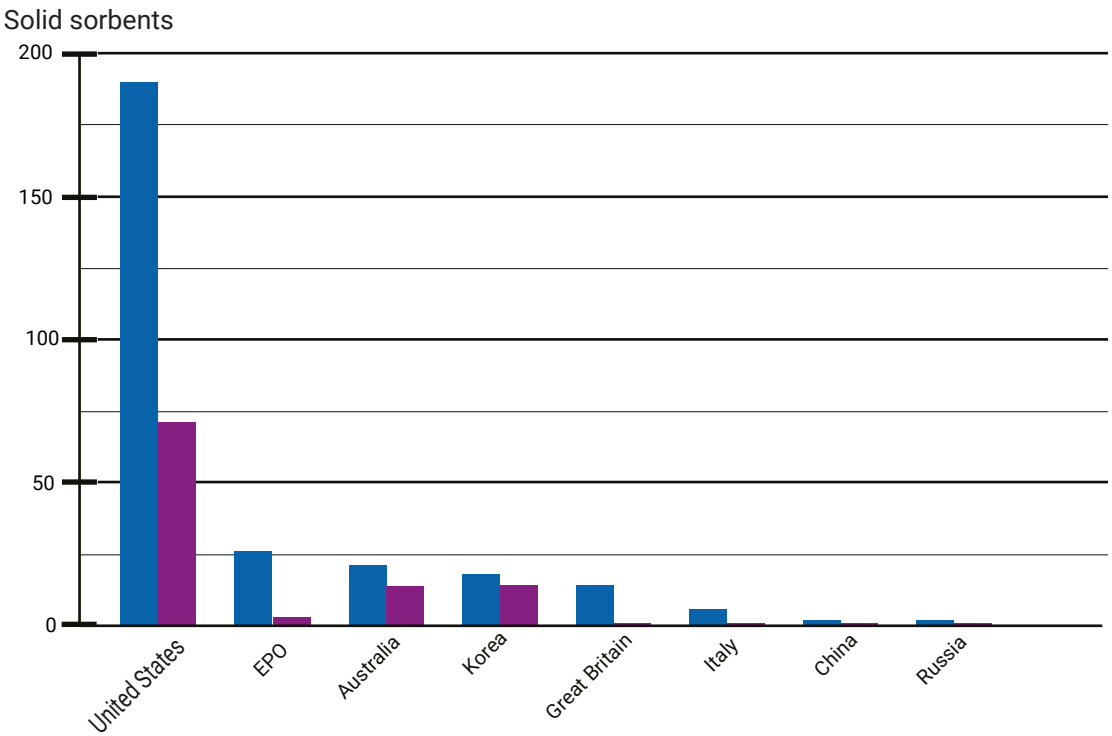
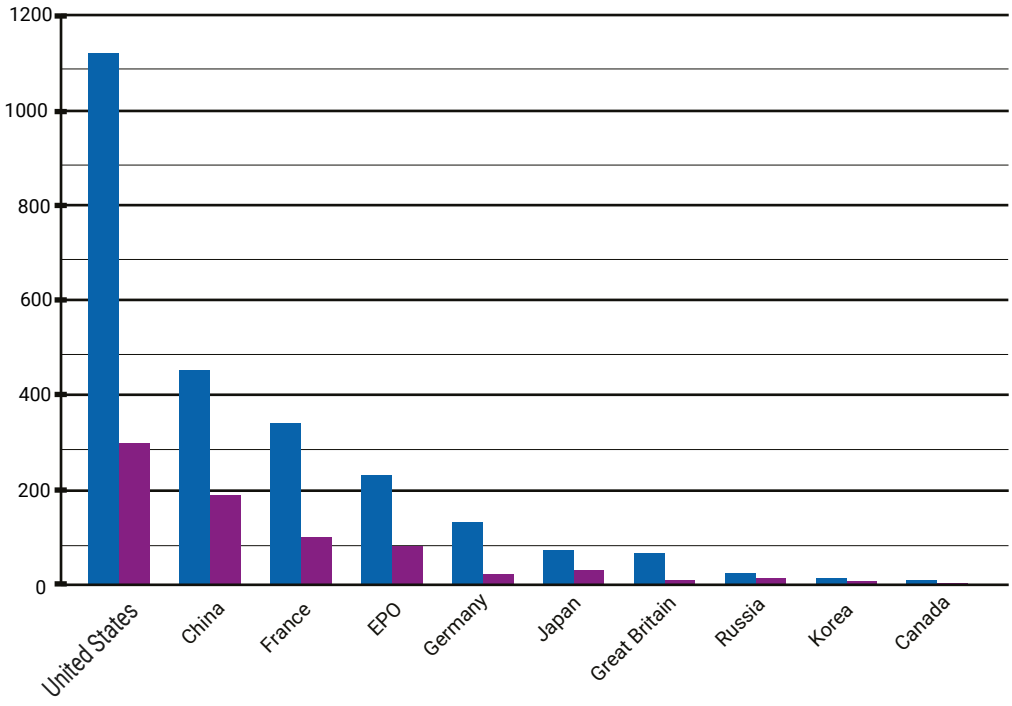


Figure 7: Number of granted patents contra applications for each sub dataset for the top countries continued

Cryogenic



Oxy Combustion

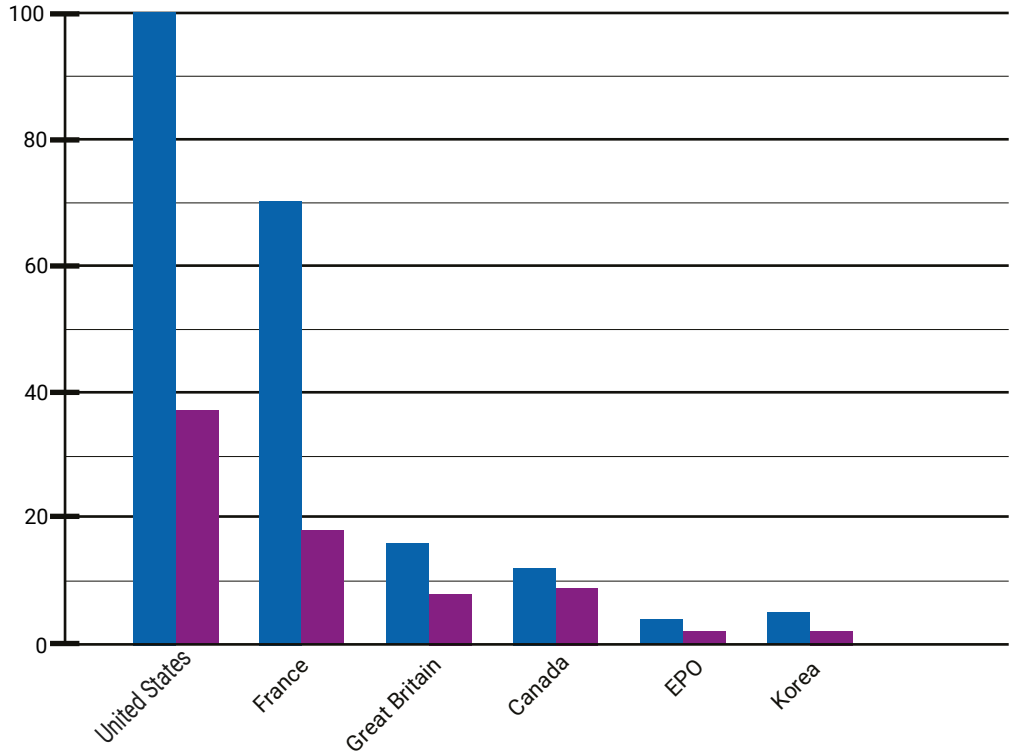
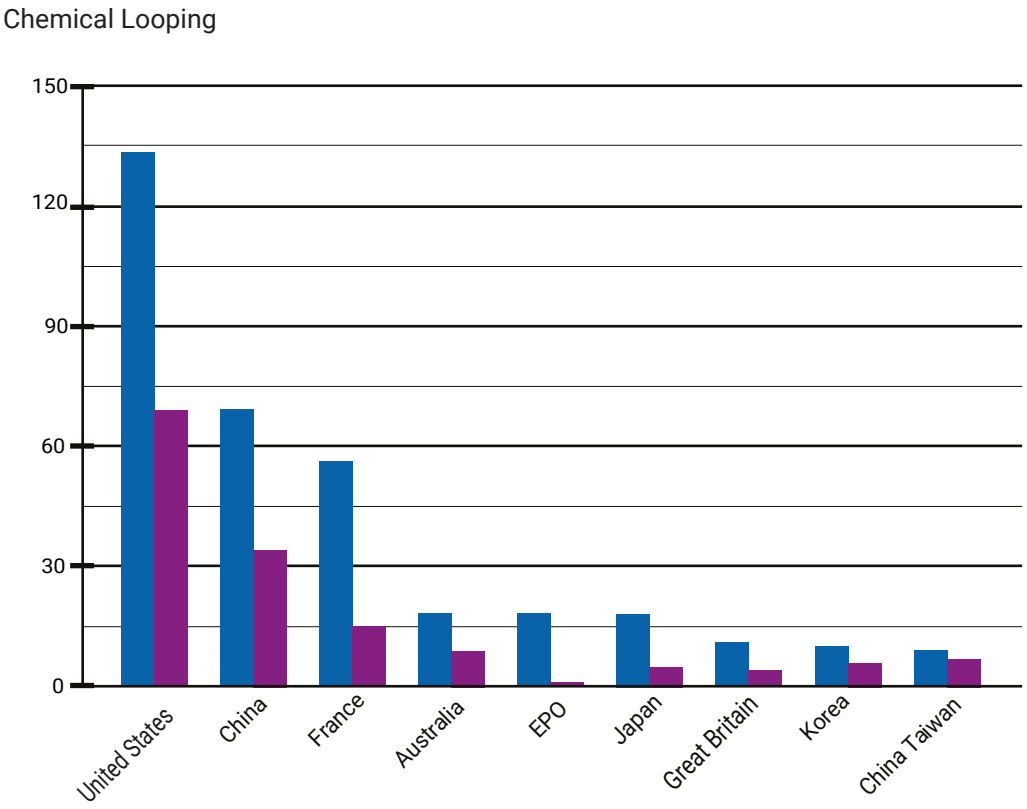


Figure 7: Number of granted patents contra applications for each sub dataset for the top countries continued



