patent trademark design
Norwegian Industrial
Property Office

Subsea production and processing technology

A patent landscape analysis

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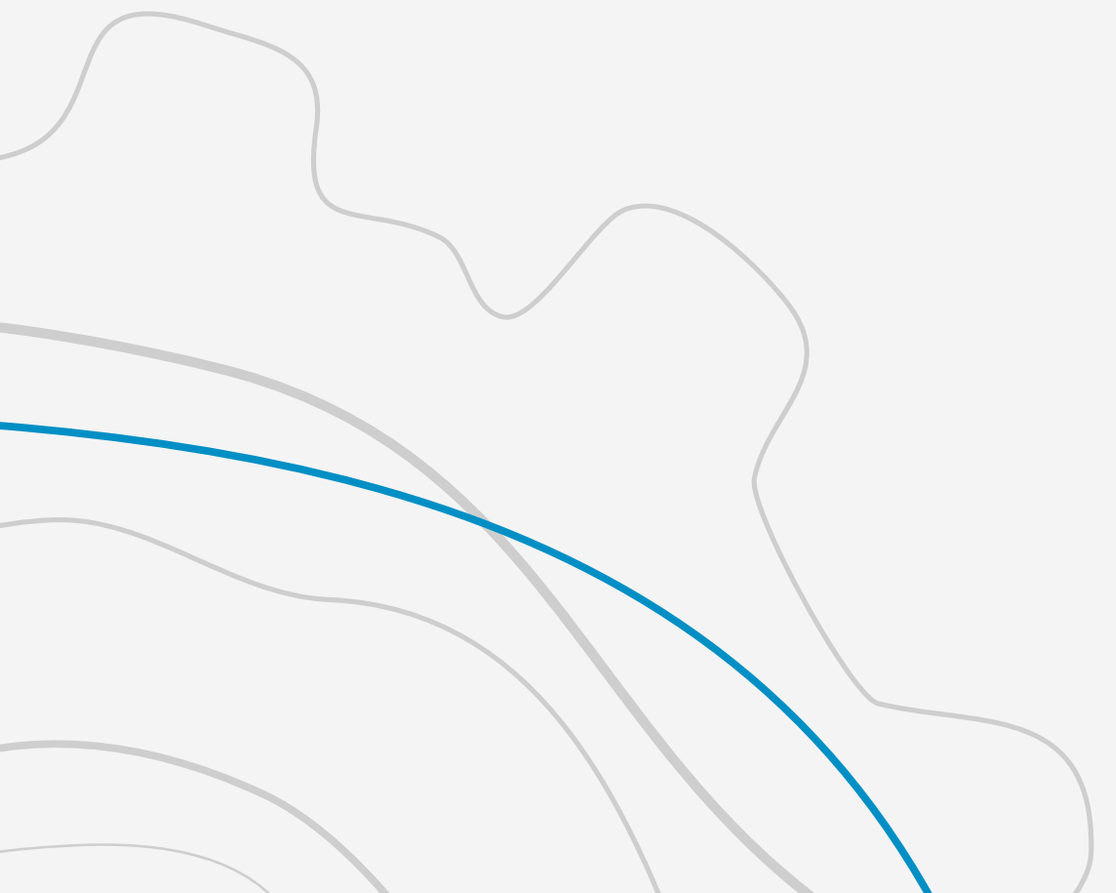
NIPO contributes to competitiveness and helps to strengthen Norwegian trade and industry in various ways. We provide knowledge and expertise concerning intellectual property rights and values, enabling businesses to secure their investments, their competitive position and create economic growth in Norwegian 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 subsea production and processing technology. This report is based on a collaboration between the Norwegian Industrial Property Office (NIPO) and The Research Council of Norway to bring knowledge of IPR into public funded research projects, in this case SUBPRO. The report aims to uncover opportunities and challenges in IPR by mapping the patent landscape in the technical area.

A patent data set consisting of nine subareas adapted for the key research areas within subsea production and processing technology was gathered and used for further analysis.

Norway holds a strong international position within production of both oil and gas, and is the largest European resource provider after Russia. However, in terms of IPR, the Norwegian oil and gas industry gets strong competition from nations like USA, United Kingdom, France and Germany.

When analysing the global patent environment for the present data set, there is no doubt that USA is the world's largest provider of patent applications, followed by Japan, China, Germany and United Kingdom. Norway is number eight on this list. The European countries are the most international focused nations, based on their degree of patent extensions, followed by USA. China is on the other side of the list, extending less than 1% of their patent applications.

When looking at the historical patenting development (1990-2014), it is important to notice that both USA and China have an ever-increasing curve of granted patents in almost all the nine analysed technical areas. One should also be aware of Canada, Russia and Korea, which also have an increasing trend in most areas. Norway has a rather stable situation in most of the areas, but shows a decrease in the areas of bulk separation and gas-oil-water treatment and an increase in the area of subsea pumping/compression and automation. For subsea systems the trend appears to be decreasing from 2004.

The area of subsea systems is clearly the most patented area within the subsea production and processing technology in Norway. Within this technological area, Norway has the fourth largest patent force worldwide, when considering the number of granted patents.

It is estimated that about 48 % of the estimated total recoverable resources on the continental shelf has been produced and sold in the 50 years of Norwegian petroleum industry. Thus, there are still large remaining resources and it is expected that the level on the Norwegian shelf will remain high for a long period. (ref http://www.norskpetroleum.no/en/production-and-exports/oil-and-gas-production/). It is therefore of great importance that Norwegian research institutions and their industry partners continue their technology development and secure their intellectual properties to ensure their freedom to operate in the future market.

The Research Council of Norway

SUBPRO
SUBSEA PRODUCTION AND PROCESSING

patent trademark design
Norwegian Industrial Property Office

Resource type: Patent Landscaping Report
Institution: The Norwegian Industrial Property Office
Partners: The Research Council of Norway and SUBPRO
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Contents

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Background

Future aspects of IPR[1] related to patents within subsea production and processing technology

1 See glossary, page 35

Subsea production and processing technology is a key enabler for exploitation of Norwegian and international oil and gas resources. Norwegian oil companies and foreign oil companies with basis in Norway, with strong support of Norwegian-based suppliers and manufacturing companies, have been in the forefront of developing subsea fields.

However, new and innovative solutions are still required to be able to increase the recovery from existing fields, enable developments of new and more demanding oil and gas fields and to reduce the cost and complexity of subsea field developments.

IPR, specially patents will be increasingly important for the Norwegian subsea industry when seeking to expand their industry internationally, or when facing competition from international companies seeking to do the same.

Understanding of the global patenting environment is an important factor for making good strategic decisions. The aim of this report is to present the available patent data within the fields of subsea production and processing technology to form a platform of knowledge for making the right decisions. The nature of IPRs is complex, and there are several different schools of thoughts related to IPR strategy. It seems to be a mastery of IPR among the actors in the present technical field, which is confirmed by the number of filed patents applications within the corresponding IPC classes over time. If you are not aware of your competitors IPR, it can cause you a lot of trouble and become very expensive. However, in the ever-increasing complexity of the technical field, it is also important to protect your own unique knowledge and ideas, both to secure the exclusive rights to your own invention, and to achieve more benefits in negotiations with investors, partners and potential licensees.

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. There are a lot of aspects that has to be taken into account, a patent application may have varying vital or legal statuses in different countries.

A patent applications' ability to be enforced depends on its legal status, which may range from declined to granted. A declined patent application is most useful in the sense that it adds to prior art, but may not be eligible for legal enforcement. A granted application can however be legally enforced and is therefore a greater threat to a competitor.

A patent application may also have a varied vital status. The vital status may be dead, pending or alive. Patent offices may also have different practice, and the lifetime of a patent may vary. A major part of patent applications from China are filed as utility models (see terminology) which is an IPR very similar to a patent, but has a lifetime from 6 to 10 years, and less stringent patentability requirements.

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Methodology

Data set overview

In this report, nine areas of technology related to subsea production and processing technology are in focus. These nine technical areas constitute the nine sub data sets in this report, which combined constitute the complete patent data set. The analysis shown in this report is based on the complete patent data set.

The nine different areas of technology are listed in Table 1. These areas are referred to as sub data sets in this report.

1. SUBSEA SYSTEMS
2. BULK SEPARATION
3. GAS TREATMENT
4. MEMBRANE TECHNOLOGY
5. OIL TREATMENT
6. WATER TREATMENT
7. PUMPING & COMPRESSION
8. AUTOMATION
9. AUXILIARY

Table 1: The different areas of technology.

Search strategy

The patent data for this report was gathered in November 2016 from different patent literature databases covering the period 1990-2016, as suggested by SUBPRO. 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 further data related to 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 SUBPRO.

Patent classification overview

The different sub data sets represent a large number of publications with several different classifications, according to the IPC classification system. The classification chart beneath (Table 2) illustrates the main relevant patent classifications for each area.

	Subsea systems	Bulk separation	Gas treatment	Membrane technology	Oil treatment	Water treatment
B01D Separation		B01D17/00 B01D17/02 B01D17/04 B01D17/06 B01D17/085* B01D19/00 B01D19/0057* B01D19/0063* B01D21/00	B01D2252/00* B01D2252/2023* B01D2252/20431* B01D2252/504* B01D2257/00* B01D2257/304* B01D2257/504* B01D2257/602* B01D2257/80* B01D51/00 B01D51/10 B01D53/14 B01D53/1456* B01D53/22 B01D53/228* B01D53/26 B01D53/263* B01D53/268* B01D53/34 B01D53/346* B01D53/52 B01D53/526* B01D53/62 B01D53/64 B01D53/52 B01D53/96	B01D61/00 B01D61/36 B01D61/38 B01D65/00 B01D65/02 B01D2311/00* B01D2311/02* B01D2311/04* B01D2311/06* B01D2311/08* B01D2311/10* B01D2311/14*		
B01J Chemical or physical processes (conducted in the presence of fluids and solid particles)		B01J8/00 B01J8/0055* B01J8/007*				
B03C Electrostatic separation of solid materials from solid materials or fluids		B03C2201/00* B03C2201/02*			B03C2201/00* B03C2201/02*	B03C2201/00* B03C2201/02*
C10L Natural gas, liquefied petroleum gas			C10L3/00 C10L3/10 C10L3/102* C10L3/106* C10L3/107*			
E21B Obtaining oil, gas, water or minerals from wells	E21B41/00 E21B41/0057* E21B41/0064* E21B41/0085* E21B41/0092* E21B43/00 E21B43/12 E21B43/121* E21B43/122* E21B43/124* E21B43/126* E21B43/128* E21B43/129* E21B43/30 E21B43/34 E21B43/36 E21B43/38 E21B43/385* E21B43/40					
Y02C CO2 capture			Y02C10/00* Y02C10/06* Y02C10/10*			

Table 2: Patent classification overview for the different sub data sets (the table continues on the following page).

	Oil treatment	Water treatment	Pumping and compression	Automation	Auxiliary
B01F mixing, e.g. dissolving, emulsifying, dispersing					B01F3/00 B01F3/04021* B01F3/04106*
B04C apparatus using free vortex flow, e.g. cyclones.	B04C1/00 B04C3 B04C5 B04C7/00 B04C11/00	B04C1/00 B04C3 B04C5 B04C7/00 B04C11/00			
C02F treatment of water, waste water, sewage, or sludge		C02F1/00 C02F1/001* C02F1/004*			
C10G recovery of hydrocarbon oils	C10G33/00 C10G33/02 C10G33/08				
F04B positive-displacement machines pumps/ compressor			F04B47/00 F04B47/06		
F04D non-positive-displacement pumps/compressor			F04D13/00 F04D13/08 F04D13/086*		
F17D pipe-line systems					F17D1/00 F17D1/005* F17D1/02
"F28D heat-exchange apparatus					F28D1/00 F28D3/00
G05B control or regulating systems in general; functional elements of such systems; monitoring or testing arrangements for such systems				G05B11/01 G05B11/60 G05B13/02 G05B17/00 G05B19/01	

* CPC Class

Table 2: (the table continues from the previous page) Patent classification overview for the different sub data sets

Search results

The magnitude of the gathered patent data in each sub data set will to a certain degree reflect the magnitude of relevant prior art existing in global patent databases within these fields. The nine different subsets are all related to offshore technology, but still they are quite different, as each of them represent their own technical area. Table 3 shows the overlap between the subsets. There are only minor overlaps between most of the technical areas, with exception of oil and water treatment as well as the auxiliary area. This means that most of the nine sub data sets show only a minor degree of correlation, and their patenting trends may therefore be quite different .

	Subsea systems	Bulk separation	Gas treatment	Membrane technology	Oil treatment	Water treatment	Pumping & compression	Automation	Auxiliary
Subsea systems	79 %	6 %	2 %	1 %	1 %	2 %	7 %	2 %	1 %
Bulk separation	8 %	64 %	5 %	3 %	6 %	12 %	0 %	0 %	1 %
Gas treatment	5 %	10 %	73 %	4 %	1 %	5 %	0 %	0 %	0 %
Membrane technology	1 %	5 %	14 %	69 %	0 %	10 %	0 %	0 %	0 %
Oil treatment	10 %	30 %	11 %	2 %	25 %	22 %	0 %	0 %	0 %
Water treatment	4 %	20 %	4 %	21 %	7 %	43 %	1 %	0 %	1 %
Pumping and compression	27 %	1 %	1 %	1 %	0 %	1 %	67 %	1 %	0 %
Automation	15 %	0 %	2 %	0 %	0 %	3 %	1 %	78 %	0 %
Auxiliary	14 %	19 %	14 %	5 %	1 %	12 %	2 %	1 %	32 %

Table 3: An overview of the overlap of publications between the different data subsets

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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 data set 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 data set, excluding countries with less than 100 applications. Figure 1b shows the distribution of the patent data set into the various technical areas (sub data sets), while Figure 1c shows the percentage of applications belonging to each sub data set for each of the top filing nations.

Figure 1a shows where the major part of the patent applications are first filed, but it does not necessarily tell us in which countries the subsea industry is most active. An explanation can be that most applicants traditionally file their priority application in their native country, even though there is little activity within the subsea and/or processing industry. Therefore the applicants extend their applications to more active countries within the technical area to ensure IPR in these countries. However, most of the patent applicants in this data set originate from countries or file applications to countries with a strong subsea industry or with great subsea resources and locations suited for subsea.

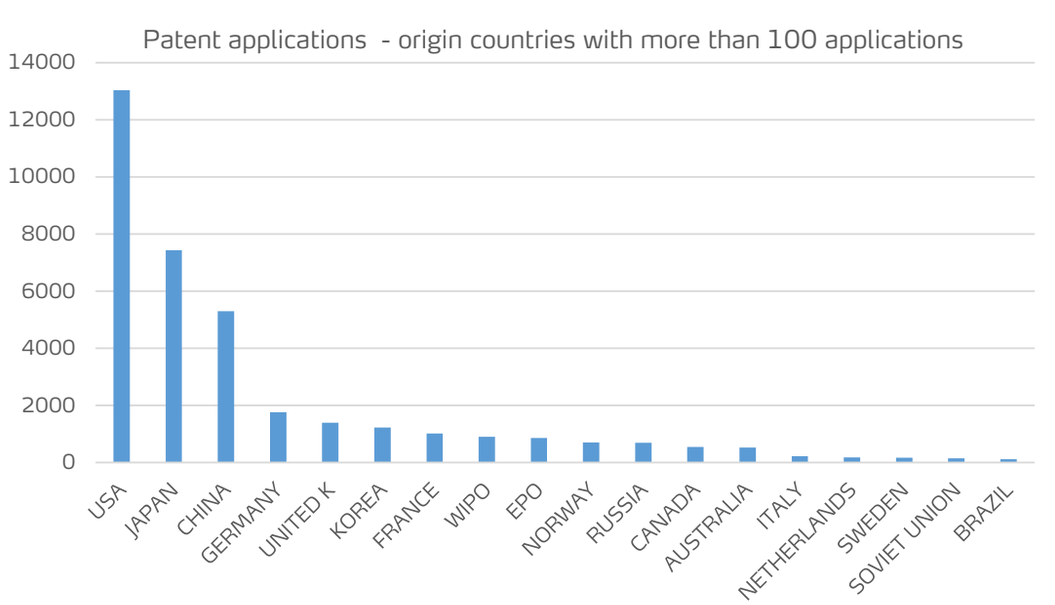


Figure 1a: Overview of the worldwide patenting activity (first filed) within the data set

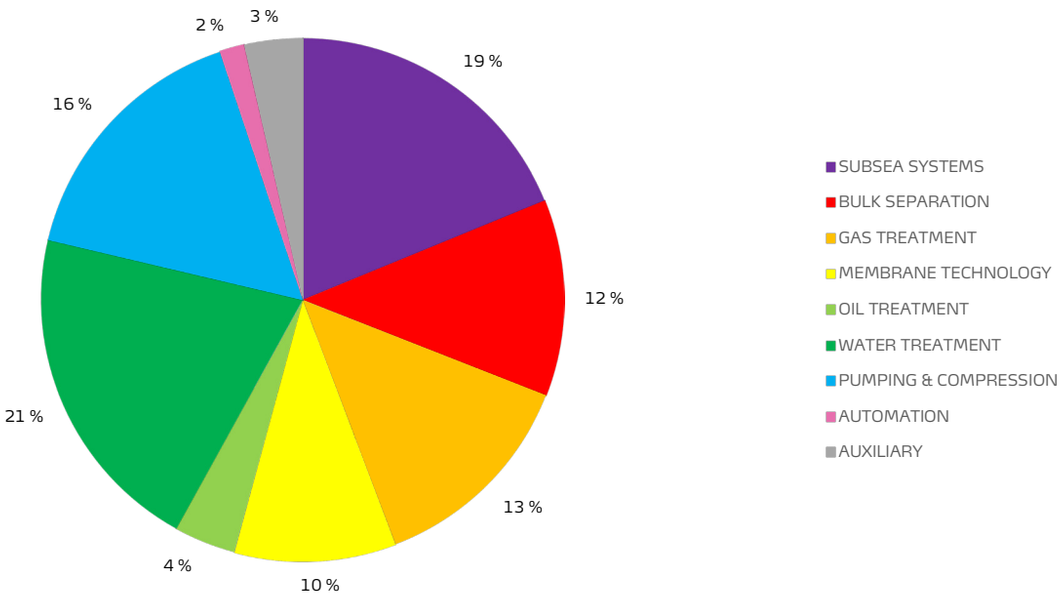


Figure 1b: Patent applications (patent data set) divided in different areas (sub data set)

Figure 1a shows that most of the applications are filed in USA, Japan and China. Japan is not amongst the top countries of oil and gas producers in the world in 2016 (see Figure 2, page 16), but is still the second most active in developing technology related to the subsea industry.