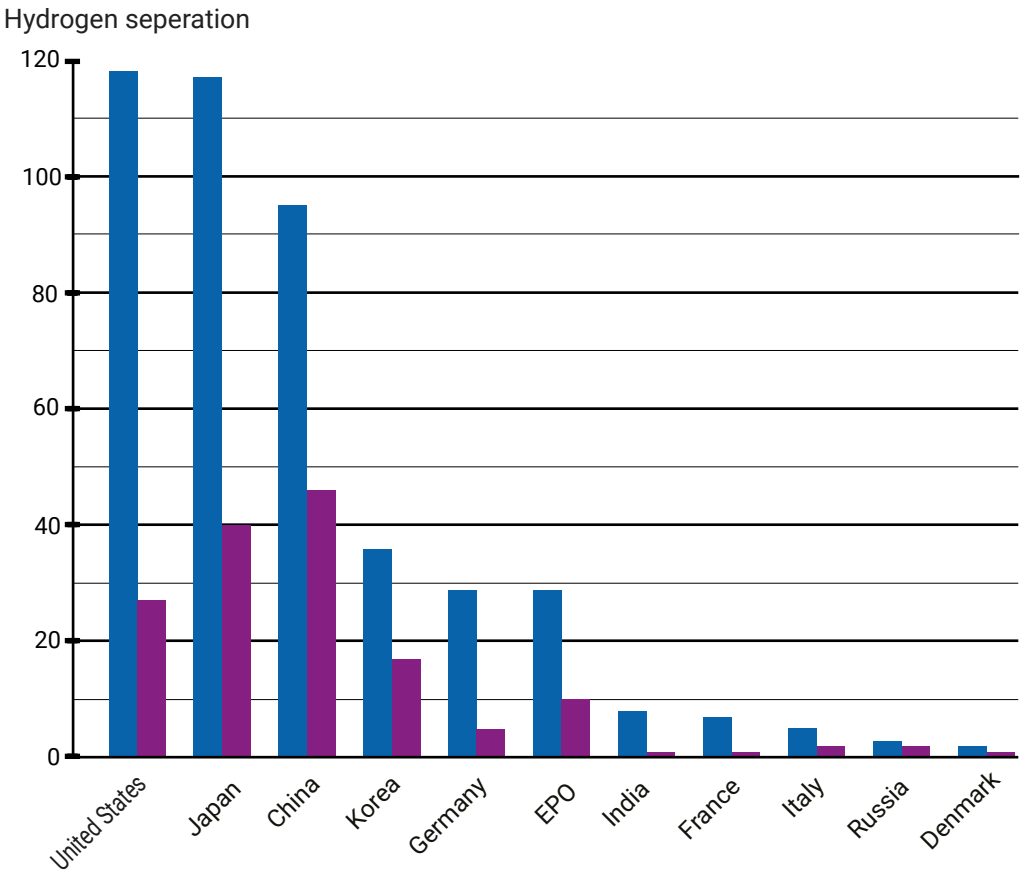


Figure 7: Number of granted patents contra applications for each sub dataset for the top countries continued

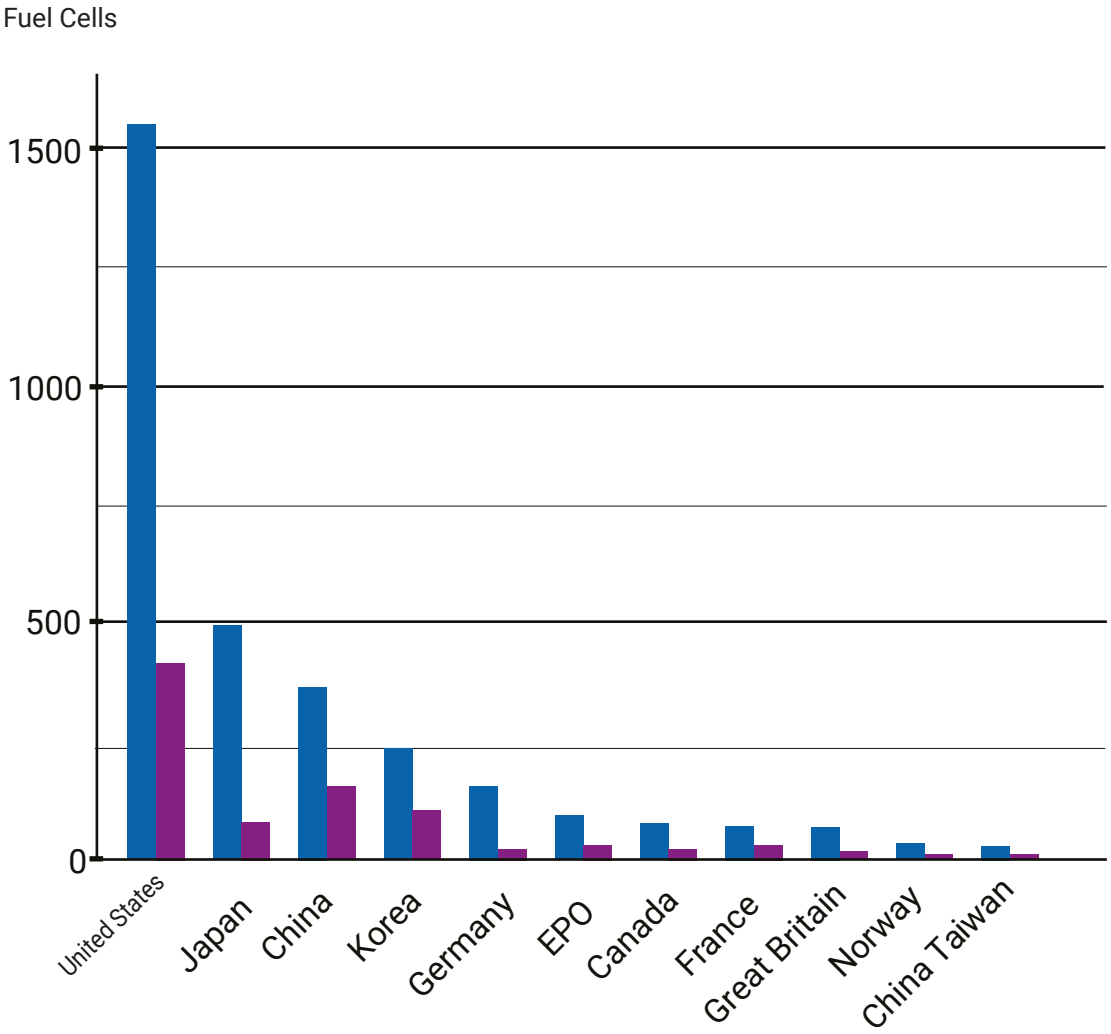


Figure 7: Number of granted patents contra applications for each sub dataset for the top countries continued

Figure 8 shows the details of Figure 5, for the granted patents providing countries in each technical area in function of time. As we see, USA and China constitute most of the patents in almost all areas with the exception of solid sorbents, oxy combustion, and hydrogen separation, where either USA or China is replaced by another country as a leading actor, we see that Norway appears in the area of fuel cells.

We note that China has had an exponential growth in patenting in all technical areas despite of the solid sorbents and oxy combustion areas, while USA has a growth until 2015 and then a decrease within all areas with the exception of cryogenic with a slight increase.

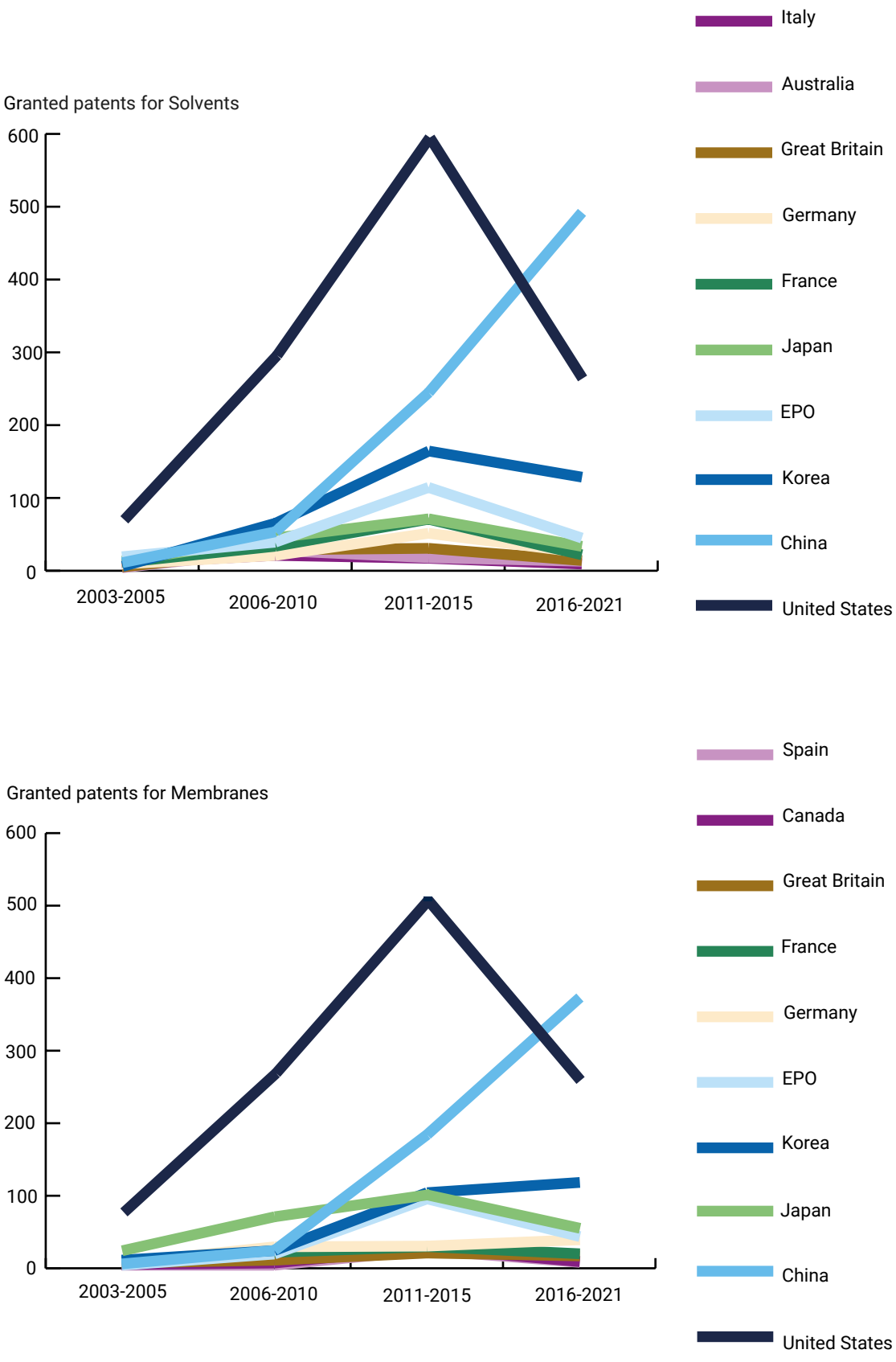


Figure 8: Historical development for granted patents in the different technical areas in the top countries