From Figure 1c we see that USA dominates in filing of patent applications for all areas except Membrane technology and Pumping & Compression where Japan and China dominate respectively. Norway has a share in Subsea systems.

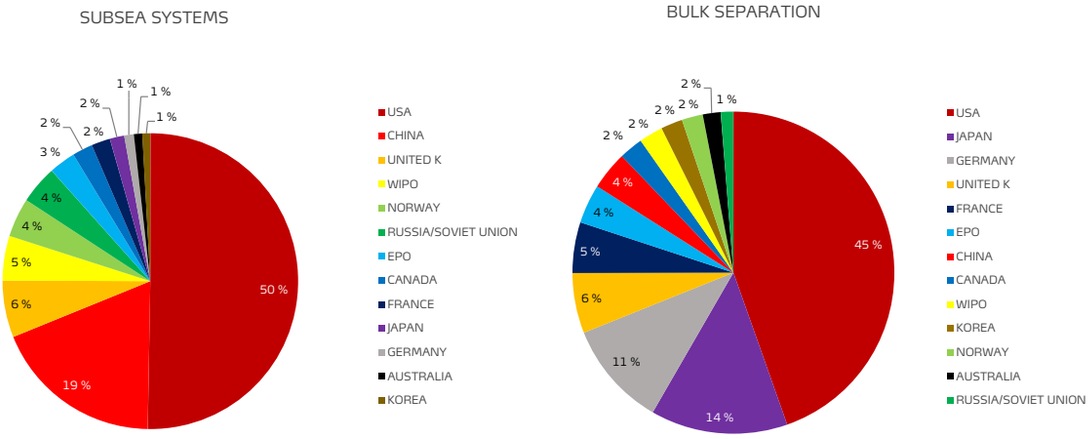


Figure 1c: Percentage of patent applications for each sub data set for the top nations (the figure continues on the following page)

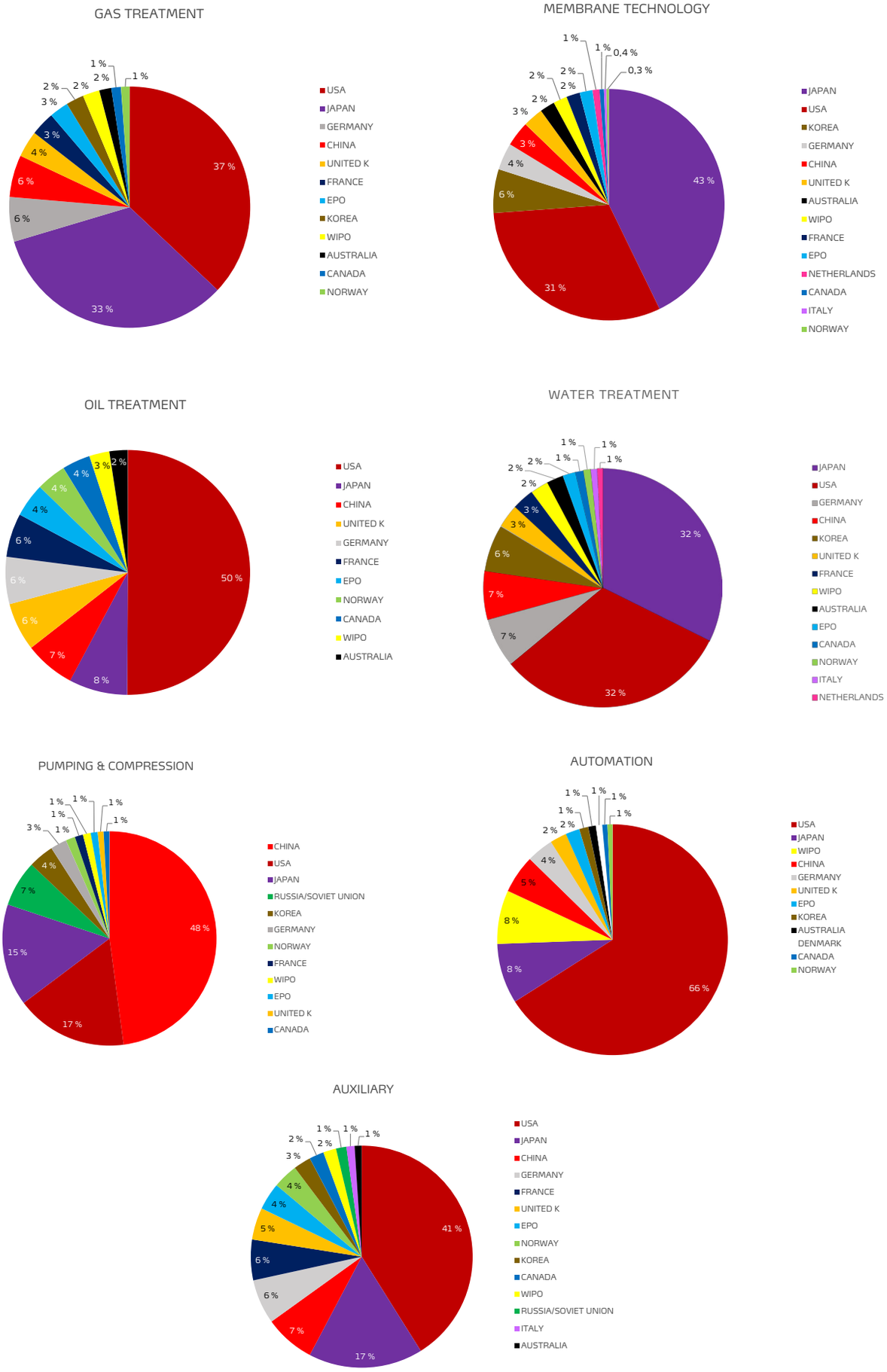


Figure 1c: (the figure continues from the previous page) Percentage of patent applications for each sub data set.

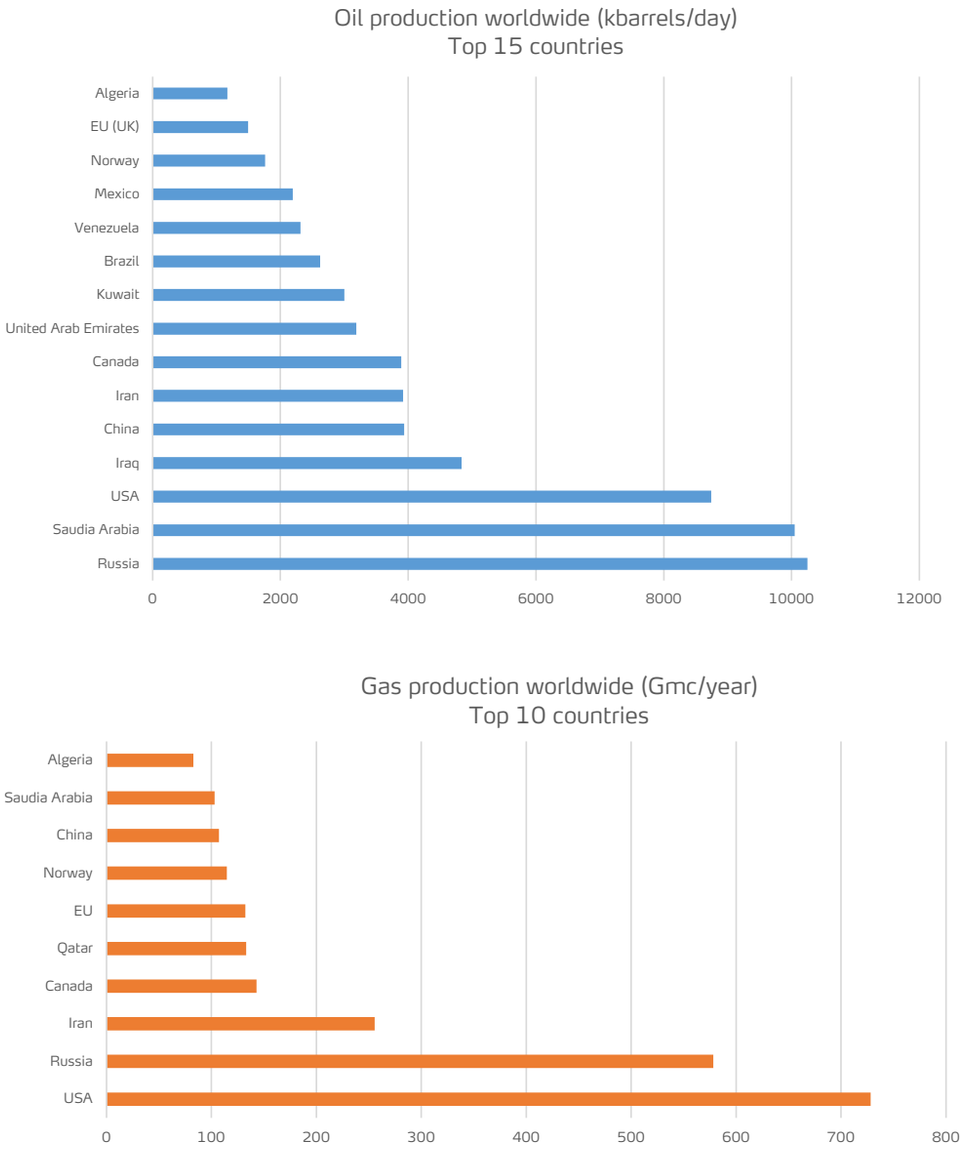


Figure 2: Oil and gas production world wide and not limited to subsea

According to Figure 2, Russia, Saudia Arabia and USA were the top three largest oil producing nations in 2016[1] worldwide. However, Russia and Saudi Arabia still represent only a minor part of the patent applications in this data set. A major part of Russian oil production has been onshore in West Siberia[2], which can be an explanation of the low presence of Russia in this data set. We note that Russia recently has increased their activity in the Far East and in the Caspian Sea and expect a tremendous increase in their offshore oil production[3], which makes it natural to expect a noteworthy increase in the number of patents in the years to come. Statistics from WIPO[4] shows that there is almost no tradition for filing of patents in Saudi Arabia, however, it seems to be an increasing IPR awareness and therefore maybe a market to follow when it comes to oil production technology.

1 https://en.wikipedia.org/wiki/List_of_countries_by_oil_production
https://en.wikipedia.org/wiki/List_of_countries_by_natural_gas_production
2 https://www.eia.gov/todayinenergy/detail.php?id=1805
3 http://ac.gov.ru/en/commentary/012008.html
4 http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=SA

International patent extensions

Table 4 provides an overview of where the patent applications in our data set of the countries/regions are extended to (Extension country) and where they are extended from (Priority country of the top filing nations/regions). We see that priority applications from USA and Japan constitute most of the extensions, followed by United Kingdom, Germany, France and Norway. A considerable fraction of the assignees files directly to the European Patent Office (EPO) or WIPO.

		Priority country/region									
		US	JP	CN	DE	GB	KOREA	FR	WIPO	EPO	NO
Extension country/region	WIPO	6885	1248	116	582	881	242	421	0	579	598
	EPO	4240	1321	44	919	640	120	664	339	0	295
	CANADA	4734	412	27	246	388	18	382	301	298	182
	USA	0	2016	125	721	794	291	716	563	549	437
	AUSTRALIA	3294	355	21	248	505	30	237	319	310	343
	CHINA	2455	1188	0	296	204	176	234	250	390	77
	JAPAN	2089	0	27	380	179	121	337	148	203	31
	GERMANY	1186	626	9	0	222	22	345	87	170	86
	BRAZIL	1453	88	6	167	233	9	212	58	205	188
	KOREA	1019	736	12	135	70	0	113	95	130	10
	NORWAY	1153	19	1	58	281	2	190	92	113	0
	MEXICO	1209	39	4	83	117	6	80	95	116	72
	AUSTRIA	533	97	4	361	153	5	184	37	144	75
	UNITED KINGDOM	1020	62	5	28	0	7	61	96	38	169
	SPAIN	475	110	2	279	110	10	231	32	101	39
	RUSSIA	603	58	13	96	44	8	101	67	147	88
	TAIWAN	496	420	5	45	14	22	32	18	36	0
	SINGAPORE	586	173	5	17	67	7	28	62	68	33
	SOUTH AFRICA	471	45	1	69	118	1	83	13	44	8
	DENMARK	275	36	0	103	107	0	129	24	106	72
	EURASIA	361	7	4	23	56	1	19	33	96	45
	ARGENTINA	401	2	1	34	22	1	36	12	50	2
	ISRAEL	329	24	0	31	19	2	27	7	12	1
	INDIA	212	75	1	34	30	14	8	24	28	4
	NEW ZEALAND	219	11	2	18	53	1	23	12	23	3
	MALAYSIA	185	37	0	10	21	6	9	2	62	7
	HONG KONG	150	52	7	12	30	1	15	7	13	4
	PORTUGAL	70	2	0	39	27	0	51	6	23	8
	POLAND	74	11	0	58	17	0	23	0	8	2
	EGYPT	81	4	0	0	18	0	11	4	27	5
	FRANCE	58	33	4	28	11	2	0	7	0	1
	COLOMBIA	98	0	0	4	10	0	8	0	13	0
	PERU	*90*	*2*	*0*	*10*	*11*	*0*	*1*	*0*	*11*	*0*
	FINLAND	*60*	*3*	*0*	*21*	*18*	*0*	*13*	*2*	*2*	*1*
	INDONESIA	*59*	*19*	*0*	*8*	*7*	*0*	*14*	*0*	*6*	*4*
	ARIPO[1]	*72*	*5*	*0*	*0*	*9*	*0*	*17*	*4*	*5*	*3*

Table 4: This table shows the geographical coverage of patent application from their priority countries/regions to their respective extension countries/regions (the table continues on the following page).

1) African Regional Intellectual Property Organization

Extension country/region	Priority country/region									
	US	JP	CN	DE	GB	KOREA	FR	WIPO	EPO	NO
HUNGARY	50	0	0	37	13	0	10	2	3	0
UKRAINE	49	1	1	19	7	0	11	0	24	0
CZECH REPUBLIC	43	3	0	34	4	0	16	2	4	1
CHILE	66	2	0	1	9	0	2	1	18	0
GREECE	24	6	0	17	20	0	20	3	3	1
NETHERLANDS	53	2	2	7	3	1	15	0	6	2
TURKEY	32	9	1	20	5	1	13	0	3	1
MOROCCO	39	0	1	1	7	0	20	5	11	0
OAPI [1]	28	0	0	0	5	0	22	1	6	9
ITALY	20	9	0	14	5	2	18	0	0	0
SLOVENIA	17	1	0	11	0	0	9	1	19	0
SLOVAKIA	23	0	0	7	8	0	10	2	0	0
PHILIPPINES	14	9	0	4	3	1	5	4	7	0
ECUADOR	36	0	0	0	2	0	4	0	0	0
TUNISIA	24	0	0	1	1	0	7	0	2	1
ROMANIA	20	0	0	3	7	0	4	1	0	0
CROATIA	13	0	0	5	0	0	2	2	11	1
VIETNAM	5	20	0	0	4	1	0	2	1	1
SWEDEN	17	5	1	3	2	0	0	1	0	1
IRELAND	10	0	0	1	11	0	4	0	0	2
GULF COUNCIL	12	5	0	1	1	0	1	0	7	0
ALGERIA	10	0	0	0	6	0	6	0	3	1
BULGARIA	8	0	0	5	3	0	6	0	0	0
COSTA RICA	10	3	0	0	3	0	2	0	2	1
YUGOSLAVIA	8	0	0	6	2	0	1	0	0	2
SWITZERLAND	6	3	1	7	1	0	0	0	0	0
CYPRUS	8	0	0	4	2	0	2	0	0	1
JORDAN	14	0	0	0	1	0	0	0	1	0
SOVIET UNION	8	0	0	3	2	0	1	0	0	2
URUGUAY	10	0	0	2	0	0	0	0	3	0
ESTONIA	0	0	0	9	0	0	4	0	0	1
BELGIUM	2	1	0	7	2	0	0	0	0	0
GEORGIA	4	0	0	2	0	0	6	0	0	0
SERBIA	1	0	0	1	4	0	0	2	4	0
GUATEMALA	9	0	0	0	2	0	0	0	0	0
DOMINICAN REPUBLIC	6	0	0	0	0	0	2	0	1	0
ICELAND	6	0	0	0	0	0	0	0	0	1
PANAMA	3	0	0	0	2	0	0	0	1	0
CUBA	2	0	0	1	0	0	2	0	0	0
ZIMBABWE	5	0	0	0	0	0	0	0	0	0
LATVIA	0	0	0	3	0	0	0	0	0	1
NICARAGUA	4	0	0	0	0	0	0	0	0	0
SAN MARINO	2	0	0	0	0	0	0	1	1	0
THAILAND	1	1	0	0	0	0	0	1	0	0
LITHUANIA	1	0	0	0	0	0	0	0	0	1
MALAWI	2	0	0	0	0	0	0	0	0	0
KAZAKHSTAN	1	0	0	0	0	0	0	0	0	0
TOTAL	**37421**	**9416**	**453**	**5399**	**5633**	**1131**	**5280**	**2847**	**4267**	**2924**

Table 4: (the table continues from the previous page) This table shows the geographical coverage of patent application from their priority countries/regions to their respective extension countries/regions.

1) African Intellectual Property Organization

Figure 3 shows the extension rate between the top 10 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 produced in the originating country. We see that France, Norway and United Kingdom 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.

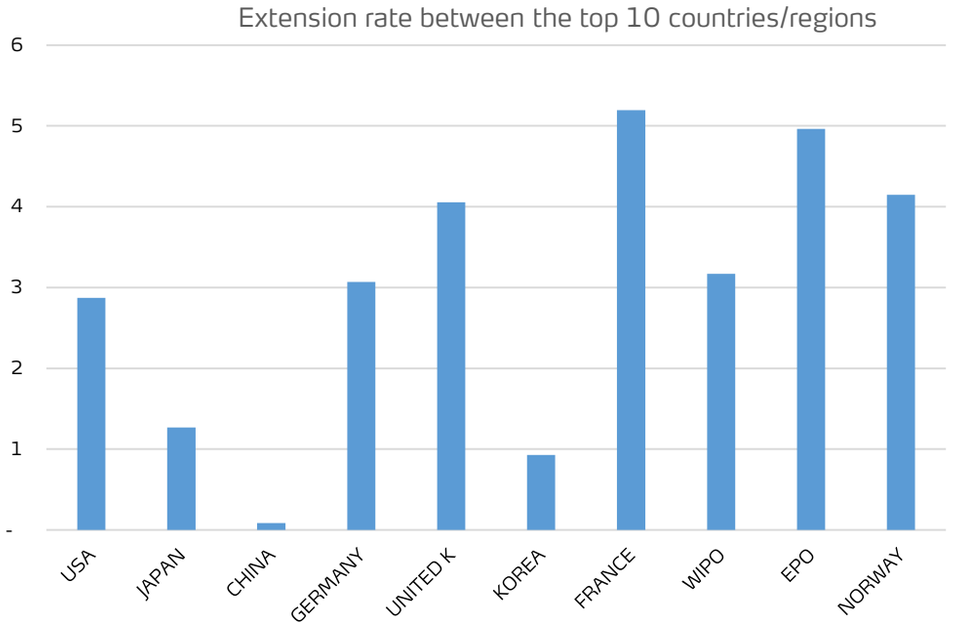


Figure 3: A comparison between the top 10 countries/regions for extended patent applications.

We see from Table 4 (see page 17-18) that US applicants often choose Canada, Australia and China for extension of their patent application to ensure IPR in these markets. Norwegian applicants extend mostly to USA, Australia and Brazil. Both American and Norwegian assignees extend a considerable share of their applications to EPO and WIPO.

Most of the applications extended to Norway originate from USA, United Kingdom and France, while most of the applications extended to USA originates from Japan, United Kingdom and Germany.

The table further shows that applications with priority in the EPO have been extended, as expected, to non-European countries. A considerable share of these applications are extended either to WIPO[1], to enter international non-European phase, or directly to USA.

It is also interesting to notice that almost 2000 patent applications are extended to Russia and EAPO (Eurasia) from the technology developing nations, while less than 30 patent applications are extended to GCC (Gulf Council), representing the world's second largest oil producing area.

1 See the IPR glossary in the back of this report

Trend analysis

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

Patent applications are made public 18 months after first filing. The numbers from 2015 and 2016 are therefore incomplete and not shown in the trend analysis.

Historical patent development

Figure 4 shows the trend for first filing of patent applications in the field of subsea in the period from 1990 to 2014. The diagram shows an approximately linear annual increase of patent filing, where the number of patent filings is almost 4 times as high in 2014 as in 1990.

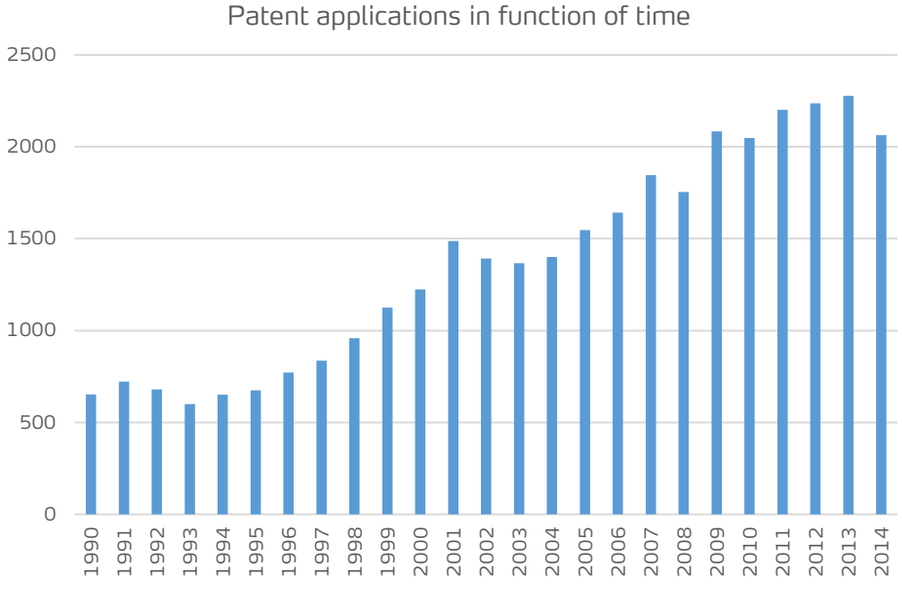


Figure 4: Number of first filed applications per year world wide within subsea processing technology.

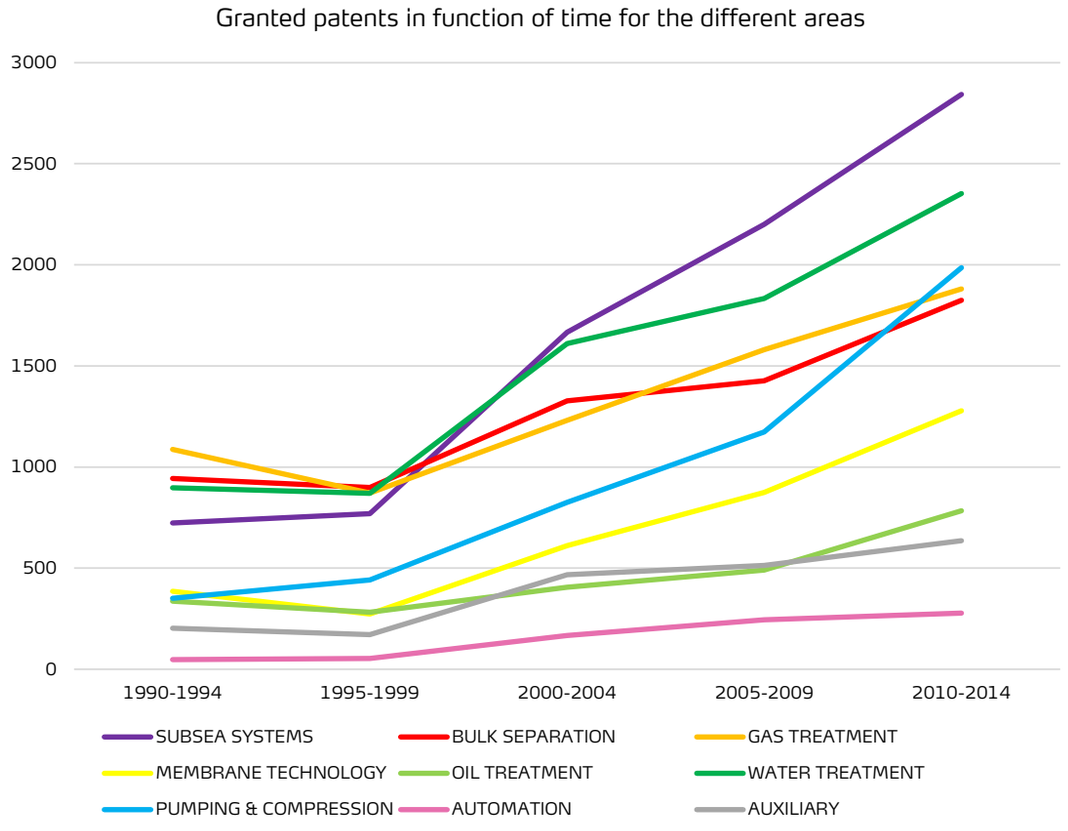


Figure 5: Historical patenting development for each patent data subset.

Figure 5 illustrates the trends for granted patents from 1990 to 2014 for the different sub data sets. We see a linear growth in patents within all areas from 1999, which may indicate both an increasing technology development and/or an increasing awareness of protection of intellectual knowledge.

International grant rates

Figure 6 illustrates the distribution of granted patents contra number of patent priority applications for the top 10 active countries within the present data set. Mostly the number of granted patens exceed the number of applications. This is expected due to the extension rate of the patent priority application (see Table 4 and Figure 3, page 17 and 19). We see that Canadian applications surpasses Japanese and Chinese applications in number of grants despite of a much lower number of priority applications (see figure 1a, page 13), which can be explained by the high number of extensions from USA (see Table 4, page 17). The main provider of patent applications, USA, clearly has the highest number of granted patents.

Note that Japan is the only country with a larger number of priority applications than granted patents. An explanation to this could be that patent filing in Japan for non-residents may be a challenge, especially due to the language. There is also a three year limit to make a request for examination, if this is not complied with, the application will never proceed to examination, which probably also will contribute to a lower ratio of grants.

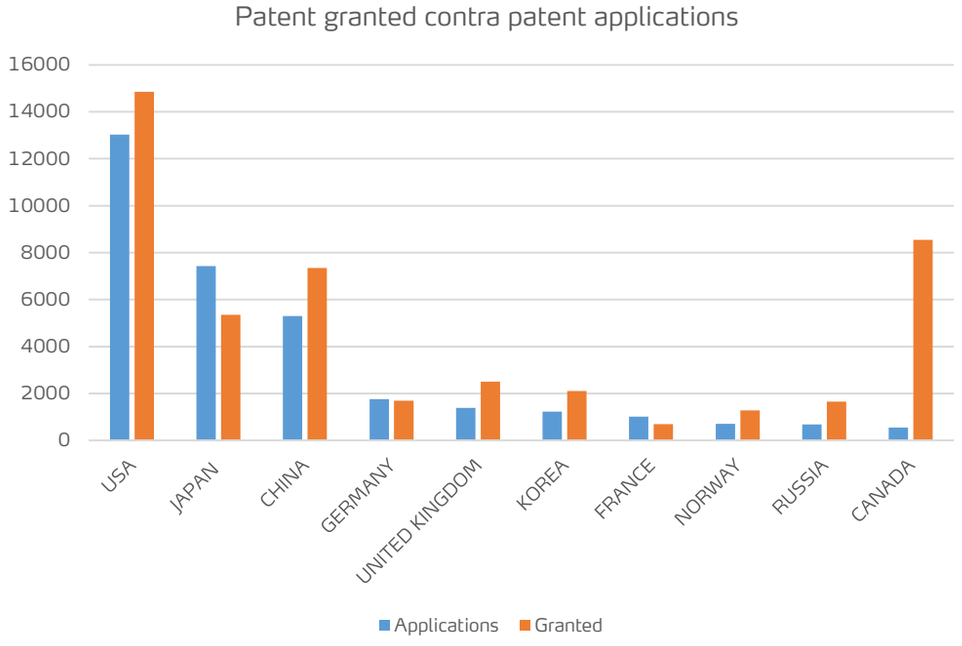


Figure 6: Number of granted patents contra applications for the top 10 countries.

Figure 7 shows the same as Figure 6, but for each sub data set.

Figure 7: Number of granted patents contra applications for each sub data set for the top 10 countries (the figure continues on the following page)

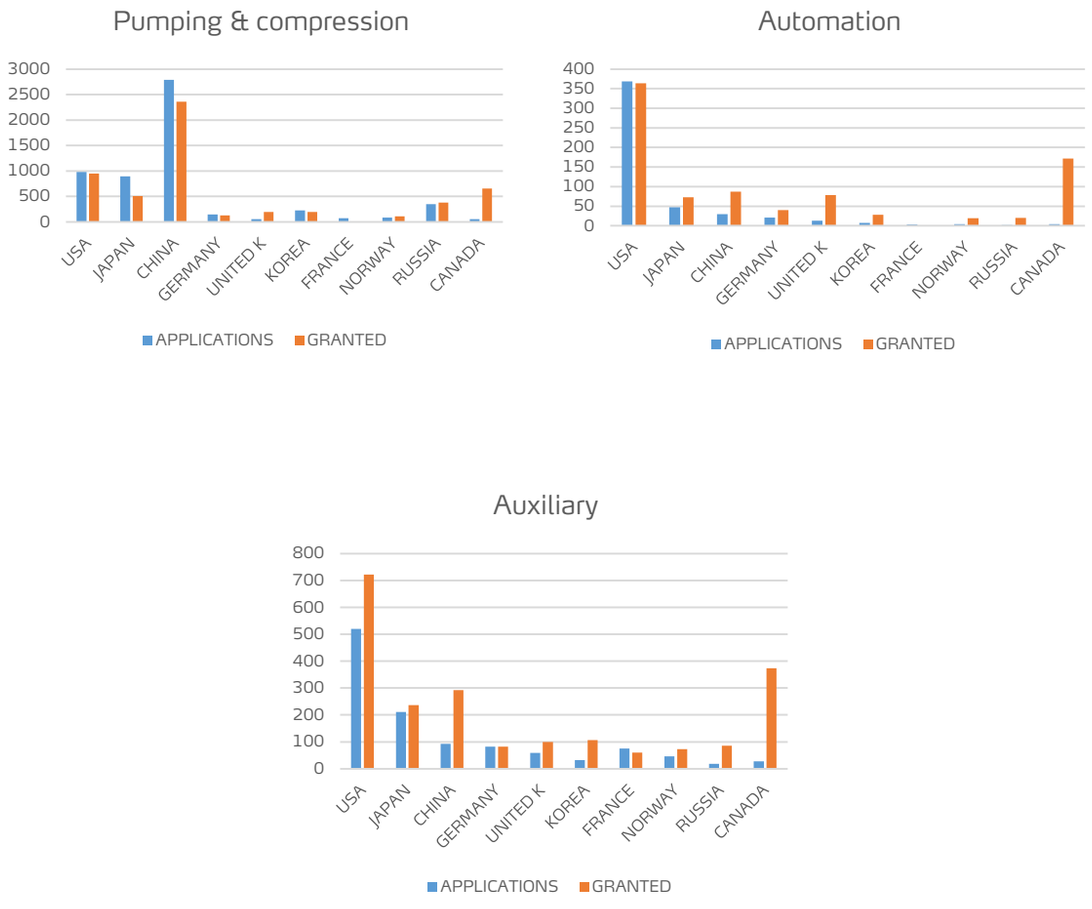


Figure 7: (the figure continues from the previous page) Number of granted patents contra applications for each sub data set for the top 10 countries.

Figure 8 shows the details of Figure 5 (see page 21), for the top 10 patent providing countries in each technical area. As we see, USA constitutes the majority of the patents in almost all areas. We see that patenting in Norway remains quite constant in time for all areas. USA, Canada and China tend to have a high growth in patenting in all technical areas from 1999 to 2014.

USA, Japan and China are pioneers in membrane technology. We note that China has had an exponential growth in the area of pumping & compression. While the other countries has a relative stable number of granted patents.