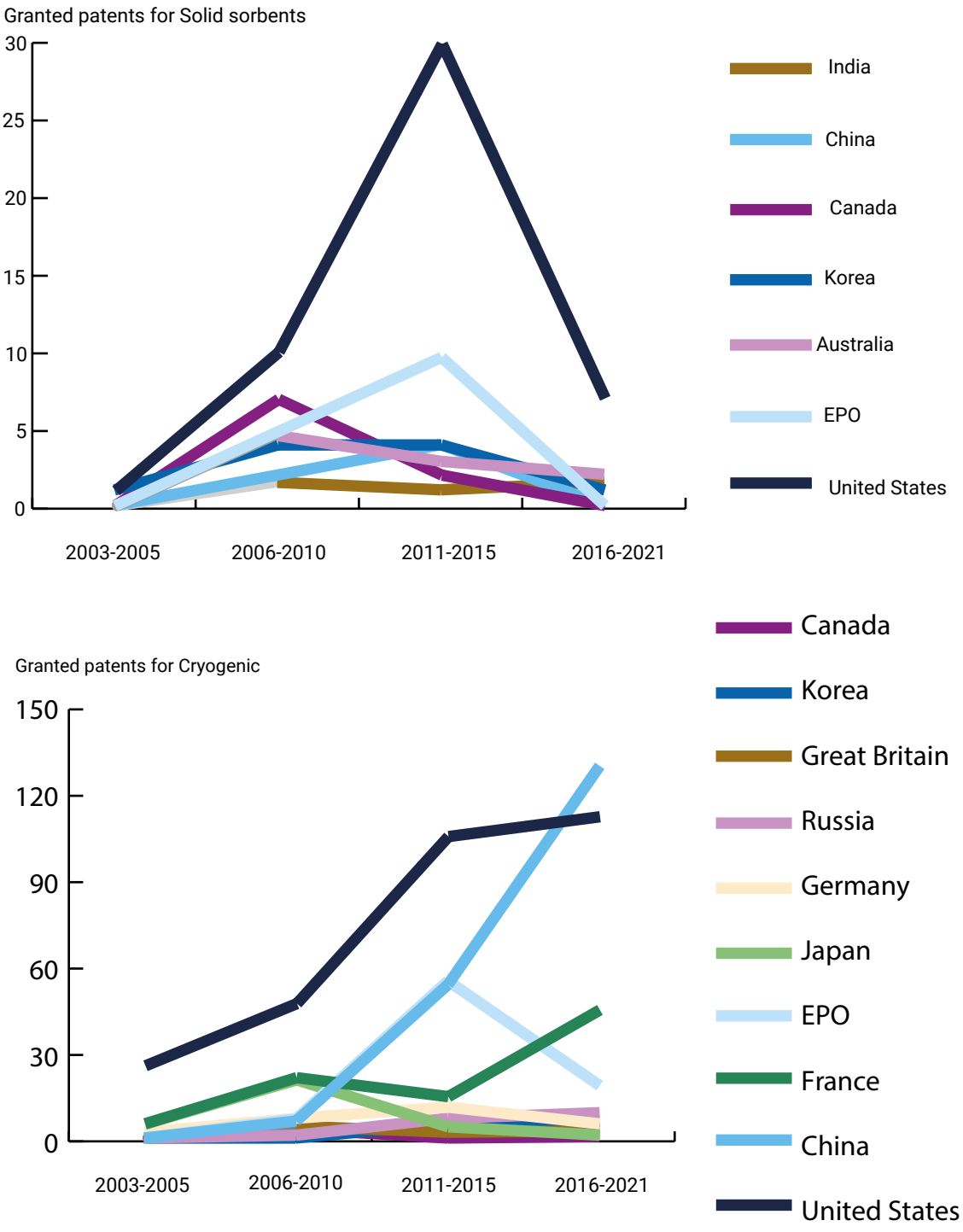
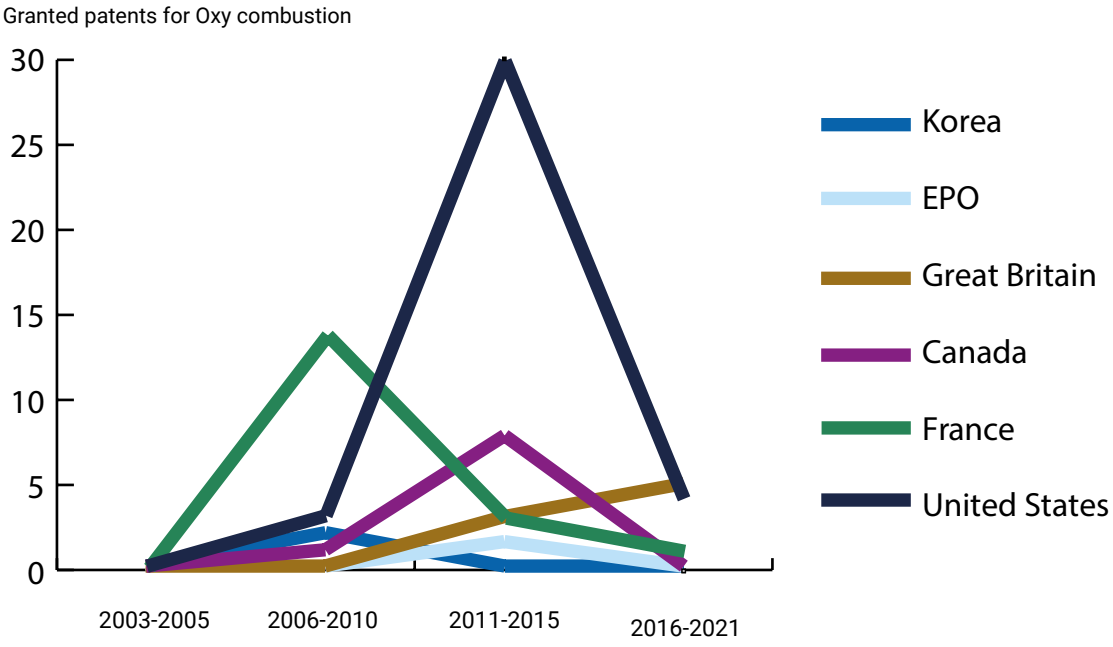


Figure 8: Historical development for granted patents in the different technical areas in the top countries continued.



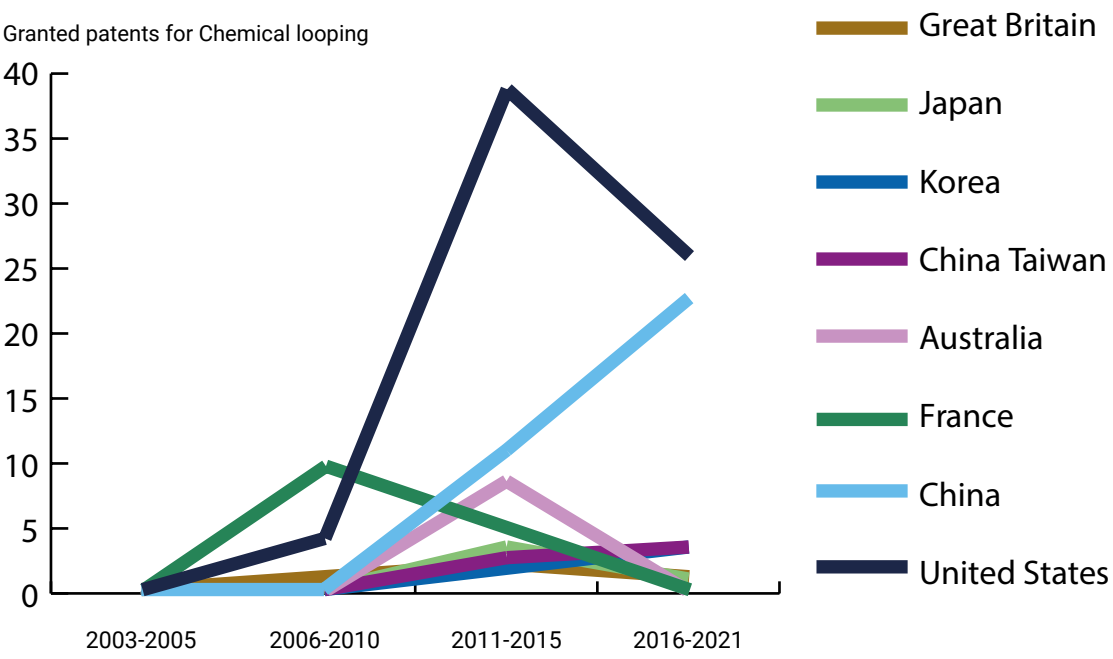


Figure 8: Historical development for granted patents in the different technical areas in the top countries continued.