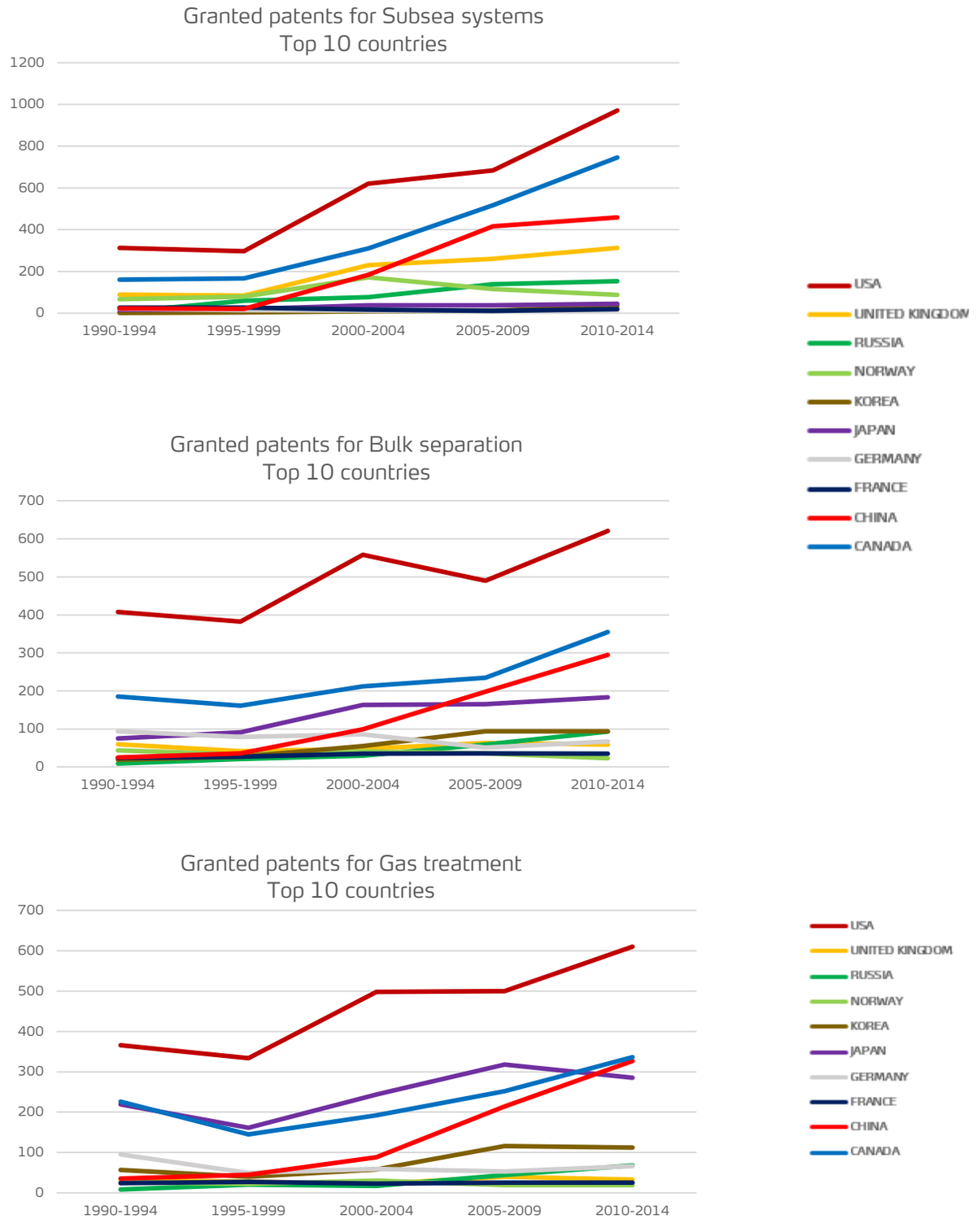
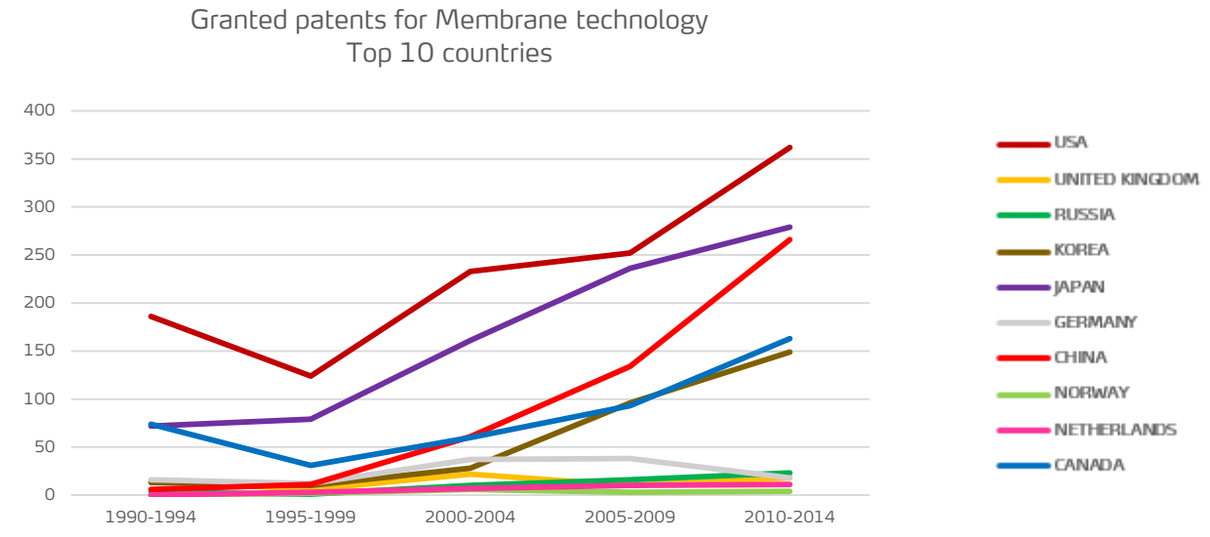
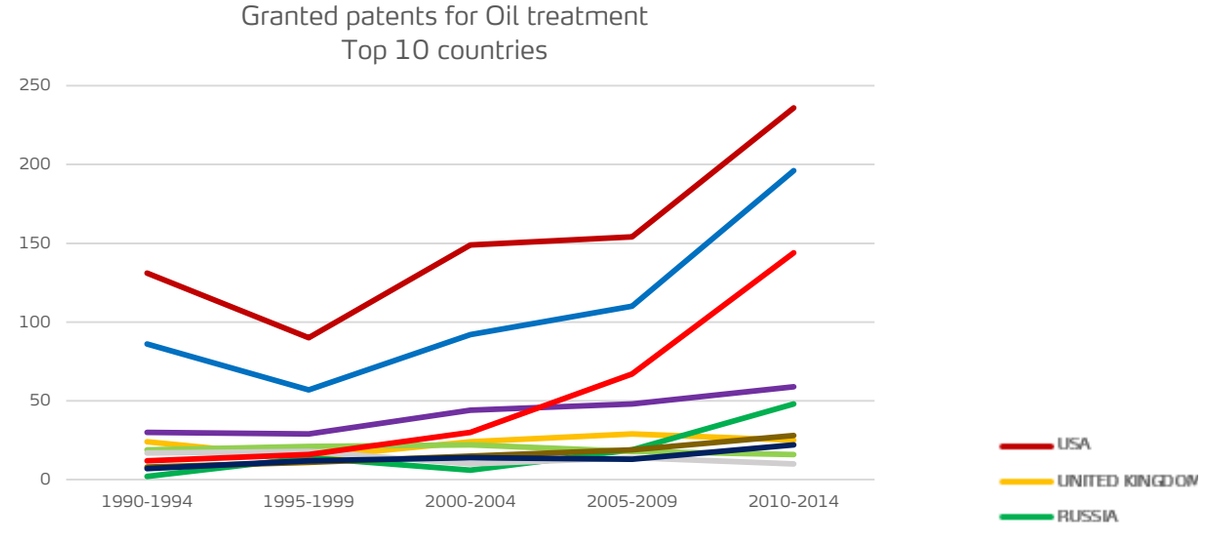


Figure 8: Historical patenting development for the top 10 patent providing countries (the figure continues on the following two pages).





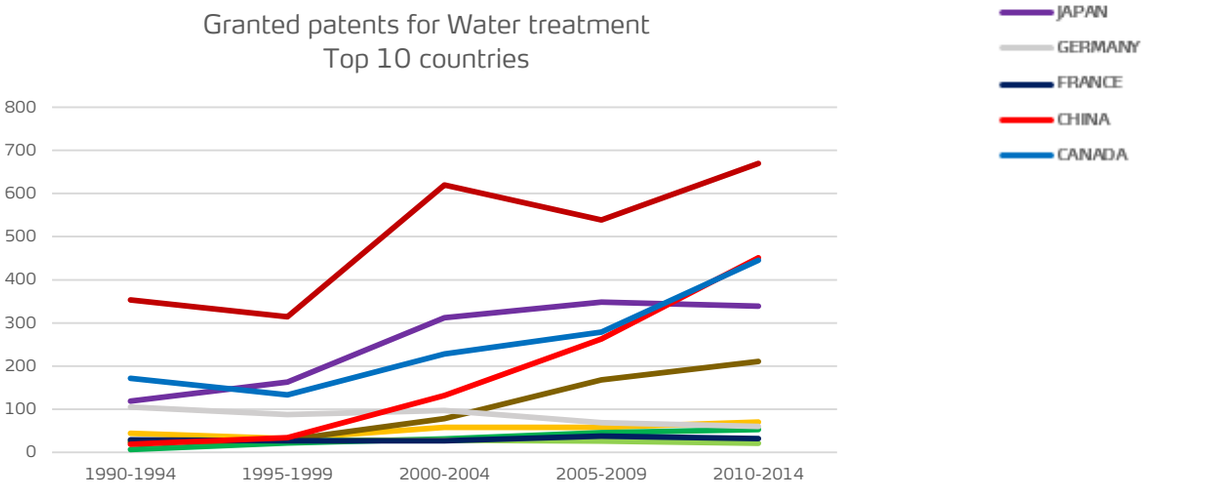


Figure 8: (the figure continues from the previous page) Historical patenting development for the top 10 patent providing countries (the figure continues on the following page).

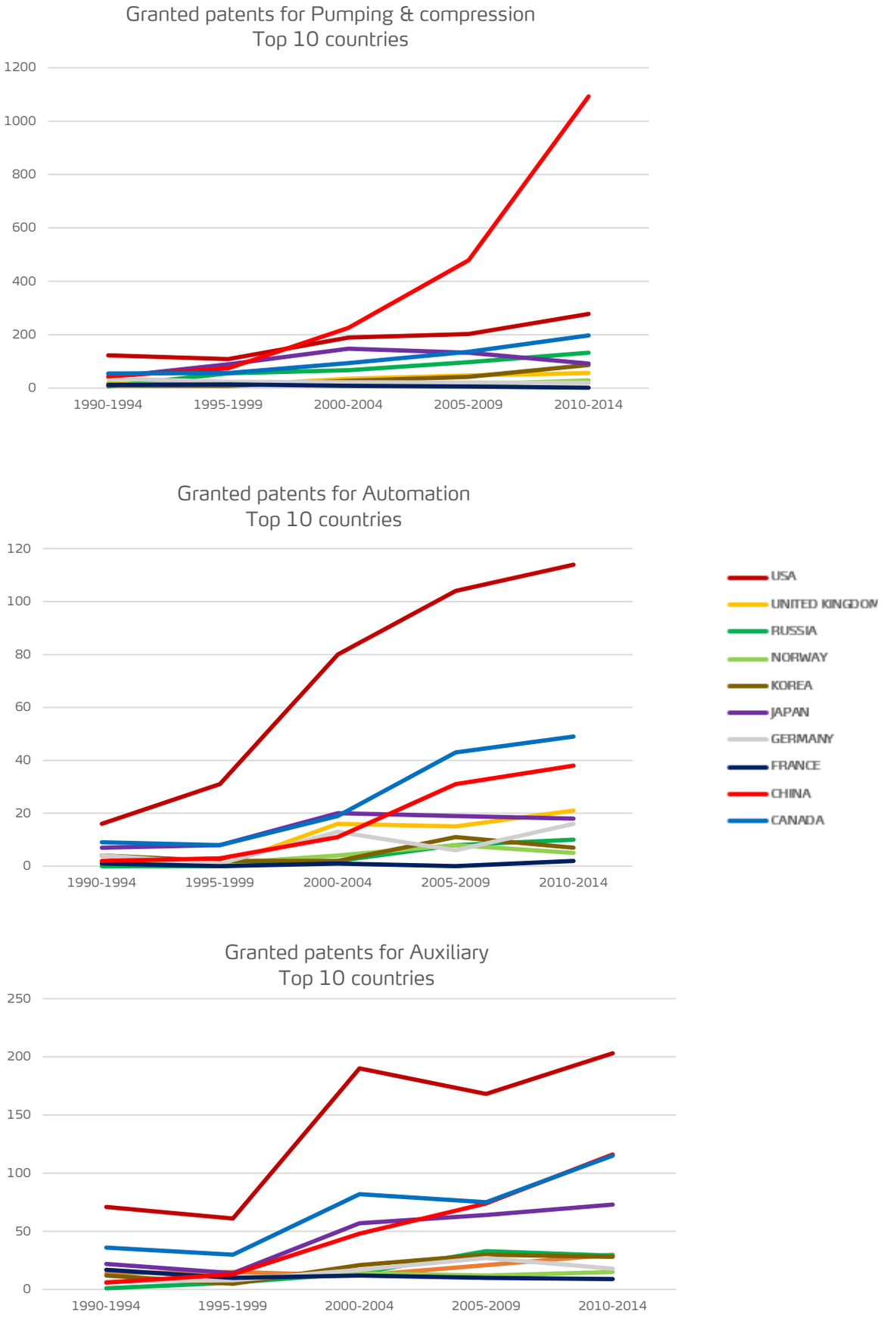


Figure 8: (the figure continues from the previous two pages) Historical patenting development for the top 10 patent providing countries.

Technology focus

Figure 9 shows the percentage of granted applications for the top countries in each sub data set, in contrary to Figure 1c (see page 14-15), 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 pumping & compression where China dominates. .

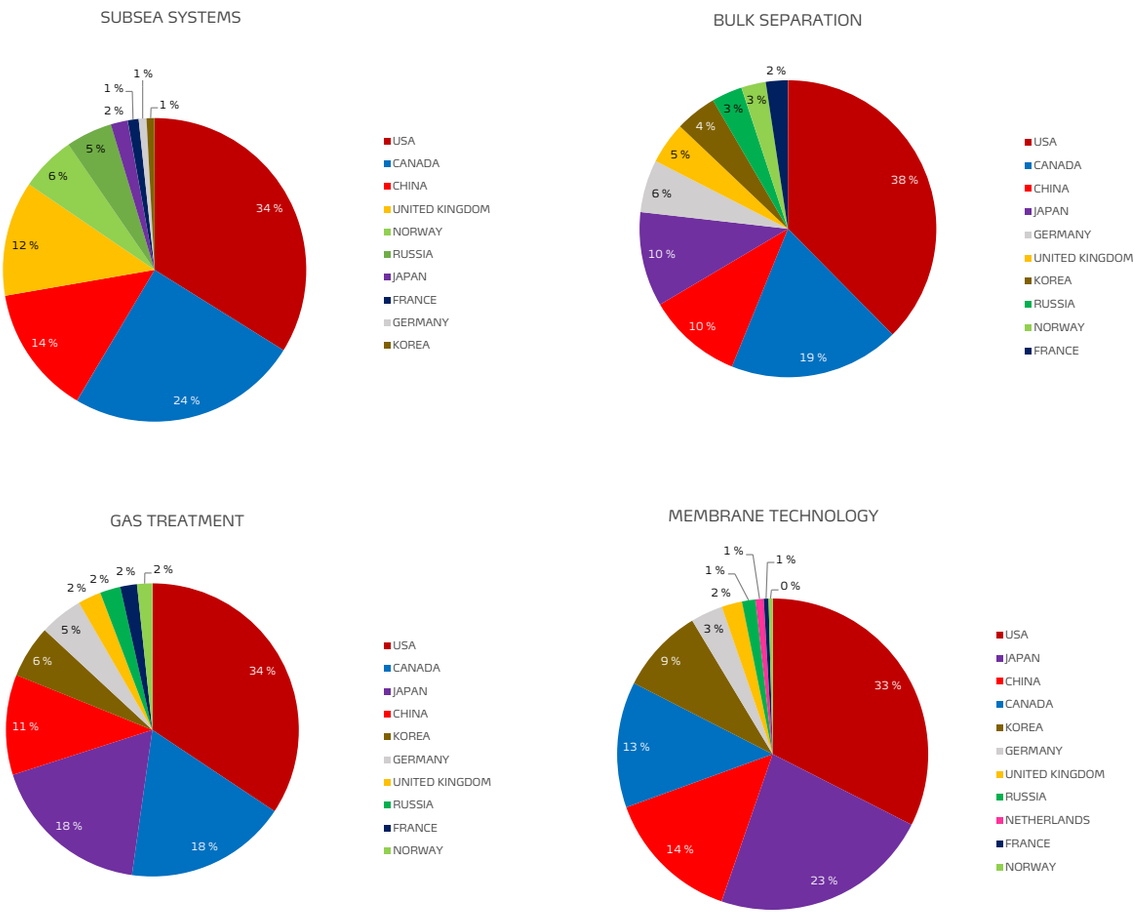


Figure 9: Percentage of granted applications for top 10 countries in each sub data set (the figure continues on the following page.

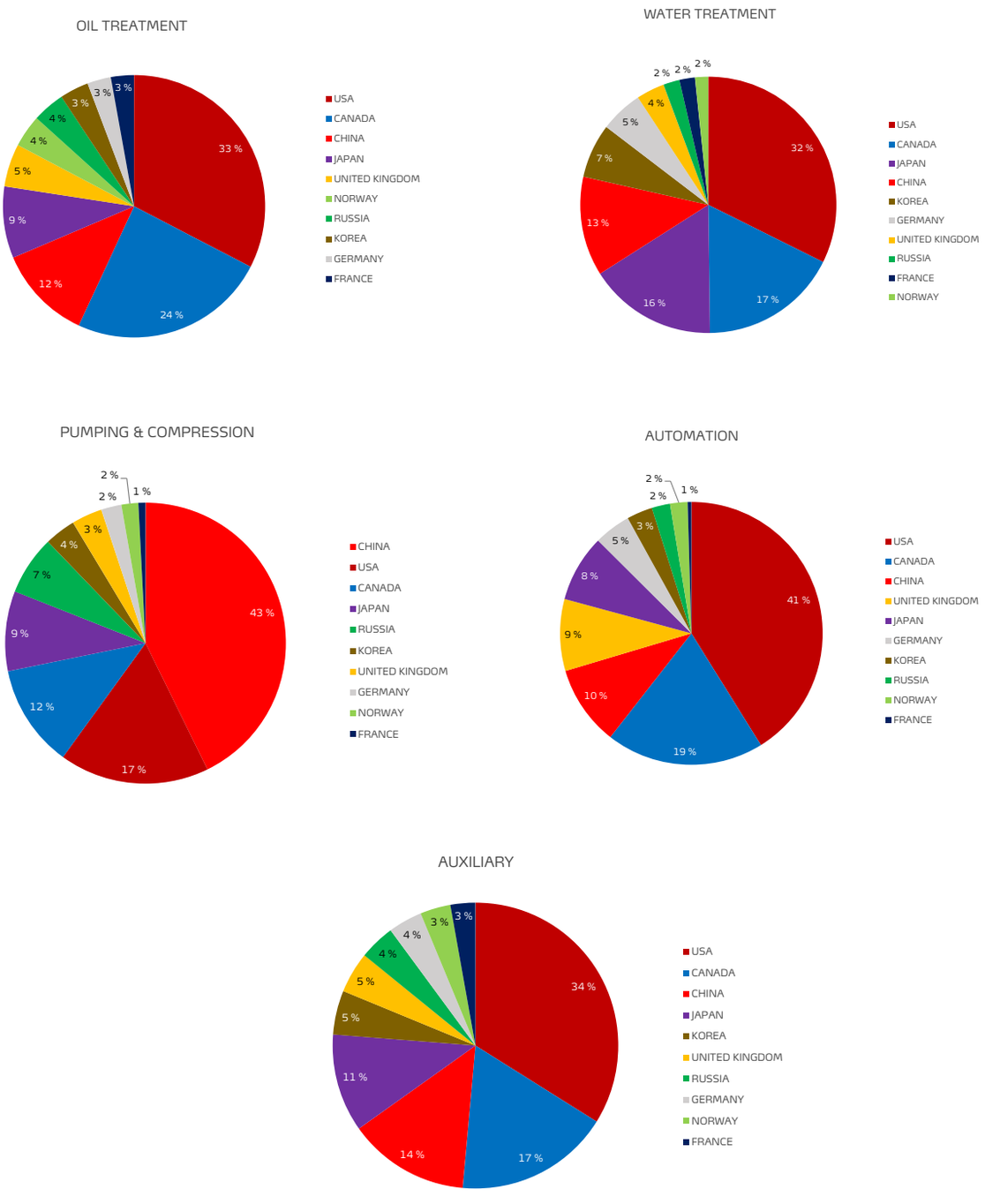


Figure 9: (the figure continues from the previous page) Percentage of granted applications for top 10 countries in each sub data set.