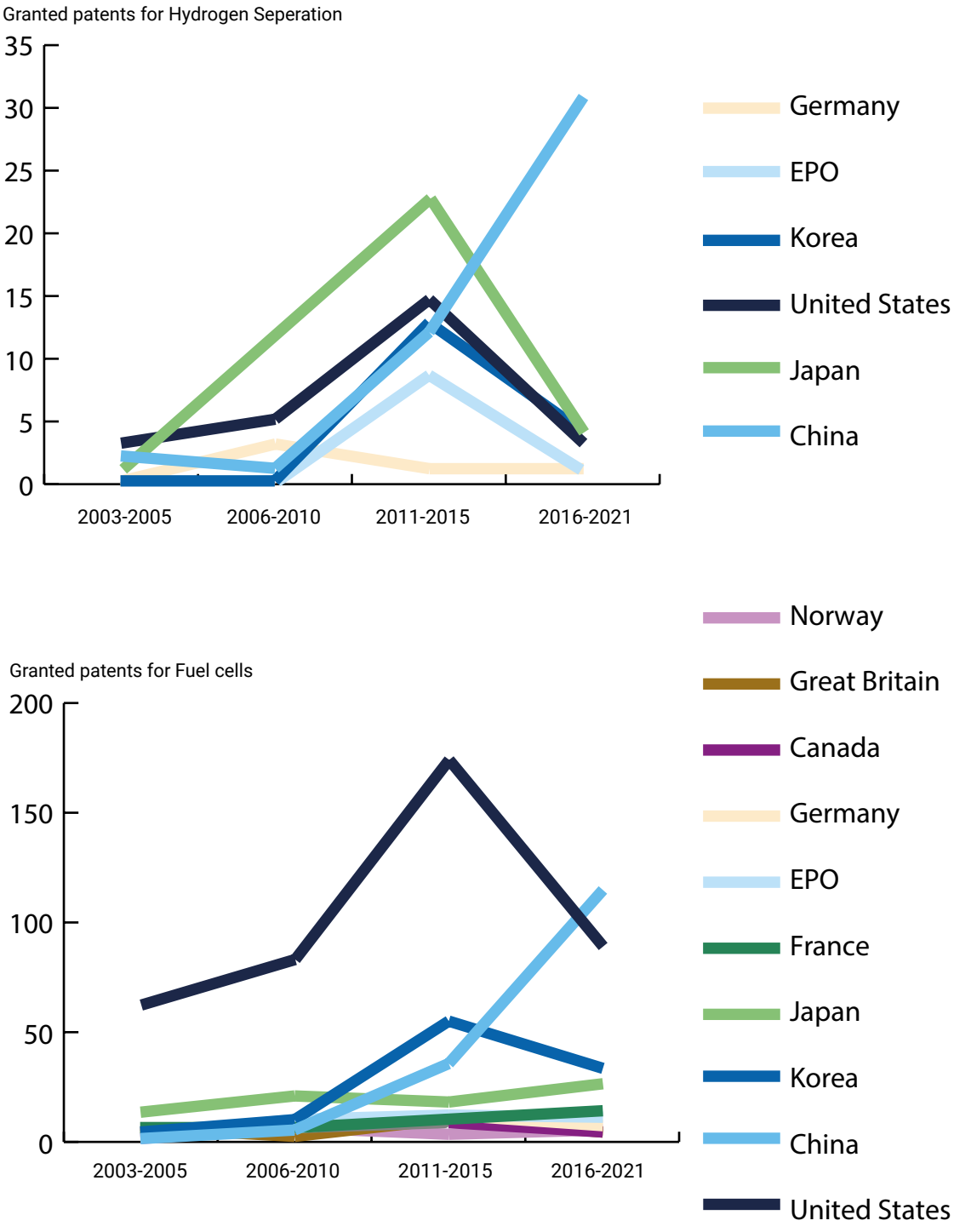


Figure 8: Historical development for granted patents in the different technical areas in the top countries continued.

Technology focus

Figure 9 shows the percentage of granted applications for the top countries in each sub dataset, in contrary to Figure 1c, showing the percentage of first filed patent applications. This illustrates which technology areas the active nations primarily are focusing on. As seen in Figure 9, USA holds the majority of the patents in all areas except of hydrogen separation where China and Japan dominate.

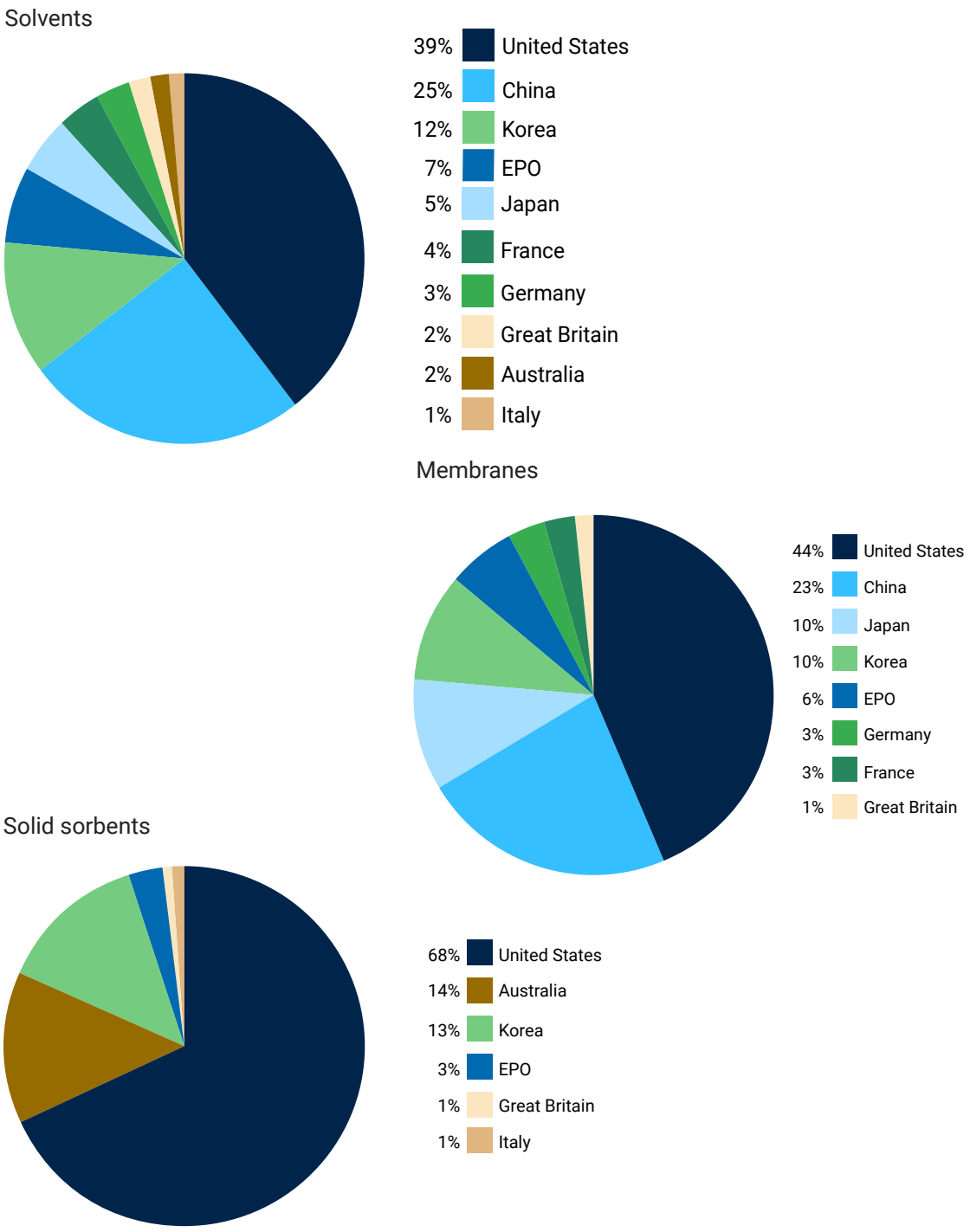
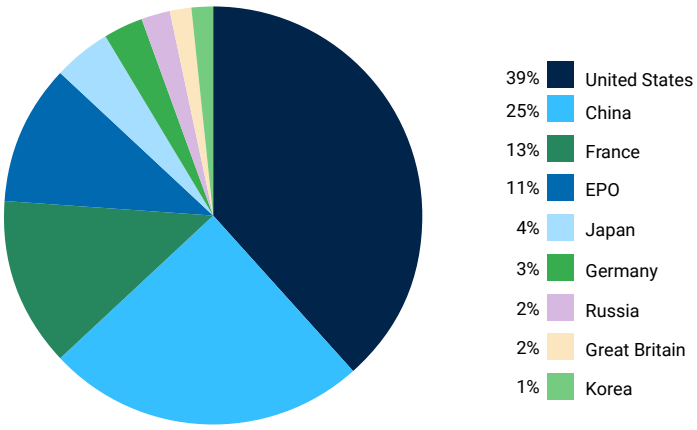
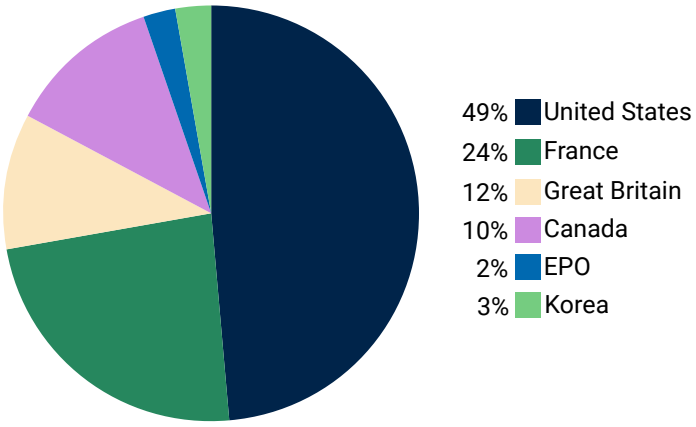


Figure 9: Percentage of granted applications for top countries in each sub dataset

Cryogenic



Oxy Combustion



Chemical Looping

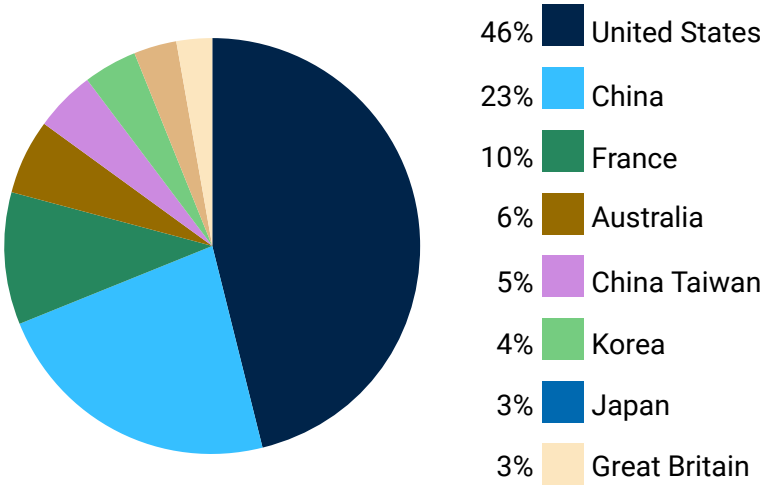
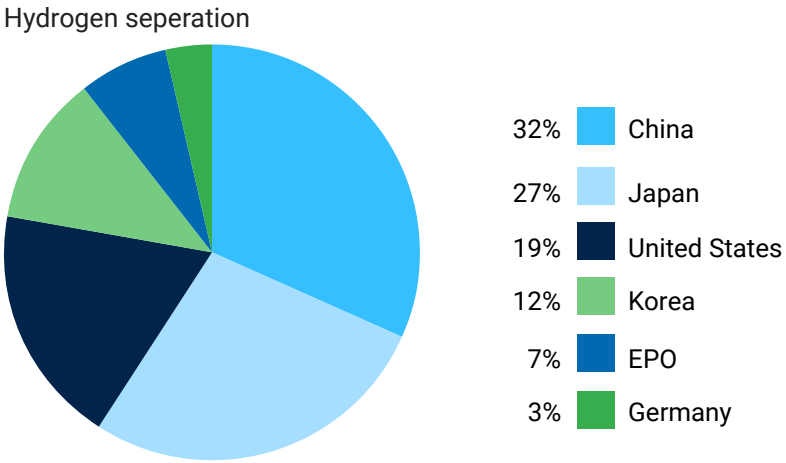


Figure 9: Percentage of granted applications for top countries in each sub dataset continued