Assignee analysis

In this chapter we focus on the patent applicant or assignee, in order to uncover which assignees are 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.

The assignees in each sub set data with number of filings (nº) is shown in Appendix A.

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 the technical area Subsea systems.

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

Note that the collaborated patents in this study is counted in patent publications and not patent families. This is to ensure that all collaborations are taken into account[1].

The collaboration networks for the other technical areas are enclosed in Appendix B.

1 For this collaboration study we have used patent publications instead of patent families. This is because collaboration maps with the use of patent families will not enlighten the entire collaboration network as patent applications may differ with respect to the representative assignee. E.g. a company might file a patent application in country A and B under the assignee name A1 and A2 and in country C with the assignee names A1, A2 and A3. In this case the representative publication for the patent family might not include assignee A3.

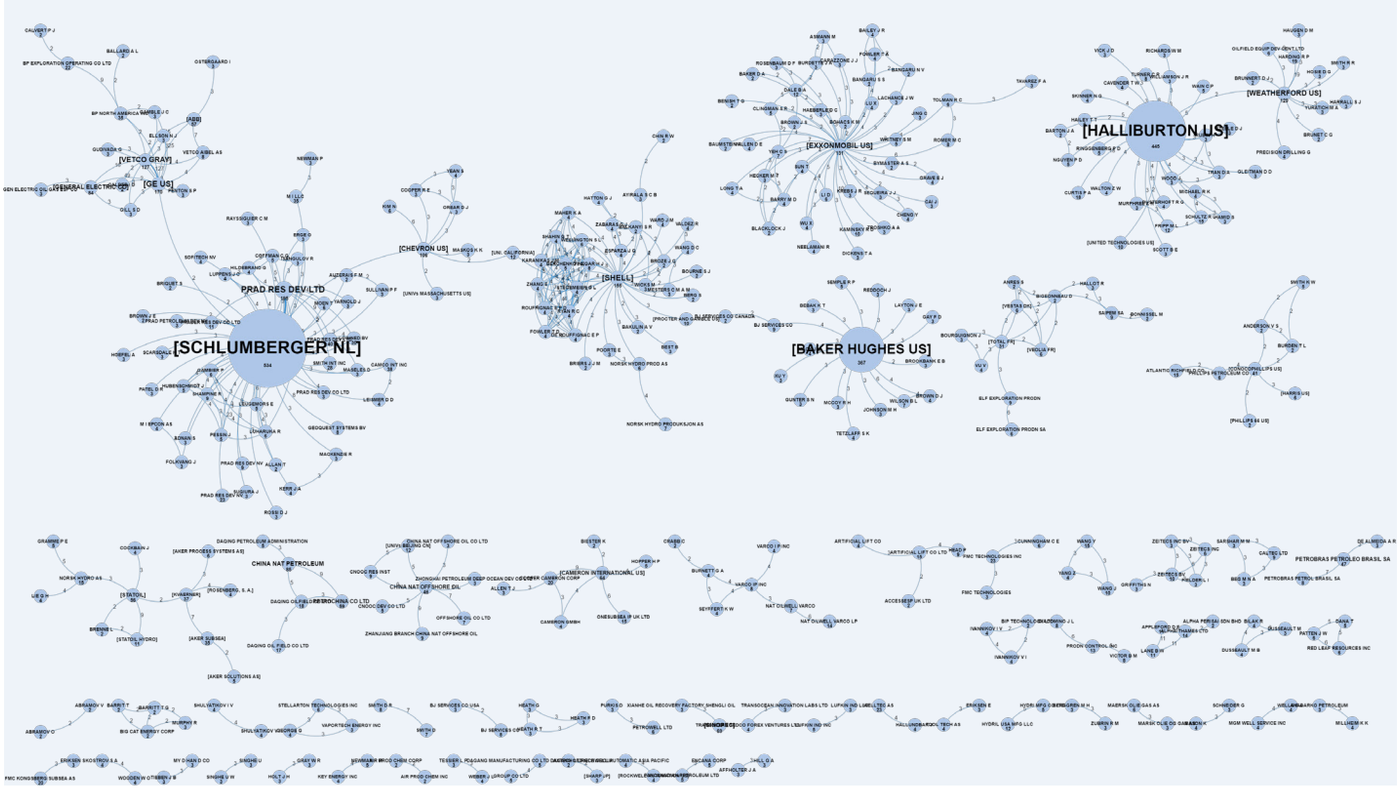


Figure 10: Collaboration network for Subsea systems.

There a many collaboration networks between assignees in this patent data set. The two largest collaboration networks in the technical area Subsea systems are depicted in Figure 11, and illustrates how complicated such a network can be.

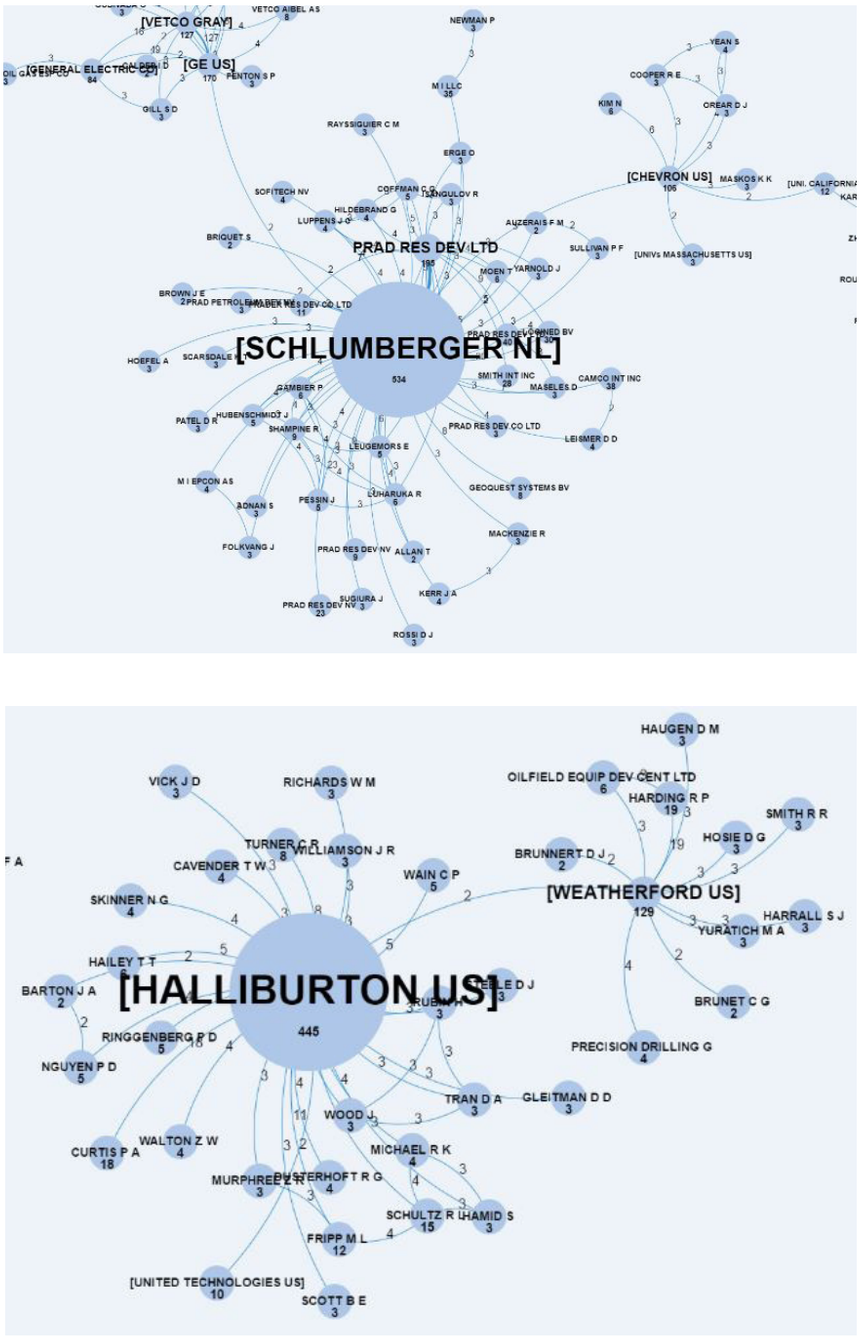


Figure 11: The two largest collaboration networks in Subsea systems

As illustrated in Appendix A wee see that the patent assignees from Norway are Statoil, FMC, Kværner, Aker Subsea and Norsk Hydro, in which Figure 12 shows their networks for the technical area of Subsea systems.

We have observed that some names could be the name of the inventor or patent attorney, as for example Cockbain who is a patent attorney.

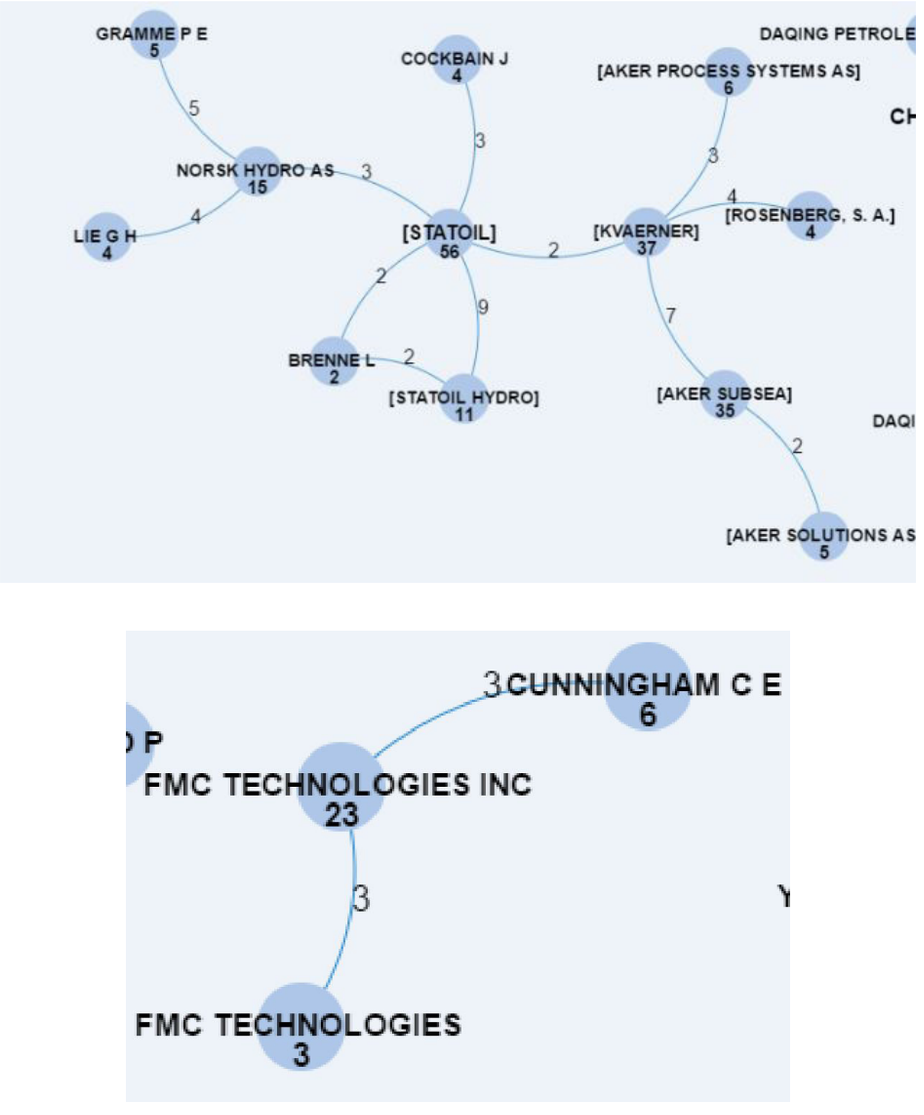


Figure 12: Norwegian collaboration networks in the area of Subsea systems.

Historical trend

Another interesting thing is to know the productivity trend over time for the different companies. Figure 13 shows, in the case of subsea systems, the historical development within patenting for the top 10 assignees within this area in the period from 1990 to 2014.

We note that Schlumberger have an exponential growth in number of filings from year 2000.

The historical trends for the other technical areas are enclosed in Appendix C.

The Norwegian assignees trend in this area are illustrated in Figure 14.

For the Norwegian assignees in the other areas where Norway are presented is enclosed in Appendix D.

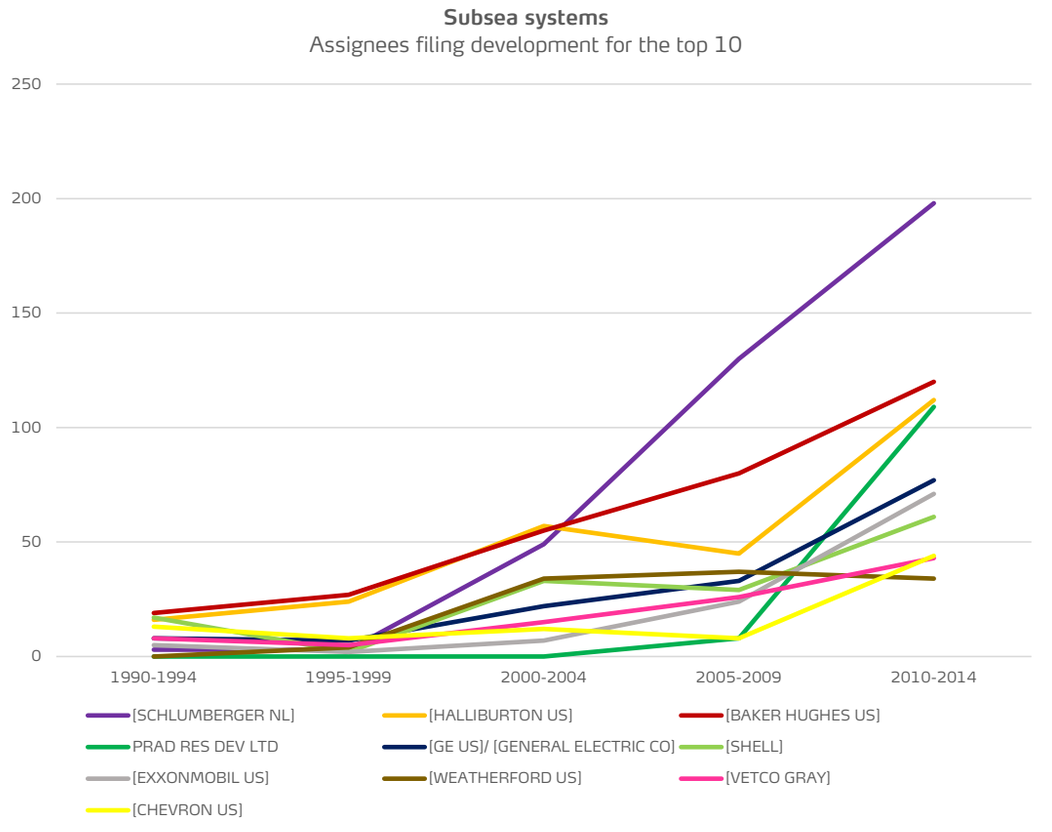


Figure 13: Historical development in filings (subsea systems) for the top 10 assignees.

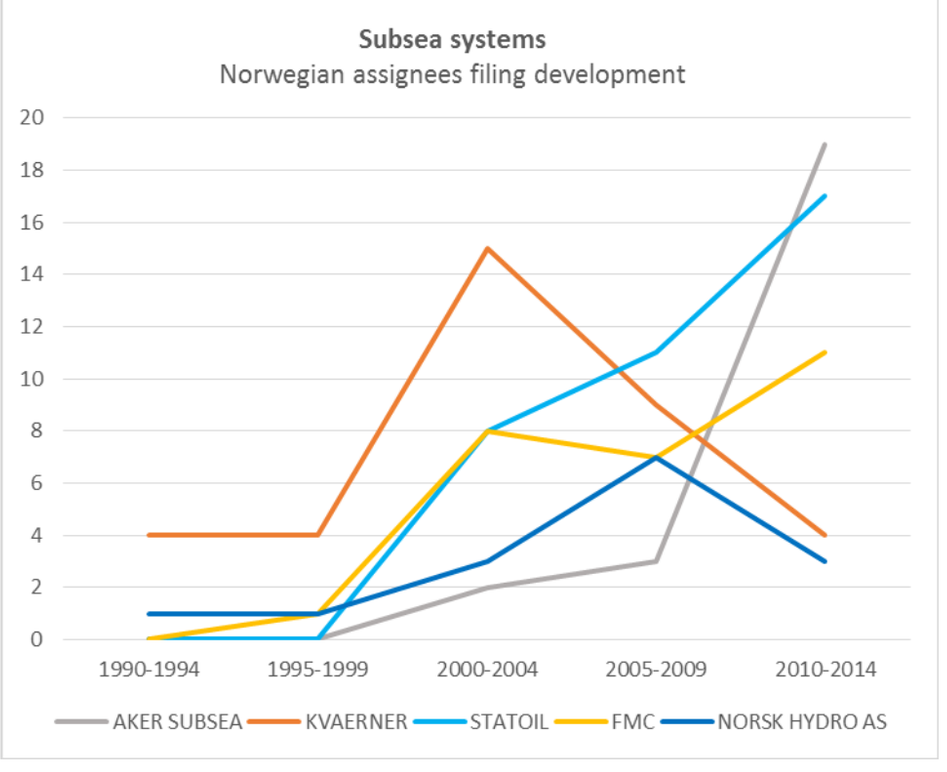


Figure 14: Historical development in filings (subsea systems) for the Norwegian assignees.