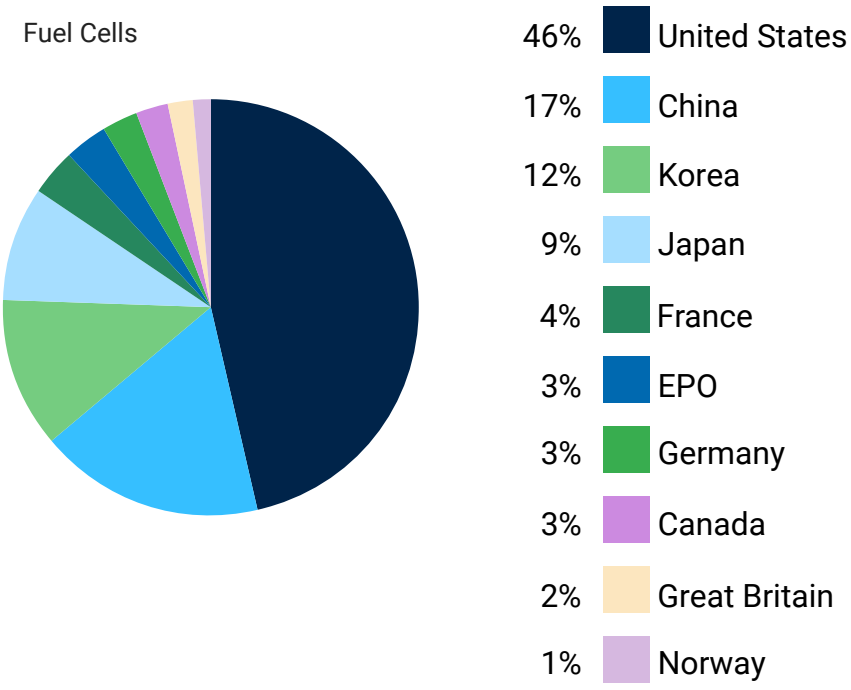


Figure 9: Percentage of granted applications for top countries in each sub dataset continued

4 Assignee analysis

Worldwide assignee analysis

In this chapter we focus on the patent applicant or assignee, in order to uncover which assignees is dominating and whom they are collaborating with. This may be a good basis for strategic decision making when mapping out potential collaborators, or potential competitors.

Collaboration networks

A patent may have joint ownership, which means that a patent application is assigned to one or more assignees. This study defines a collaboration as a joint ownership of a patent. A patent collaboration indicates a mutual interest in the commercial value of the patent. In this chapter we look at collaboration networks.

Patent collaborations can be illustrated in several ways, but for complex collaboration networks, a graphical representation is often preferred. The term collaboration map is used here as a graphical presentation of several collaboration networks. An example of a collaboration network is illustrated in Figure 10 for Carbon Capture technology.

The numbers on the lines connecting the different collaborators show the number of common patent applications.

Note that the collaborated patent in this study is counted in patent publications and not patent families. This is to ensure that all collaborations are taken into account.

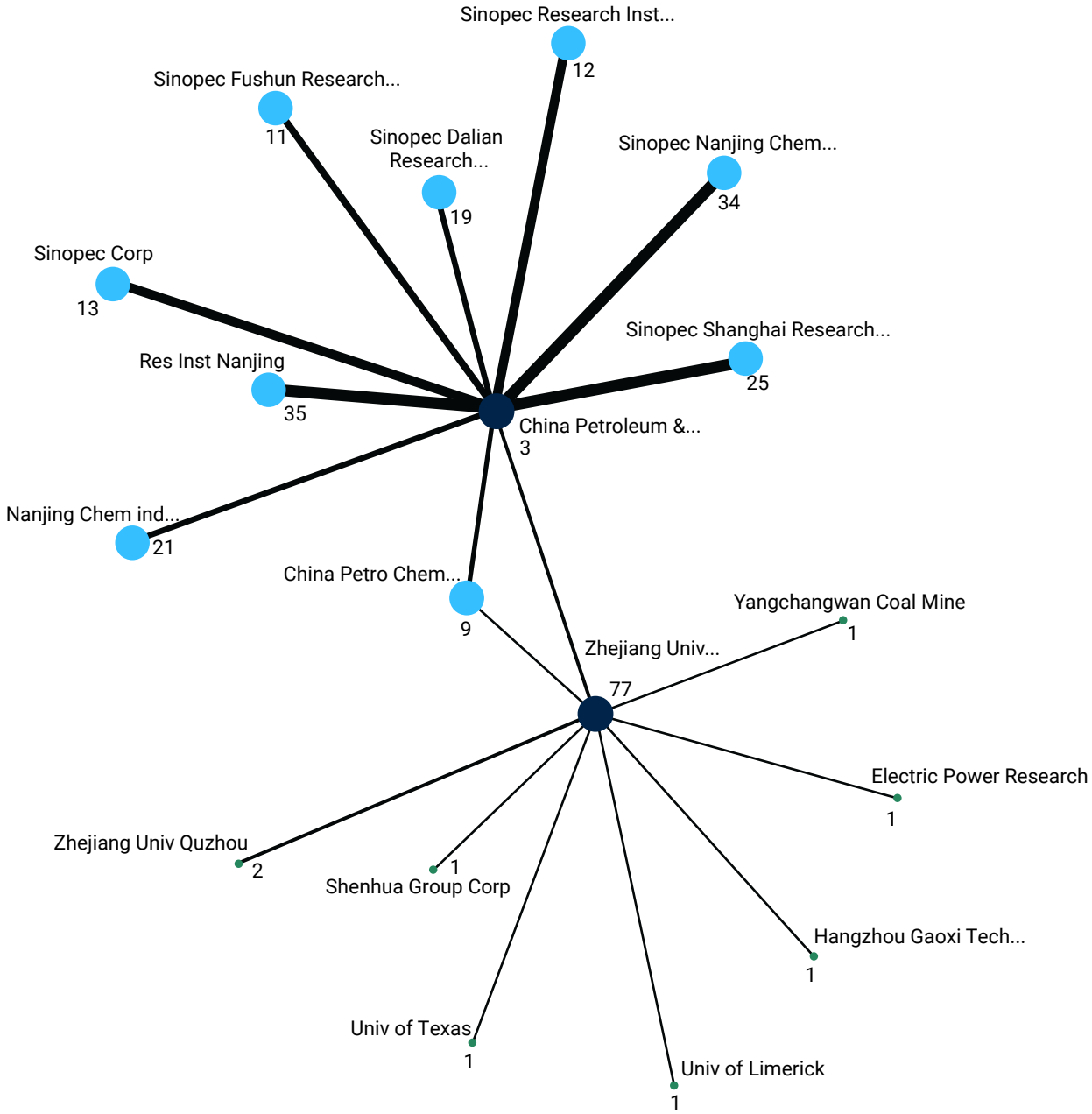
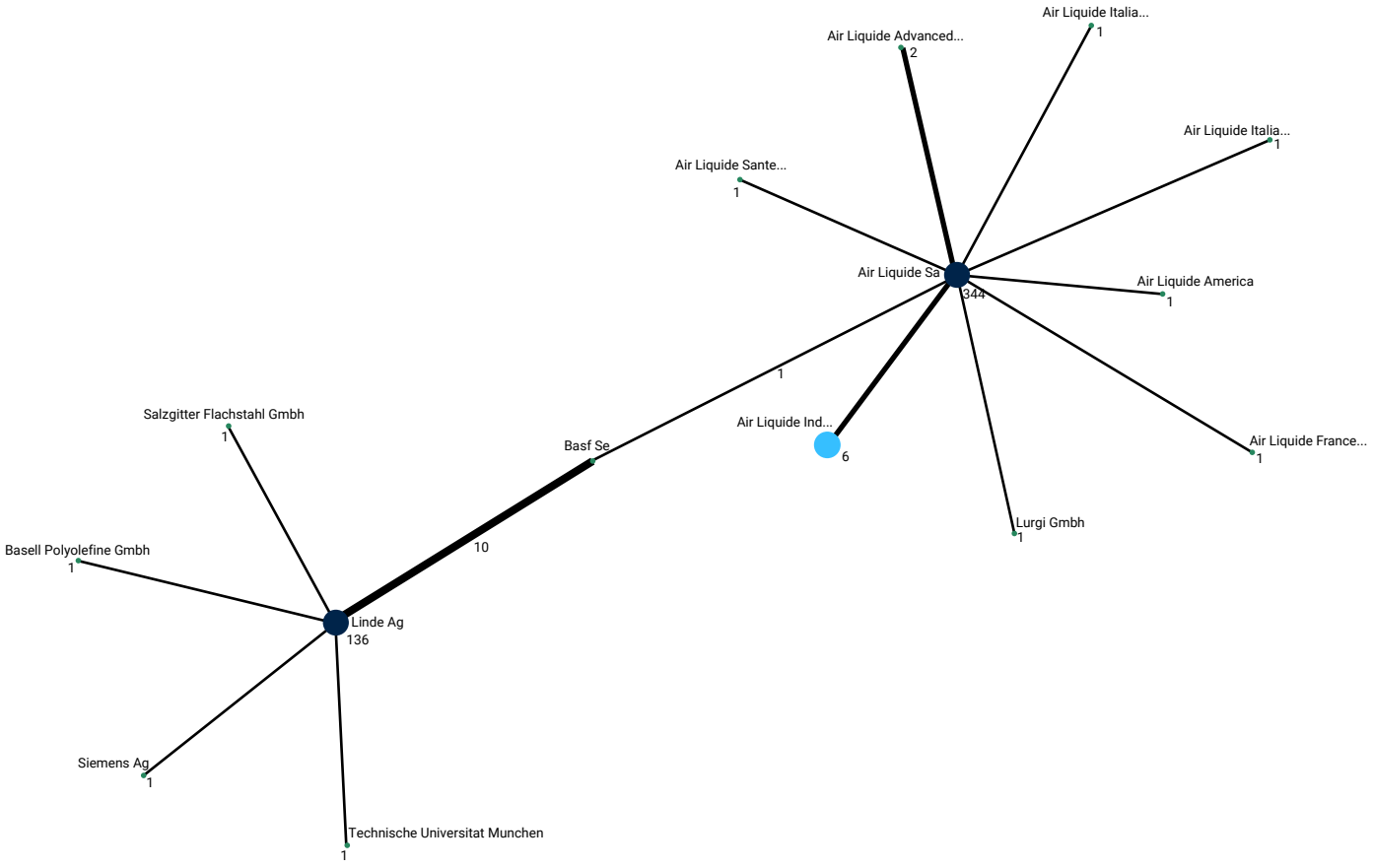