Observations

The following observations are found throughout the report, and restated here for easy reference. This landscape analysis is based on 37.240 patent applications (origin) which has resulted in 49.800 granted patents. A patent data set 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 subsea production and processing technology in Norway, should follow competitors from USA, United Kingdom, France and Germany most closely. Most foreign patents in Norway, that may hinder operations in the home market, come from these countries. There is also reason to believe that players from United Kingdom, France and Germany additionally file patents through the EPO to secure their IPR in Norway.

USA is unquestionably the world's most important country for IPR within the analyzed data set, with 1/3 of the priority patent filings worldwide, and having as much as 75 % more priority patent filings than the second largest country, Japan. Norway is number 8 on this list, if we ignore the international and regional systems handled by WIPO and EPO.

With one exception, USA is the world leader within all technologies analyzed in the present report. Within the area of pumping and compression, China is the front nation with 2,5 times as many granted patents within this technology as the second nation on the list, USA. The European countries have only a minor share in this part of the industry.

Norwegian companies and R&D-institutions patent most in the field of subsea systems. With 6 % of the granted patents, we have the fifth largest patent force in this technological area worldwide. after USA, Canada, China and UK. However, while USA, Canada, China, UK and Russia all show an increase in their granted patents, figure 8 shows a decreasing trend for Norway from 2004 within this field.

China shows an impressing increase in number of patent applications and granted patents. This is in full compliance with the overall increase in number of patent applications in China the last years. In 2015 the Chinese Patent Office received close to 1 million patent applications, 32 times as many as received in the beginning of the century[1].

There is an ever-increasing focus on offshore oil production in Russia, and enormous expectations to the production numbers. Therefore, it could be worthwhile for Norwegian actors in this market to pay attention to the Russian technology development and consider whether they should protect their own technology in this market.

Saudi Arabia, the world's second largest oil producer, does not seem to have any tradition for protection of intellectual properties, as only a microscopic part of the patent applications within the present data set is transferred to the national patent office of Saudia Arabia or the regional office GCC. However, as the three largest offshore oil fields in the world are located in the Persian Gulf[2], it is important to note that statistics from WIPO shows a gradual increase in both number of patent filings and grants in Saudi Arabia over the last ten years[3]. Even though Norwegian companies do not have any tradition to file their applications to the Gulf region, they should be aware of the increasingly interest of IPR in this region.

1 http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=CN
2 https://www.forbes.com/sites/williampentland/2013/09/07/worlds-five-largest-offshore-oil-fields/#7e21fb183194
3 http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=SA

Glossary of Intellectual Property related terms

This IPR terminology contains basic expressions used that are frequently used within IPR analysis, mainly those IPRs concerning patents.

IPR: Intellectual Property Rights, exclusive rights protecting inventions, names, logos, design and other innovations.

Invention: A new device, composition or process. To be patentable, the invention has to be a practical solution of a problem, where the solution has a technical characteristic, a technical effect and is reproducible.

Patent: Protection of a concrete solution of a technical problem, an invention.

Patent application: A request pending at a patent office for grant of a patent for the invention described and claimed in the application.

Priority: If several assignees file a patent application for the same invention, the assignee who was the first to file will achieve the patent right. The assignee, who filed an application in a country, can claim priority in other countries of interest. This right is valid in 12 months from the day of filing in the first country - the priority day. The priority implies that the assignee has a precedence to others who have filed a patent application on the same invention after the priority date.

Patent publication: A broad term, comprising both granted patent applications and pending patent applications. All patent applications are published, and therefore made public, within 18 moths after filing date, unless the patent application is withdrawn by the applicant.

Patent family: A collection of applications and patents concerning the same invention worldwide. This means that at patent family includes all documents (patent applications and patents) with exactly the same priority, including the initial priority application and all the subsequent applications worldwide.

Prior art: All information that has been made available to the public in any form before the priority date. Anything can be prior art.

EPO: The European Patent Office receives, examines and makes decisions of European patent applications according to the rules in the European Patent Convention (EPC).

Patent office: A governmental or intergovernmental organization controlling the issue of patents.

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.

Patent extension: Filing of patent application to further countries, either directly to each national government or through international or regional organizations that simplifies the application process, e.g. through PCT or EPO.

Patent classification: There are two main classification systems for patents, IPC (International Patent Classifications) and CPC (Cooperative Patent Classification). The CPC system is the newest and contains both the IPC-classes as well as more detailed classes (see worldwide.espacenet.com/classification).

Utility model: An intellectual property right to protect inventions available in a number of countries. It is very similar to a patent, but usually has a shorter term of protection (6 to 15 years) and less stringent patentability requirements.

PCT: Patent Cooperation Treaty is a worldwide convention of patent cooperation that simplifies the process to apply for patents in other countries.

WIPO: World Intellectual Property Organization is one of UN's special organizations with 188 member states. The main aim is to encourage the global development of IPR.

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.

Appendix A

The assignees for the different technical areas

Subsea systems	n°	Bulk separation	n°	Gas treatment	n°	Membrane technology	n°
[Schlumberger NL]	534	[Exxonmobil US]	80	[Mitsubishi]	159	Toray Ind inc	138
[Halliburton US]	445	[Shell]	70	[Toyota]	145	[Mitsubishi]	117
[Baker Hughes US]	367	[IFP Energies Nouvelles FR]	57	[Hitachi]	136	[Kubota JP]	115
Prad Res Dev Ltd /Nv	258	[Chevron US]	53	[Honeywell US]	74	[Hitachi]	111
[GE US]/[General Electric Co]	254	[Mitsubishi]	52	[Exxonmobil US]	72	Kurita Water Ind Ltd	79
[Shell]	155	[Honeywell US]	48	[Shell]	71	[Asahi Kasei Kogyo Kk Dwac Asah Dwac C]	74
[Exxonmobil US]	131	[General Electric Co]	34	[GE US]/[General Motors US]	68	[Siemens]	61
[Weatherford US]	129	[BASF]	33	[IFP Energies Nouvelles Fr]	64	[Sumitomo Group]	58
[Vetco Gray]	127	[Hitachi]	30	[BASF]	60	[NGK Insulators JP]	47
[Chevron US]	106	[Total FR]	28	[Sumitomo Group]	58	[Nitto Denko JP]	44
China Nat Petroleum	85	[Statoil]	27	[NGK Insulators JP]	53	[Panasonic JP]	44
Petrochina Co Ltd/Petrochina Company Ltd	74	[Baker Hughes US]	23	[Panasonic JP]	52	[Ebara JP]	43
[Sinopec]	69	[Schlumberger NL]	22	[Shokubai JP]	44	Organo Corp	40
[Cameron International US]	64	[Cameron International US]	19	[Chevron US]	42	[GE US]	38
[ABB]	57	[Toshiba JP]	19	[Evonik DE]	39	[Honeywell US]	37
BP Exploration Operating Co Ltd / BP North America Inc	57	[ABB]	18	Cataler Ind Co Ltd	39	Pall Corp	36
[Statoil]	56	[Evonik DE]	18	Air Prod Chem Inc	35	Filter Wastewater Group Inc	28
[IFP Energies Nouvelles FR]	51	[Kvaerner]	18	[Air Liquide FR]	33	[Univs Singapore SG]	27
Petrobras Petroleo Brasil SA	47	[Panasonic JP]	18	[Johnson Matthey GB]	30	Daicel Chem Ind Ltd	26

(the table continues on the following pages)

Subsea systems	n°	Bulk separation	n°	Gas treatment	n°	Membrane technology	n°
China Nat Offshore Oil	46	[Siemens]	17	[Dow US]	29	Shinko Pantec Co Ltd	26
FMC Kongsberg Subsea AS / FMC Technologies Inc	43	Degremont	17	[Praxair US]	29	[Dow US]	24
[Conocophillips US]	41	[Johnson Matthey GB]	16	Mazda KK	28	[Fuji Film Co]	22
Camco Int Inc	38	Otv SA	16	[Renault Nissan FR]	27	Daisen Membrane Systems KK	22
[Kvaerner]	37	[Ecolab US]	15	[Corning US]	26	Metawater KK	22
[Aker Subsea]	35	[Sumitomo Group]	15	[Honda JP]	26	Zenon Inc	22
Daqing Oil Field Co Ltd	35	[Uni. California]	15	[Mitsui JP]	26	[Toshiba JP]	21
M I LLC	35	Kurita Water Ind Ltd	15	Nippondenso Co Ltd	26	Millipore Corp	21
Landmark Graphics	34	Passavant Werke AG	15	[Babcock Power Inc Dwac Babw Dwac C]	25	Evoqua Water Technologies Llc	20
[Saudi Aramco SA]	31	Thermaco Inc	14	[Siemens]	24	Kolon Ind Inc	20
[Total FR]	31	[Dow US]	13	Cataler Corp	24	[Chevron US]	19
Logined BV	30	Air Prod Chem Inc	13	[Nssmc JP]	23	[Exxonmobil US]	19
[Siemens]	29	Methanol Casale SA	13	[Statoil ASA]	22	[Shell]	19
Smith Int Inc	28	Organo Corp	13	[Alstom FR]	21	[Univs Massachusetts US]	19
Univ China Petroleum	27	[Conocophillips US]	12	Osaka Gas Co Ltd	21	Nkk Corp	19
Welltec AS	23	[Halliburton US]	12	[Suzuki JP]	20	[Kobe Steel JP]	18
Cooper Cameron Corp	20	[Procter And Gamble US]	12	[Toshiba JP]	20	[Samsung KR]	18
Harding R P	19	[Univs Massachusetts US]	12	Membrane Inc	19	[Sekisui JP]	18
Curtis P A	18	Petrobras Petroleo Brasil SA	12	[Uni. California]	18	Asahi Chem Corp	18
Artificial Lift Co Ltd	15	[Ebara JP]	11	[United Technologies US]	18	[BASF]	17
Atlantic Richfield Co	15	[Veolia FR]	11	[Univs Texas US]	18	[Univs Colorado US]	17
Norsk Hydro AS	15	Aibel AS	11	[Denso JP]	17	[Veolia FR]	17
Onesubsea Ip UK Ltd	15	Conoco Specialty Prod Inc	11	[Conocophillips US]	16	[Mitsui JP]	16
Schultz R L	15	Eni Spa	11	[Ebara JP]	16	Otv SA	16
		Kruyer J	11	Agency Ind	16	Liu C	15
		M I LLC	11	Chiyoda Corp	16	Oasys Water Inc	15
		[Babcock Power Inc Dwac Babw Dwac C]	10	Ube Ind Ltd	16	[3M US]	14
		[Battelle Memorial Institute CH]	10	[Riken JP]	15	[Dupont US]	14
		[Jx Holdings JP]	10	[Univs New York US]	15	Ube Ind Ltd	14
		[Kellogg Brown Root Inc]	10	Ishikawajima Harima Heavy Ind	15	[Ecolab US]	13
		[Mann Hummel DE]	10			[Sharp JP]	13

(the table continues from the previous page)

Oil treatment	N°	Water treatment	N°	Pumping & Compression	N°	Automation	N°	Auxiliary	N°
[Exxonmobil US]	88	[Hitachi]	193	[Baker Hughes US]	159	[Schlumberger NL]	42	[IFP Energies Nouvelles FR]	34
[Shell]	60	[Mitsubishi]	170	[Ebara JP]	124	[Halliburton US]	33	[Mitsubishi]	29
[Chevron US]	56	[Kubota JP]	141	[Schlumberger NL]	113	[GE US]	25	[GE US]/[General Motors US]	25
[IFP Energies Nouvelles FR]	52	Toray Ind Inc	125	Tsurumi Seisakusho KK	112	Prad Res Dev Ltd	20	[Exxonmobil US]	24
[Honeywell US]	38	Kurita Water Ind Ltd	121	Shin Meiwa Ind Co Ltd	85	Landmark Graphics	12	[Shell]	22
[Statoil ASA]	29	[Panasonic JP]	91	China Nat Petroleum	83	[Siemens]	11	[Hitachi]	16
Conoco Specialty Prod Inc	18	[Ebara JP]	70	[Hitachi]	81	[Hitachi]	10	[Schlumberger NL]	15
[GE US]/[General Electric Co]	17	[Sumitomo Group]	68	[Kubota JP]	81	[ABB]	9	Methanol Casale SA	12
[Saudi Aramco SA]	13	Han S K	68	[Sinopec]	81	[Baker Hughes US]	9	[Honeywell US]	10
[Total FR]	13	[Siemens]	61	Petrochina Company Ltd	63	[Fisher Rosemount US]	9	[Sumitomo Group]	10
[Baker Hughes US]	12	[Asahi Kasei Kogyo Kk Dwac Asah Dwac C]	57	Daqing Oil Field Co Ltd	50	[Caterpillar US]	8	Carrier Corp	10
[Jx Holdings JP]	12	Otv Omnium Traitements Valorisation SA / Otv SA	55	Prad Res Dev Ltd	40	[Exxonmobil US]	8	[Statoil ASA]	9
[Mitsubishi]	11	[Toshiba JP]	53	[GE US]	37	[Mitsubishi]	8	Shin Meiwa Ind Co Ltd	9
Kruyer J	11	[GE US]	51	[Weatherford US]	37	[Weatherford US]	7	[Babcock Power Inc Dwac Babw Dwac C]	8
[BASF]	10	Organo Corp	51	Shandong Shouguang Kunglong Petroleum Ma/Shandong Xingyuan Mining Equip Group Co	35	[IBM US]	6	[Chevron US]	8
[Cameron International US]	9	[Ecolab US]	40	Wang Y /Wang Z	32	[Vestas DK]	6	[Panasonic JP]	8
[Kvaerner]	9	[Veolia FR]	35	Dalian Deep Blue Pump Co Ltd/Dalian Sifang Electric Pump Co Ltd	31	[Alstom FR]	5	[Daikin CN]	7
[Sinopec]	9	[Sharp JP]	31	[Mitsubishi]	30	[Rockwell Automation US]	5	[Halliburton US]	7
Aibel AS	8	[Nitto Denko JP]	30	Kawamoto Seisakusho KK	30	[Sony JP]	5	[Vetco Gray]	7
Eni Spa	8	Shinko Pantec Co Ltd	30	[Aker Subsea AS]	26	Coffman C G	5	Behr Gmbh Co	7
[ABB]	7	[Exxonmobil US]	29	Hefei Evergrande Jianghai Pump Ind Co	26	Geoquest Systems BV	5	[Boc Group Inc]	6
[Conocophillips US]	7	[NSSMC JP]	28	Ishigaki Kiko KK	26	[Honeywell US]	4	[Evonik DE]	6
[Hitachi]	7	[Shell]	27	[Siemens]	25	[Seagate Technology US]	4	[Hyundai KR]	6
[Schlumberger NL]	7	[Ngk Insulators JP]	26	Tatneft Stock Co	24	[Univs Heilongjiang CN]	4	[Praxair US]	6
Amoco Corp	7	Nkk Corp	26	Taizhou Taifeng Pump Ind Co Ltd	23	[Vetco Gray]	4	[Sharp JP]	6

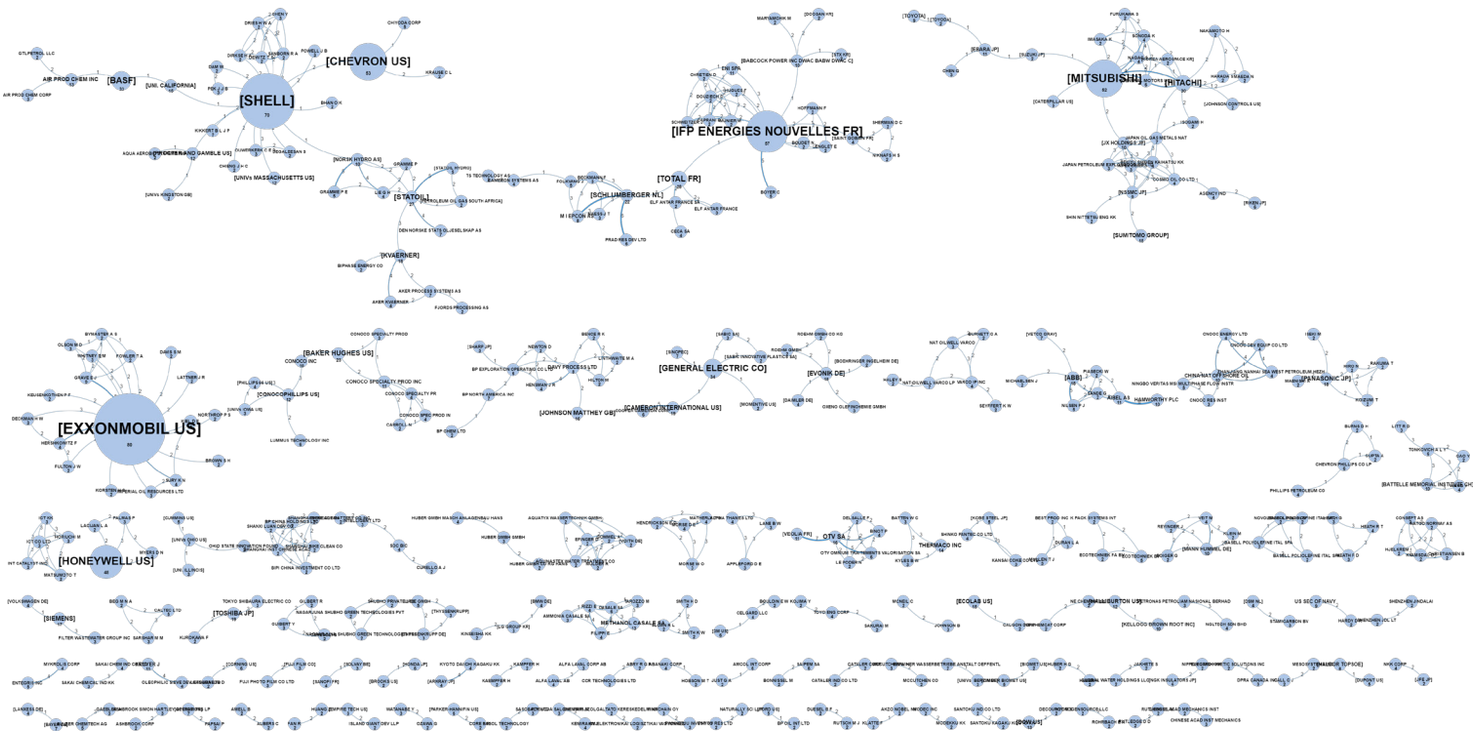
(the table continues from the previous pages)