Figure 10: Collaboration network for Carbon Capture Technology



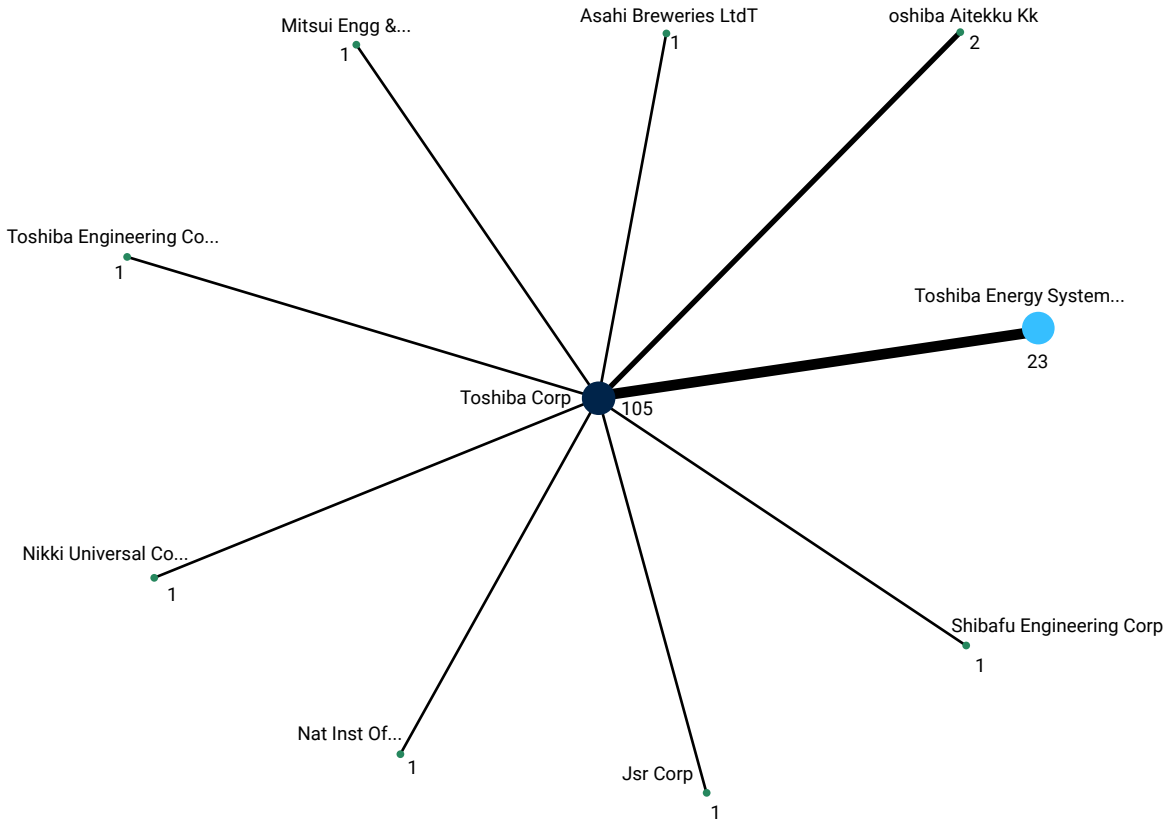


Figure 10: Collaboration network for Carbon Capture Technology continued

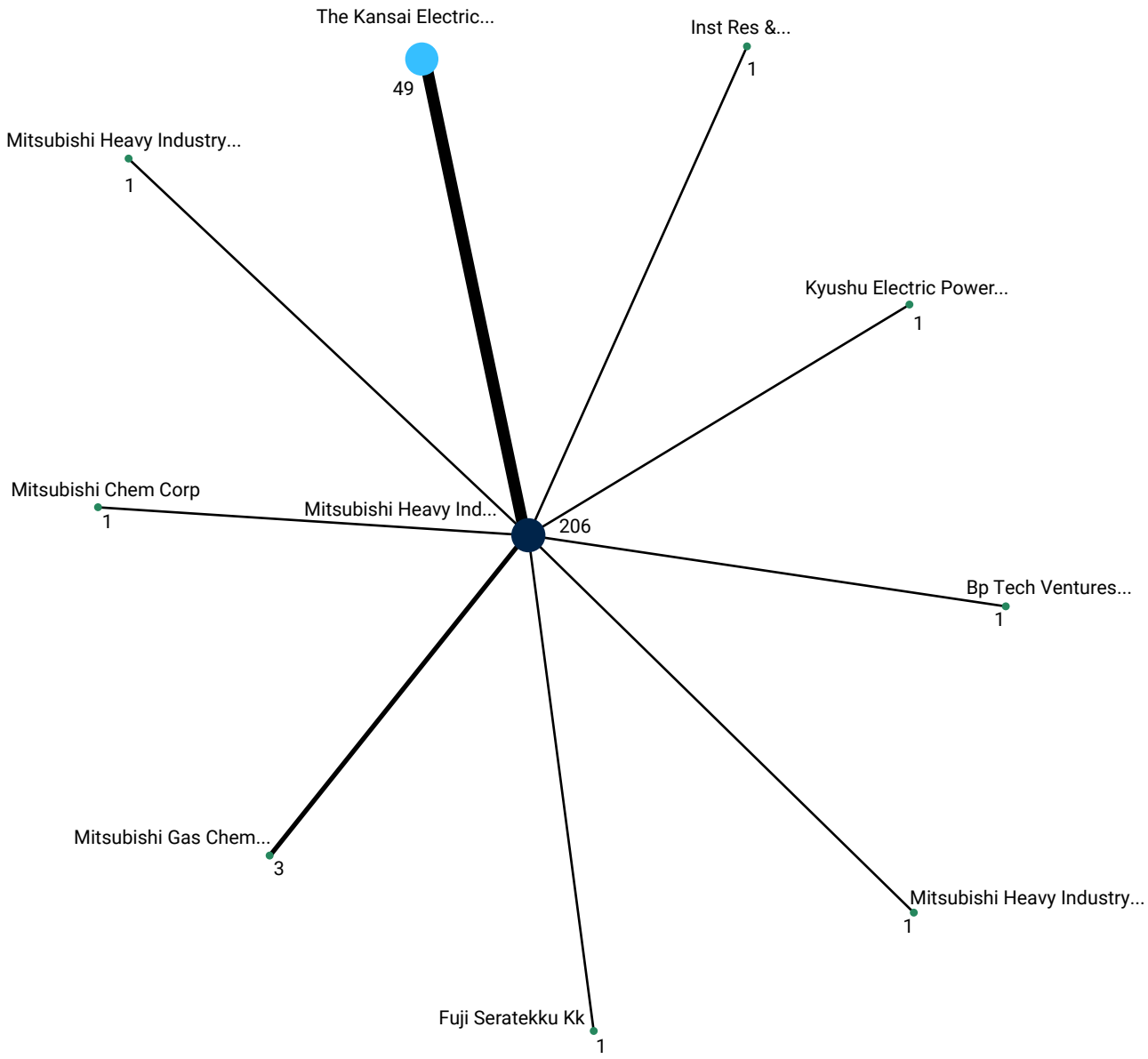


Figure 10: Collaboration network for Carbon Capture Technology continued

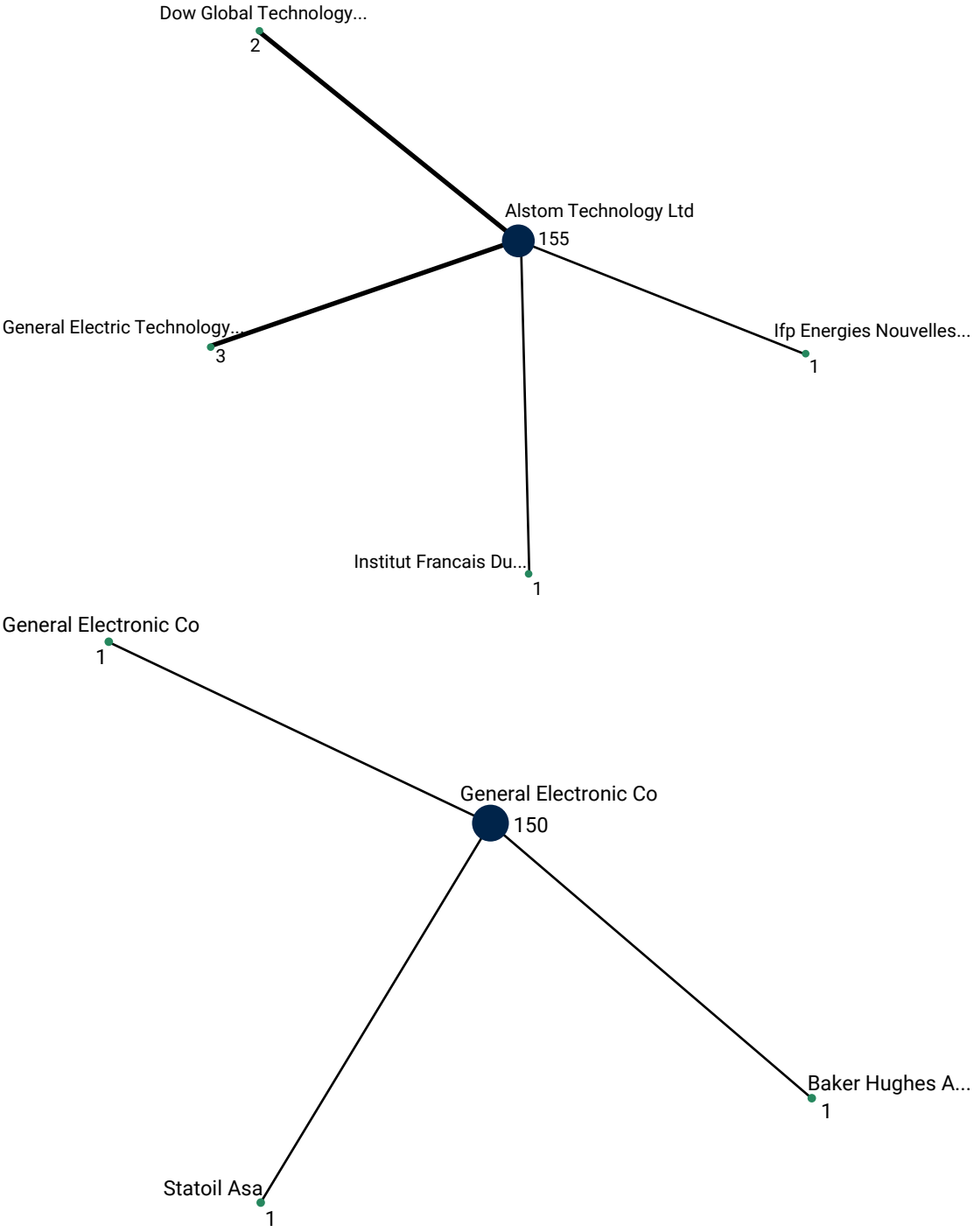


Figure 10: Collaboration network for Carbon Capture Technology continued

Norwegian Assignees analysis

Table 5 shows assignees from Norway with more than two patent applications, clearly showing that Statoil (now Equinor) and Aker are the main actors. Figure 11 shows their collaboration networks, and we observe that 37% of the assignees stand alone with no collaboration.

STATOIL/EQUINOR	33
AKER	12
SARGAS AS	7
SINVENT (SINTEF)	7
NORSK HYDRO ASA	5
NTNU	5
INST ENERGITEKNIK	4
COMPACT CARBON CAPTURE AS	3
FJELL BIODRY AS	3
ZEG POWER AS	3
AMTECH AS	2
BERGEN TEKNOLOGIOVERFØRING AS	2
ENGSL MINERALS DMCC	2
ENPRO AS	2
FMC KONGSBERG SUBSEA AS	2
GREENCAP SOLUTIONS AS	2
LIYUAN DENG (NTNU)	2
UNI I OSLO	2
KARBON CCS LTD	2

Table 5: Patent applications filed in Norway from the top Norwegian assignees

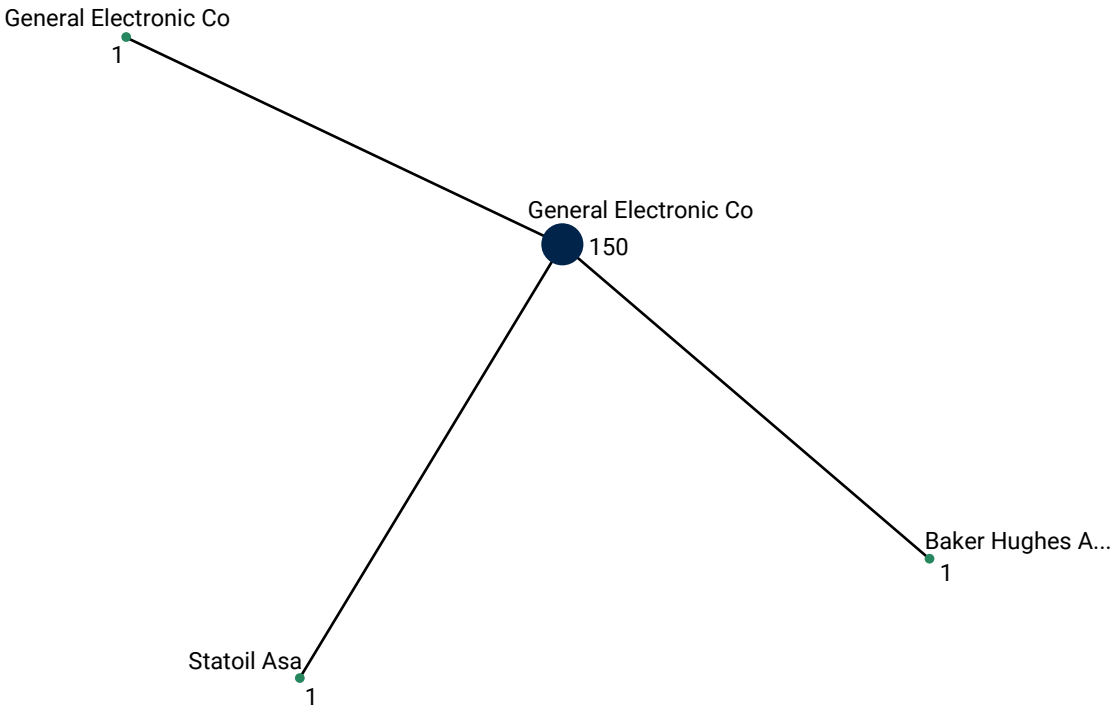


Figure 11: Norwegian collaboration networks in Carbon Capture Technology

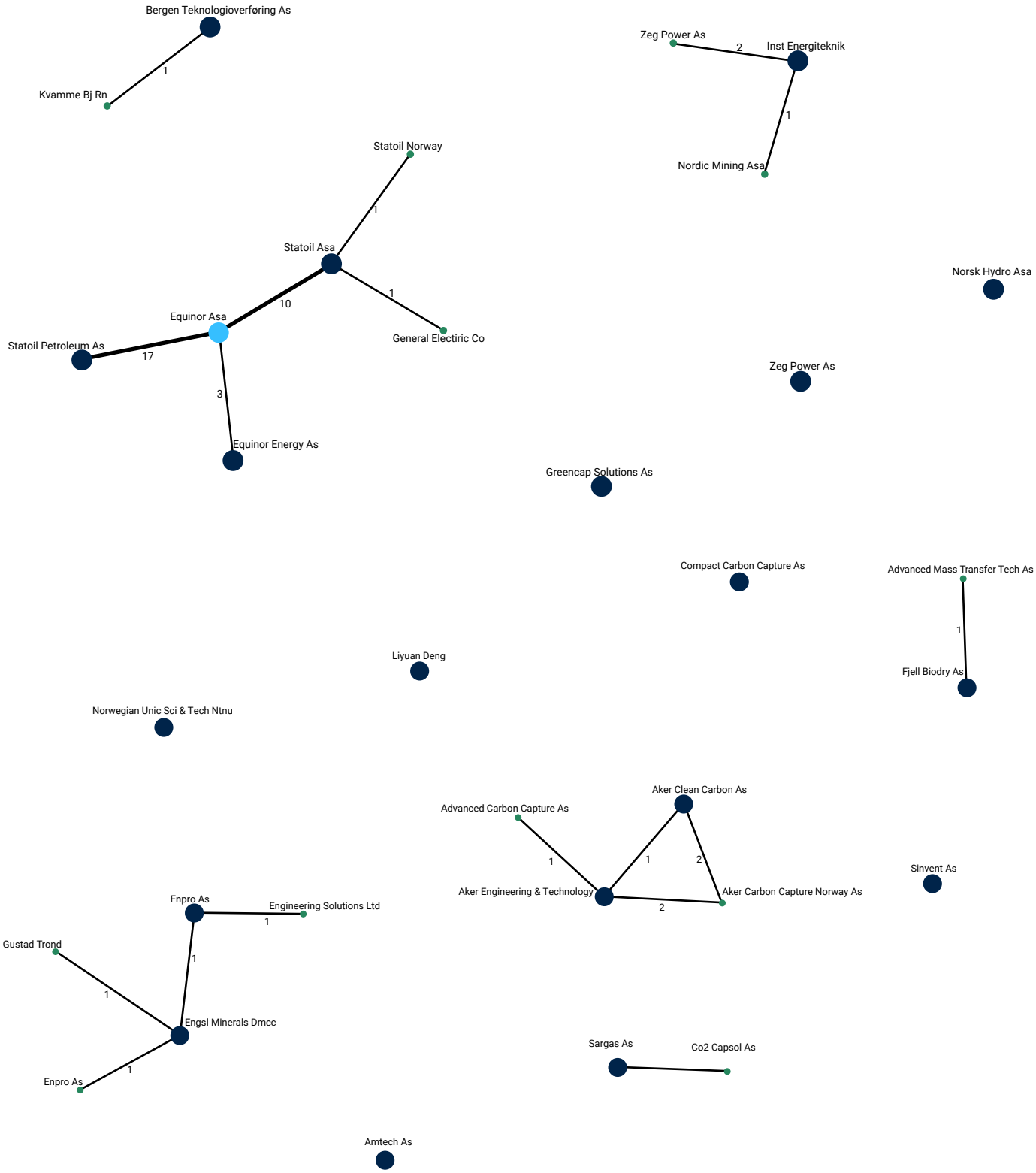


Figure 11: Norwegian collaboration networks in Carbon Capture Technology continued

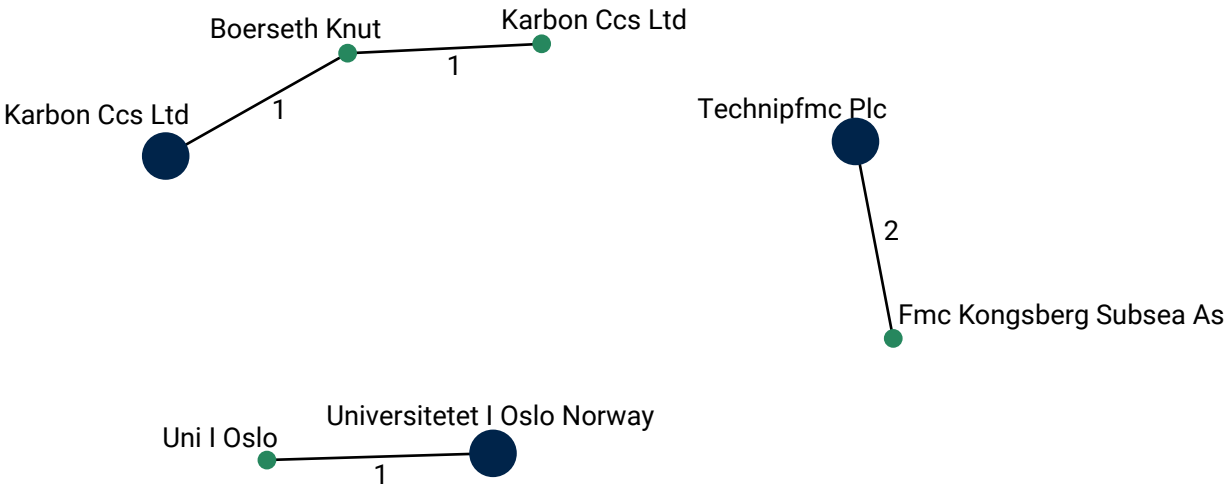


Figure 11: Norwegian collaboration networks in Carbon Capture Technology continued

Historical Trend

Another interesting thing is to know the productivity trend over time for the different companies. Figure 12 shows the historical development within patenting for the top 10 assignees worldwide within Carbon Capture technology in the period from 2001 to 2021.

We note that China Petroleum has an exponential growth in number of filings from year 2010, which is an important reason for the growth in number of filings from China in general.

The Norwegian assignees trend is illustrated in Figure 13.