Oil treatment	N°	Water treatment	N°	Pumping & Compression	N°	Automation	N°	Auxiliary	N°
Hamworthy PLC	7	[Chevron US]	25	Ningbo Jushen Pumps Ind Co Ltd	22	Hildebrand G	4	[Siemens]	6
Patten J W	7	[Sekisui JP]	24	[Halliburton US]	21	Luppens J C	4	[Total FR]	6
Petrobras Petroleo Brasil SA	7	Degremont	24	[Uni. Jiangsu CN]	21	Rosemount Inc	4	China Nat Offshore Oil	6
Red Leaf Resources Inc	7	Zenon Inc	24	Nishijima Seisakusho KK	21	[Boeing US]	3	Kerfoot W B	6
[Haldor Topsoe]	6	Metawater KK	23	[Vetco Gray]	19	[Brooks US]	3	Prad Res Dev Ltd	6
[Johnson Matthey GB]	6	[Samsung KR]	22	Ge Oil Gas Esp Inc	19	[Cameron International US]	3	[Baker Hughes US]	5
[Kellogg Brown Root Inc]	6	Daisen Membrane Systems KK	22	[Ifp Energies Nouvelles FR]	18	[Chevron US]	3	[Caterpillar US]	5
[Mann Hummel DE]	6	Daicel Chem Ind Ltd	21	Petroleum Administration	17	[Eaton IE]	3	[Eaton IE]	5
[Procter And Gamble US]	6	Evoqua Water Technologies Llc	21	Camco Int Inc	16	[General Motors US]	3	[Kobe Steel JP]	5
Aker Process Systems AS	6	[Baker Hughes US]	20	Csic Zhongnan Equip Co Ltd	16	[Honda JP]	3	[Technip]	5
China Nat Offshore Oil	6	[Kobe Steel JP]	20	Jiangsu Guoquan Pump Co Ltd	16	[Lockheed Martin US]	3	Bp North America Inc	5
Dana T	6	[Total FR]	20	KSB AG	16	[Panasonic JP]	3	Cullinane J T	5
Japan Oil Gas Metals Nat	6	[Mitsui JP]	19	Chengdu Andisheng Measurement Co Ltd	14	[Raytheon US]	3	FMC Kongsberg Subsea AS	5
Stone Webster Process Inc	6	[Uni. California]	19	Ma B	14	[Toshiba JP]	3	Logined BV	5
[Babcock Power Inc Dwac Babw Dwac C]	5	[Fuji Electric JP]	18	Dresser Rand Co	13	Bonissone P P	3	Nagao S	5
[Dow US]	5	[Cameron International US]	17	Zhang J	13	Brain Corp	3	Norsk Hydro AS	5
[Ecolab US]	5	[Dow US]	17	Zhejiang Fengqiu Pump Ind Co Ltd	13	Entegris Inc	3	Sonoda K	5
[Phillips 66 US]	5	[Schlumberger NL]	17	[Panasonic JP]	12	Erge O	3	Tsurumi Seisakusho KK	5
[Univs Massachusetts US]	5	[BASF]	16	Grundfos AS	12	Isangulov R	3	[Air Liquide FR]	4
Boyer C	5	[Procter And Gamble US]	16			Subbu R V	3	[Aker Subsea AS]	4
Carroll N	5	Cote P L	16			[Asml NL]	2	[BASF]	4
Consept AS	5	Filter Wastewater Group Inc	16			[Bosch DE]	2	[Johnson Controls US]	4
		Meidensha Corp	16			[Deere US]	2	[JX Holdings JP]	4
		[Univs Singapore SG]	15			[Ford US]	2	[NSSMC JP]	4
						[Immersion US]	2		

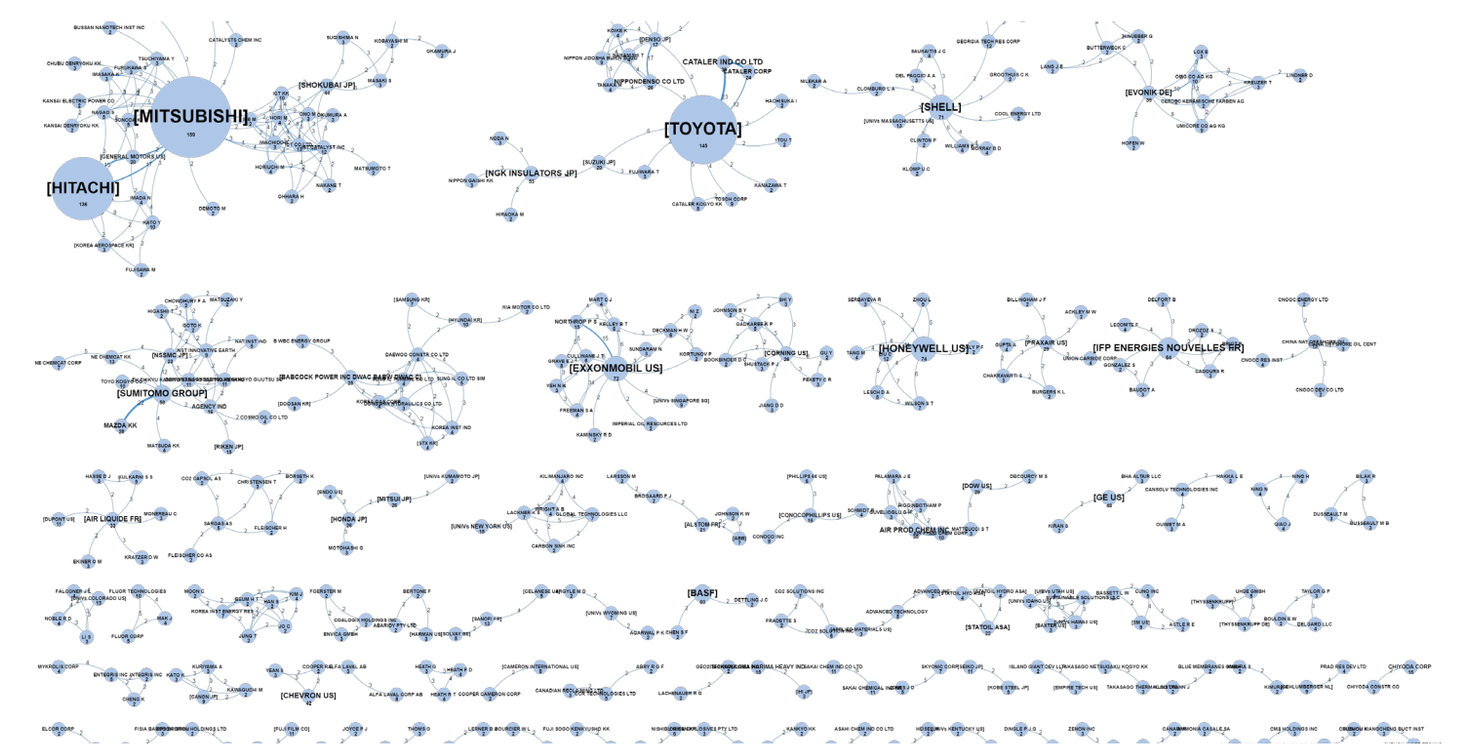
(the table continues from the previous pages)