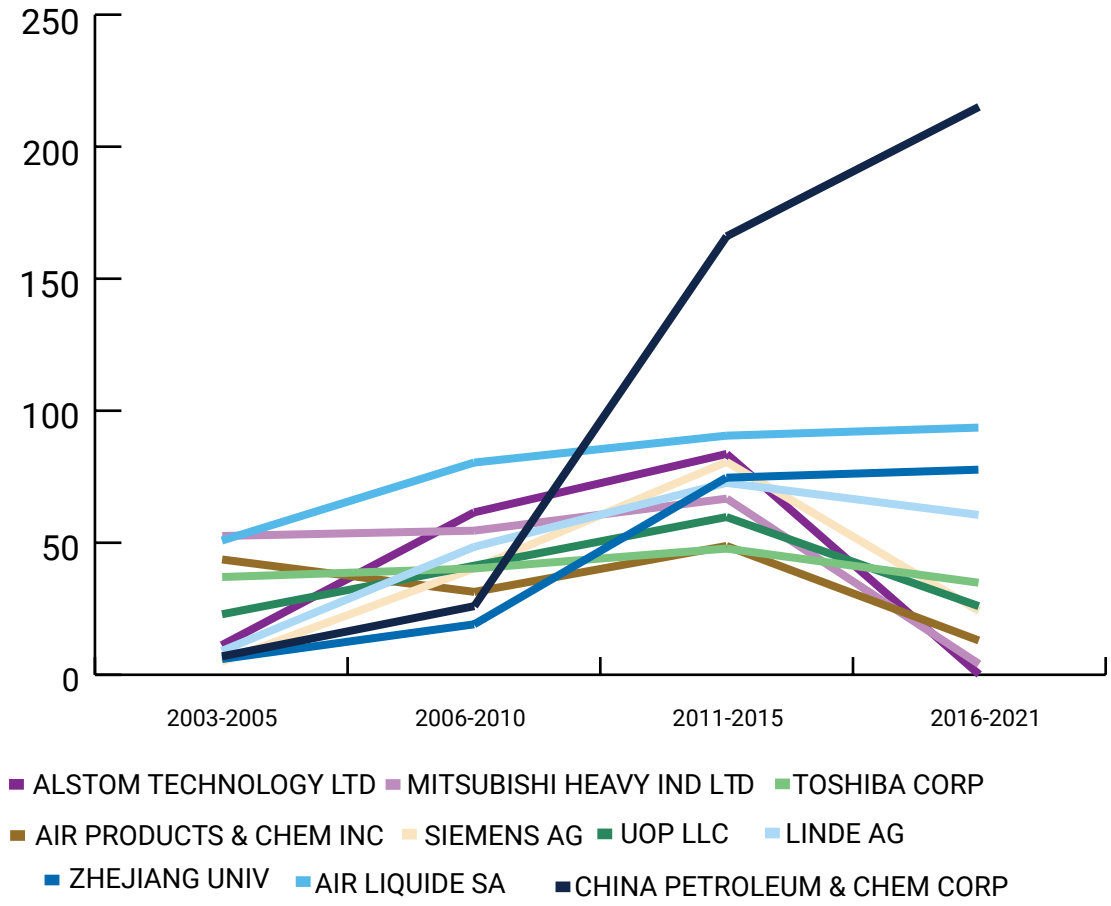


Figure 12: Historical development in filings for the top 10 assignees worldwide

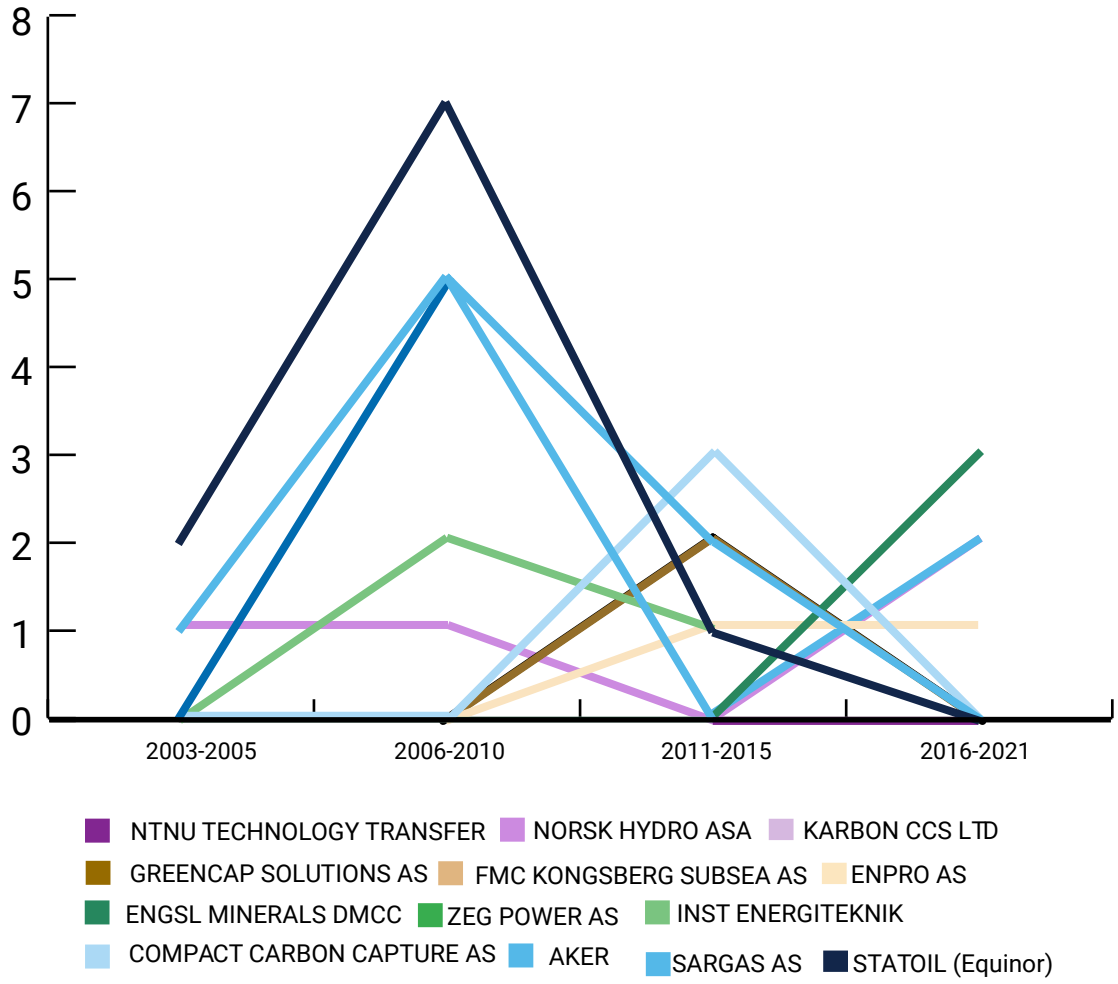


Figure 13: Historical development in filings for the Norwegian assignees

5 Observations

Observations

The following observations are found throughout the report and restated here for easy reference. This landscape analysis is based on approximately 31 000 patent applications (origin) which has resulted in more than 20 000 granted patents. A patent dataset of this magnitude will not be completely accurate in terms of relevance, but on a larger scale, it may give a good indication about the patenting development for the technologies at hand.

Those concerned with Carbon Capture technology in Norway, should follow competitors from USA, France, Japan, Germany and Great Britain most closely. A plurality of foreign patents in Norway, that may hinder operations in the home market, come from these countries. There is also reason to believe that assignees from Great Britain, France, and Germany additionally file patents through EPO to secure their IPR in Norway.

USA is unquestionably the world's most important country for IPR within the analysed dataset, with 1/3 of the priority patent filings worldwide, and having as much as 37 % more priority patent filings than the second largest country, China. Norway is also present on this list, even when ignoring the international patent applications handled by EPO. As mentioned earlier, we will not get an exact picture in such an analysis, as the patent assignees are free to file their priority applications to the patent authority they might prefer. However, a plurality of the assignees files their priority application to the authority in their home country or region, and such a perspective will therefore give the most precise picture of the patent situation.

With one exception, USA is the world leader within all technologies analysed in the present report. Within the area of hydrogen separation, China and Japan are in front with almost 2 times as many granted patents within this technology as USA which is the third nation on the list. The European countries have only a minor share in this part of the technology.

China shows an impressing increase in number of granted patents in almost all areas from 2010. This is in full compliance with the overall increase in number of patent applications in China the last years. In 2020 the Chinese Patent Office received close to 1,5 million patent applications, a growth of filings of 50 % over a five-year period and more than 300 % the last decade . This enormous growth in China is also reflected in the present analysis, regarding Carbon Capture technology.

3 https://www3.wipo.int/ipstats/index.htm?tab=patent

6 Terminology

Terminology

This list contains terminology and basic expressions frequently used within immaterial rights, focused on expressions concerning patents.

- **IPR:** Intellectual Property Rights, immaterial rights. Exclusive rights protecting inventions, names, logos, design and other innovations.
- I**nvention:** a practical solution of a problem, where the solution has a technical characteristic, a technical effect and is reproducible.
- **Patent:** Immaterial protection of an invention. The protection is a national protection, and an application should be filed in the countries where protection is needed. Regional and global application procedures exist.
- **Patent application:** A request pending at a patent office for grant of a patent for the invention described and claimed in the application. All patent applications are published, within 18 months after filing date, unless the patent application is withdrawn by the applicant.
- **Utility patent:** An intellectual property right is a form of protection used in several countries. It is customary for this type of protection to have lower requirements for inventive step than for patents, and that the protection period is shorter. Norway does not have such protection.
- **Priority:** If several people apply for a patent for the same invention, the person who has the earliest filing date for the application will be entitled to the patent. The filing date may therefore be important in some cases. If you have applied for a patent for an invention in one country, you may claim priority in other countries where others have applied for the same invention. This right is valid for 12 months from the date the application was filed in the first country - the priority date. Priority means that the applicant takes precedence over others who have applied for a patent for the same invention after the priority date.
- **Priority application** – the first patent application in a patent family, typically the first application describing an invention.
- **Patent family:** A collection of patent applications covering the same or similar technical content. The applications in a family are related to each other through priority claims.
- **Patent authority:** A governmental or intergovernmental organization controlling the issue of patents.
- **EPO:** The European Patent Office receives, processes, and decides European patent applications based on rules given by the European Patent Convention (EPC).
- **WIPO:** World Intellectual Property Organization is the global forum for IP, an agency of the United Nations, which mission is to lead the development of a balanced and effective international IP system that enables innovation and creativity for the benefit of all.
- **PCT:** Patent Cooperation Treaty is a worldwide convention of patent cooperation that simplifies the process to apply for a patent of the same invention in several countries.
- **Patent extension:** Within 12 months of the priority date an application can be extended to other patent authorities with priority from the priority application. The extended application is then examined as it was filed on the priority date. The patent application can be filed directly to each national authority or through international or regional organizations that simplifies the application process, such as PCT or EPO.
- **Patent kind code:** A code system indicating the status of a patent document. Patent documents often retain the same identification number throughout the application process, and this code indicates whether the document is still an application, a granted patent, a utility model, etc.

- **Prior art:** Anything that has been made available, or disclosed, to the public in any form before the priority date.
- **Patent classification:** All patents are classified according to the subject to which the invention relates in order to make it easier for a patent examiner to find similar inventions and assess whether the invention is already known.
- **IPC Classification:** International Patent Classification is a classification system that makes it possible to find the information of importance for the examination. All patent applications filed to NIPO are classified according to IPC.
- **CPC classification:** Cooperative Patent Classification is mainly based on the IPC classification system but contains more subgroups than IPC and hence makes it possible to classify more detailed than IPC. NIPO has been using CPC for classification of patent applications since October 2015, this in addition to the IPC classification system.

More information: https://www.cooperativepatentclassification.org/home