Appendix B

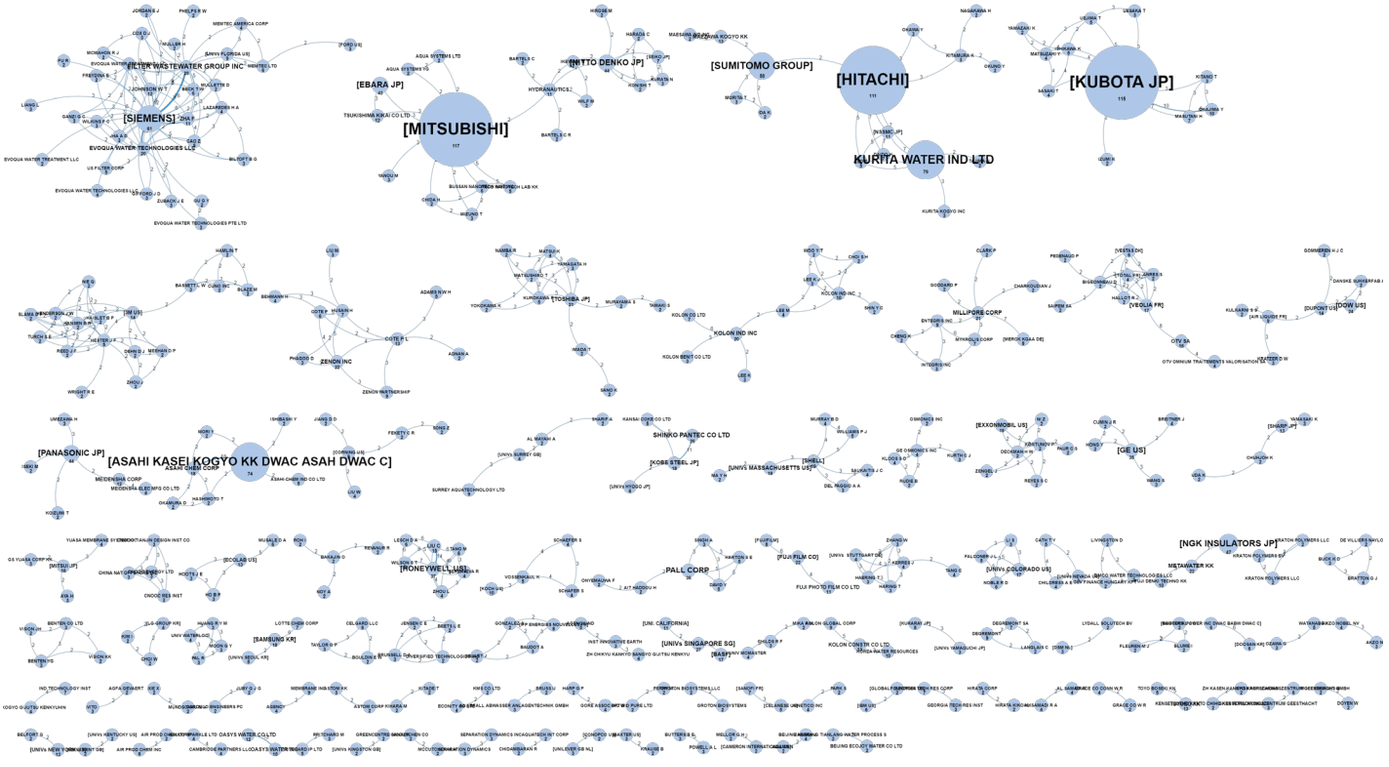
Collaboration networks



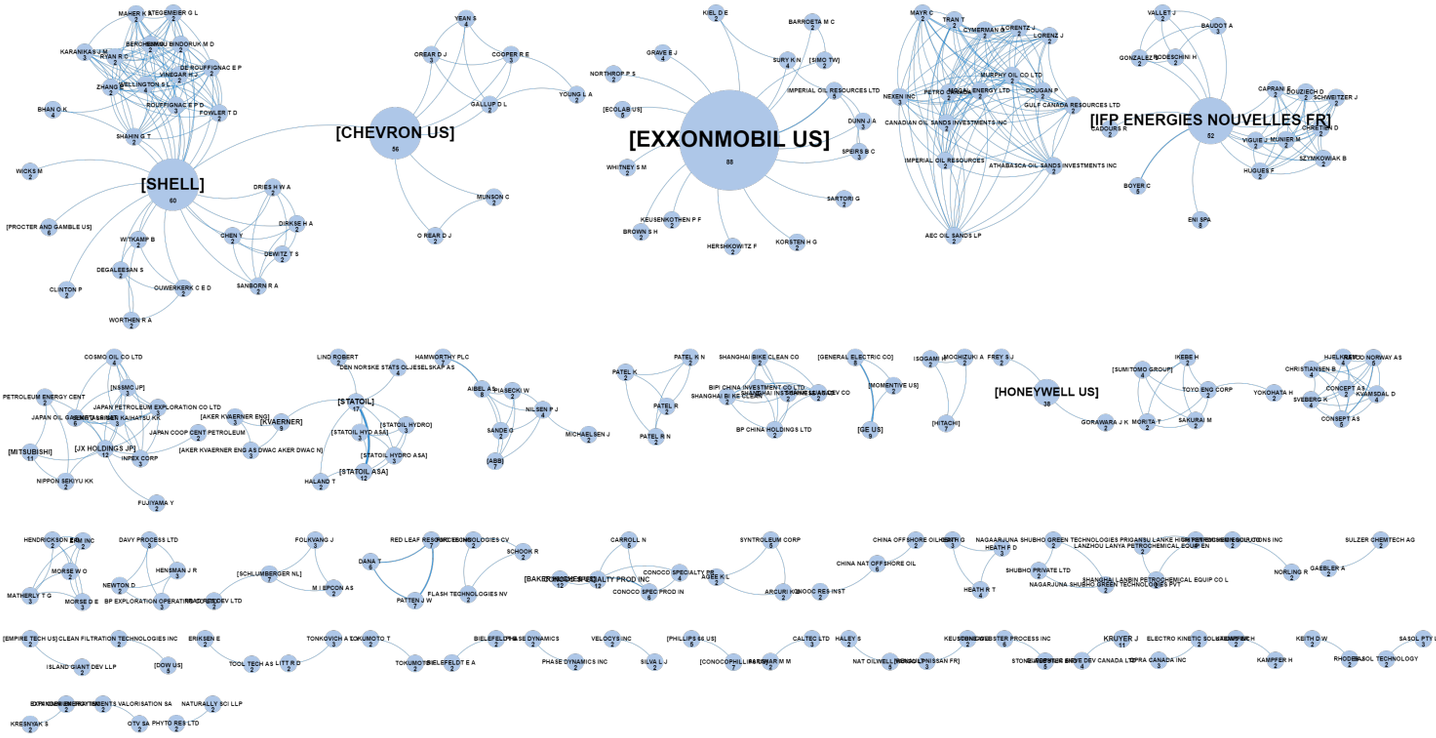
Bulk separation



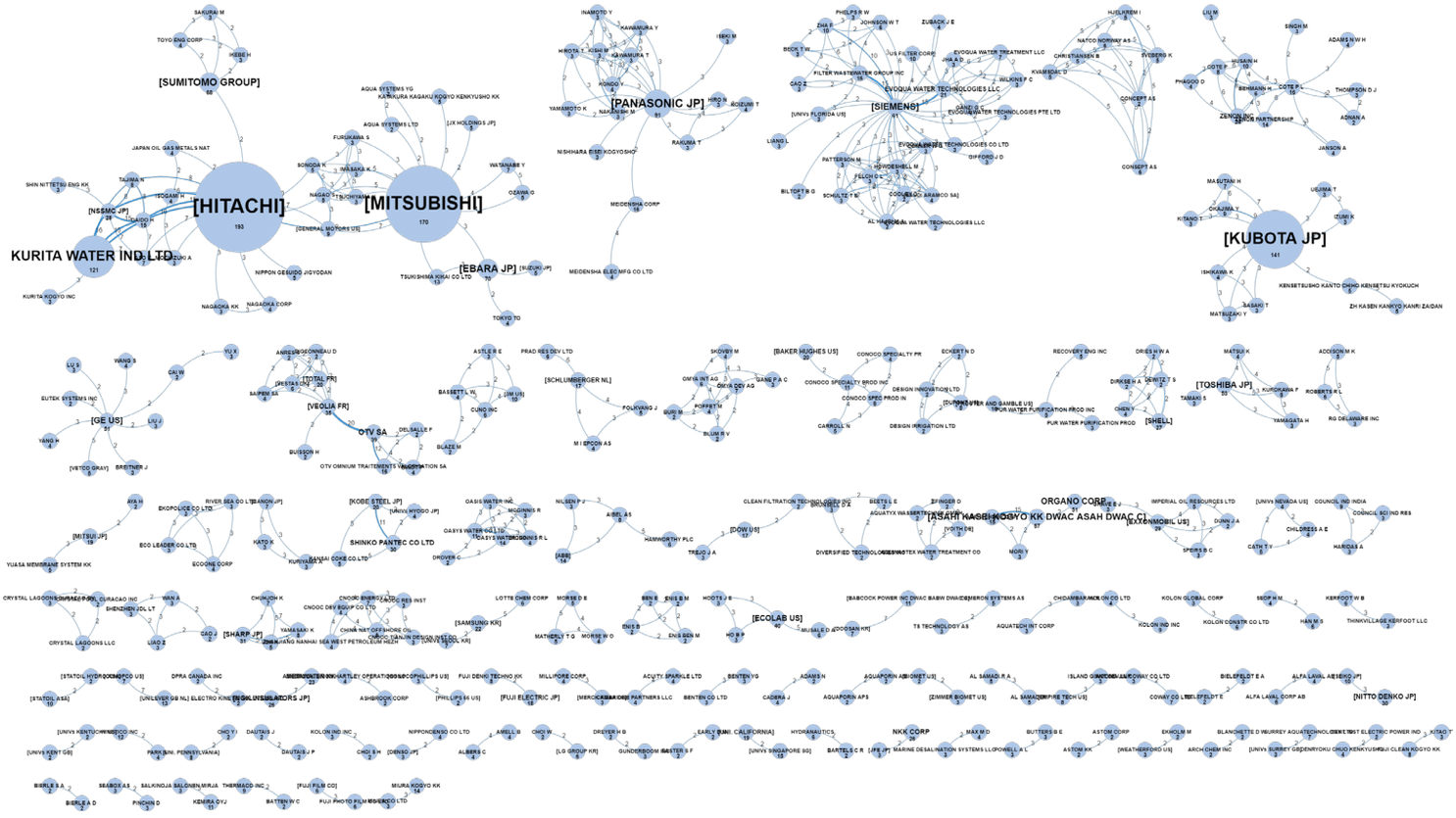
Gas treatment



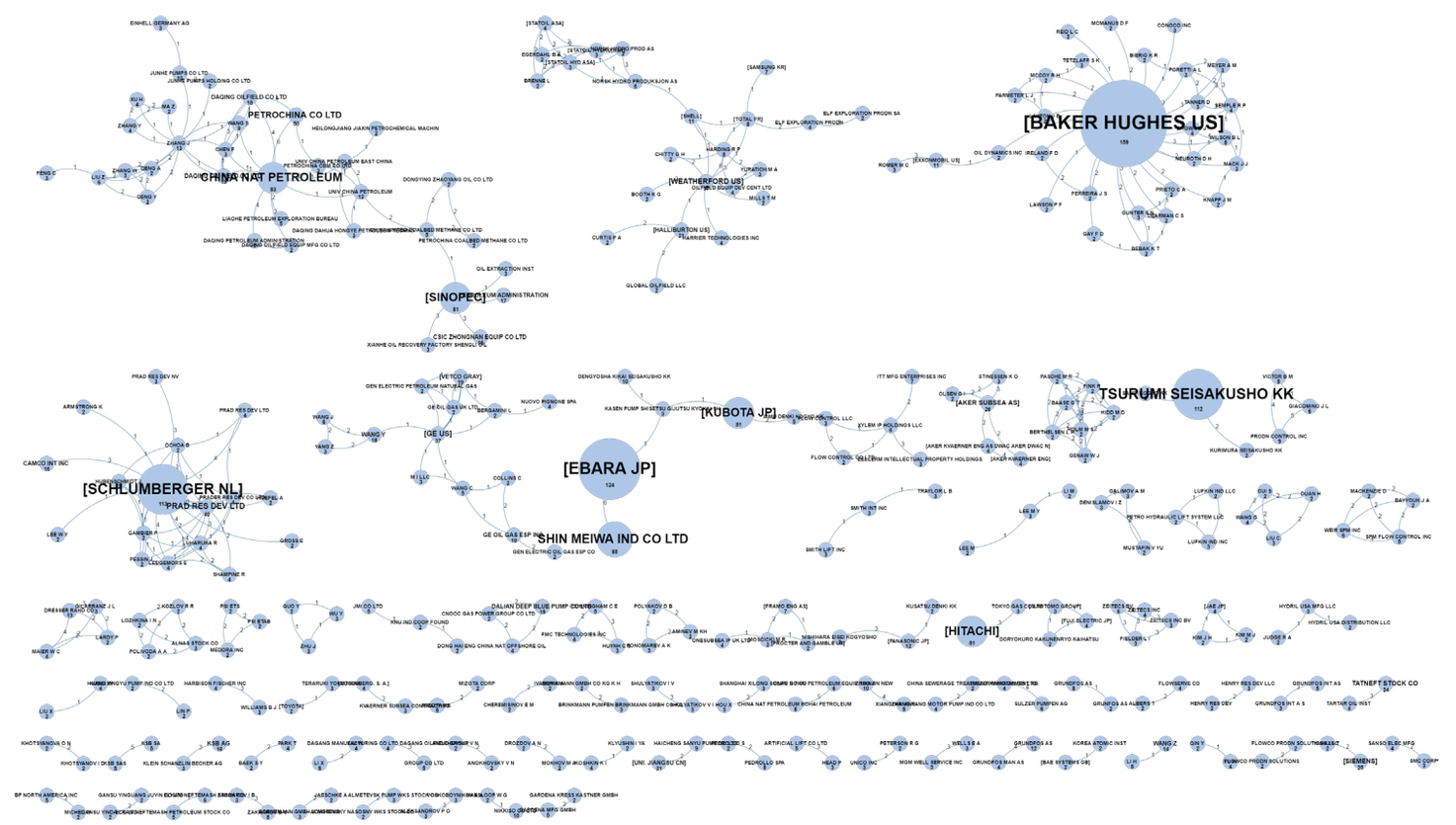
Membrane technology



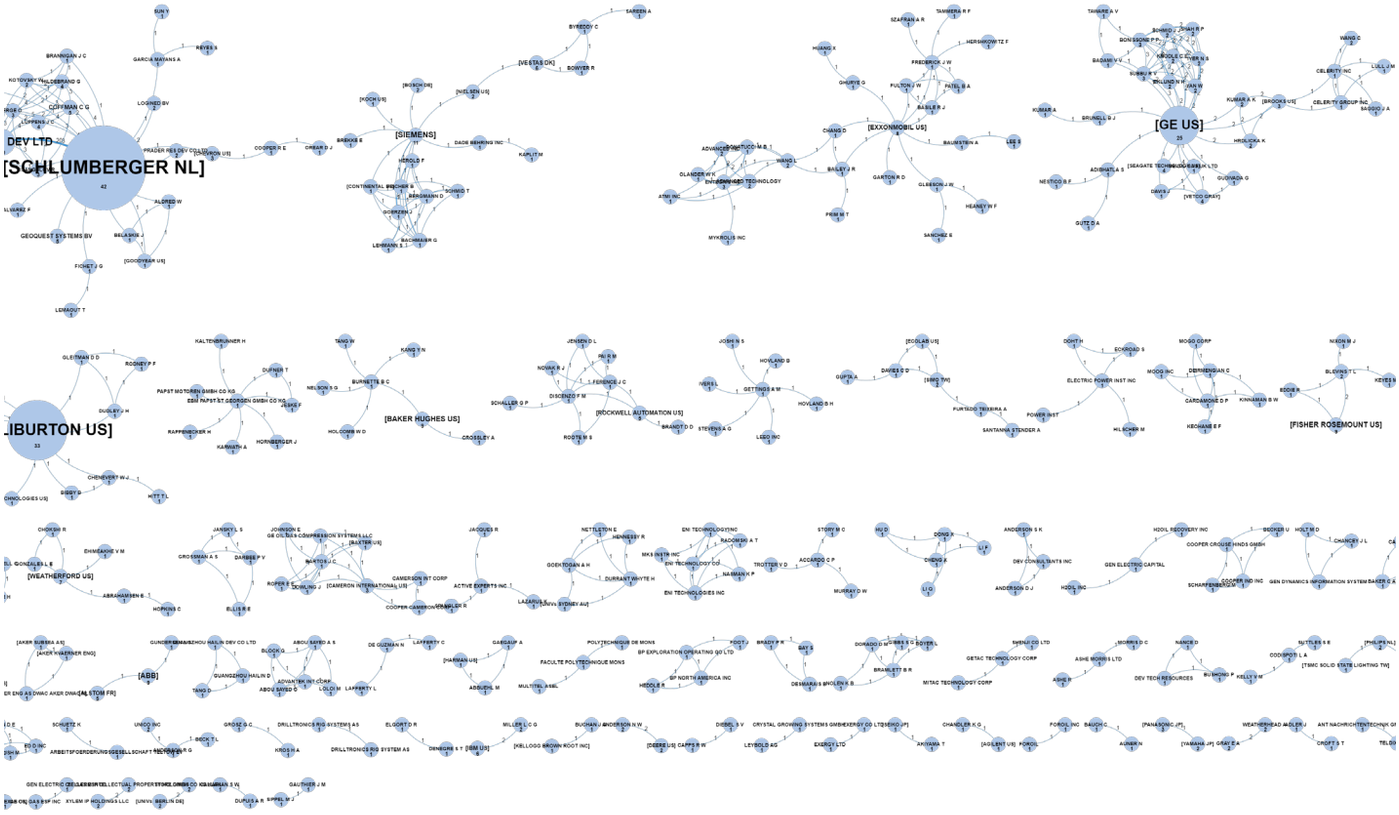
Oil treatment



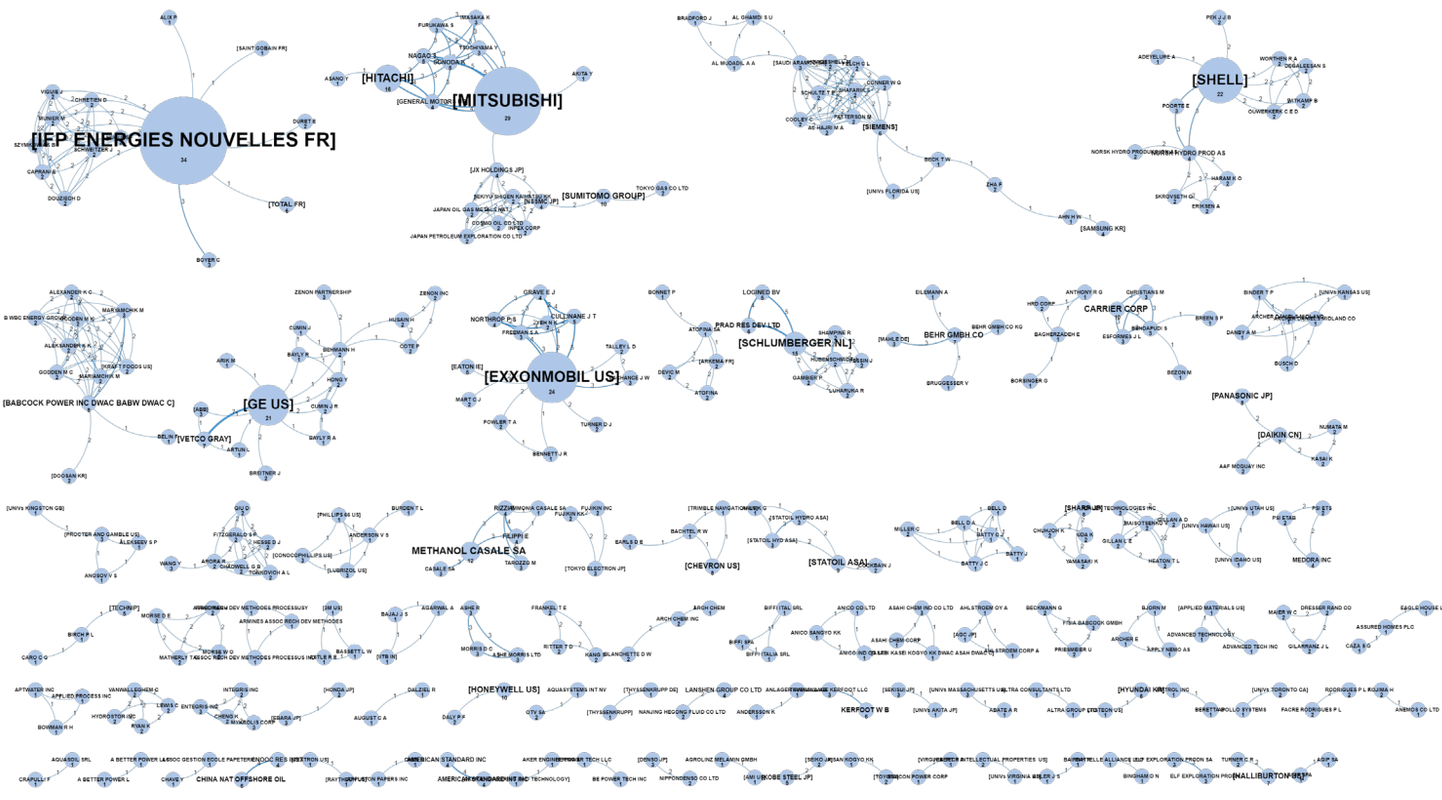
Water treatment



Pumping & compression

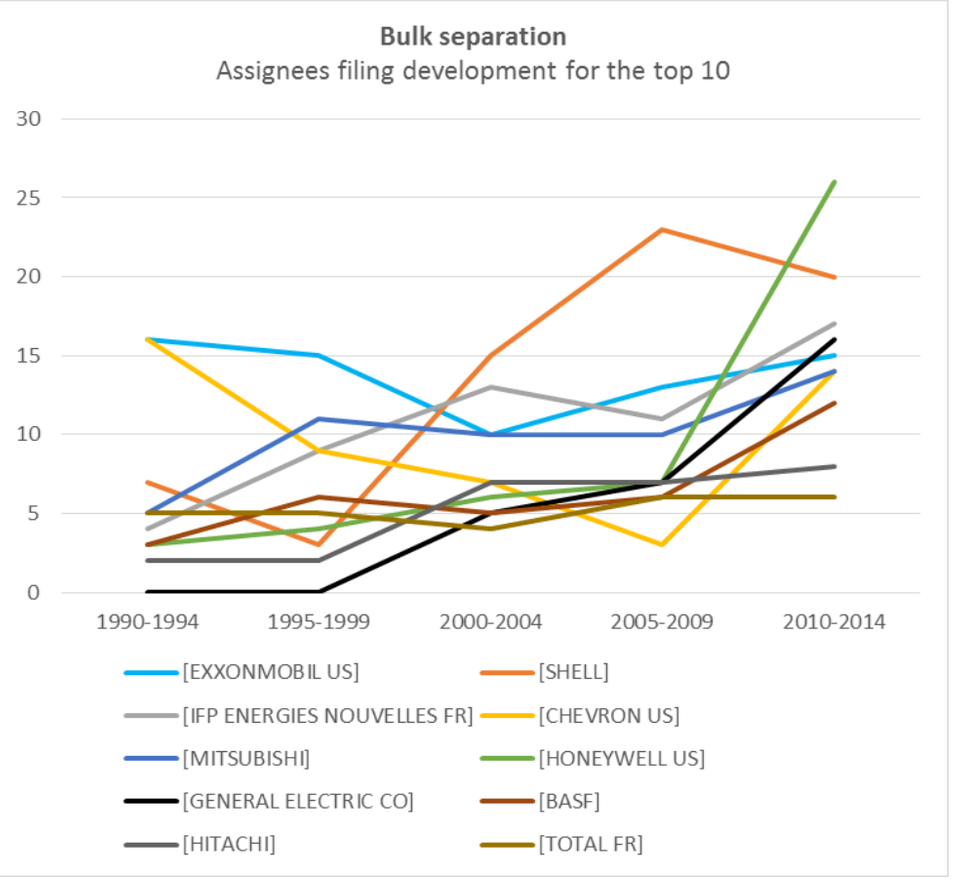


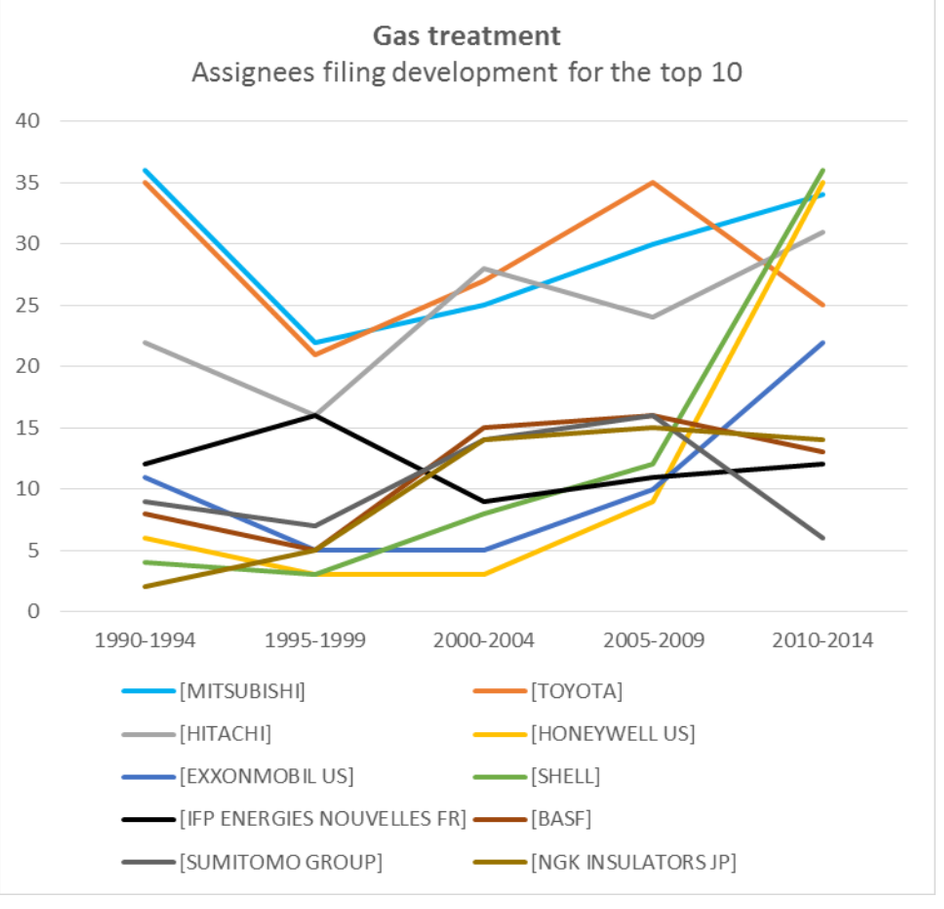
Automation

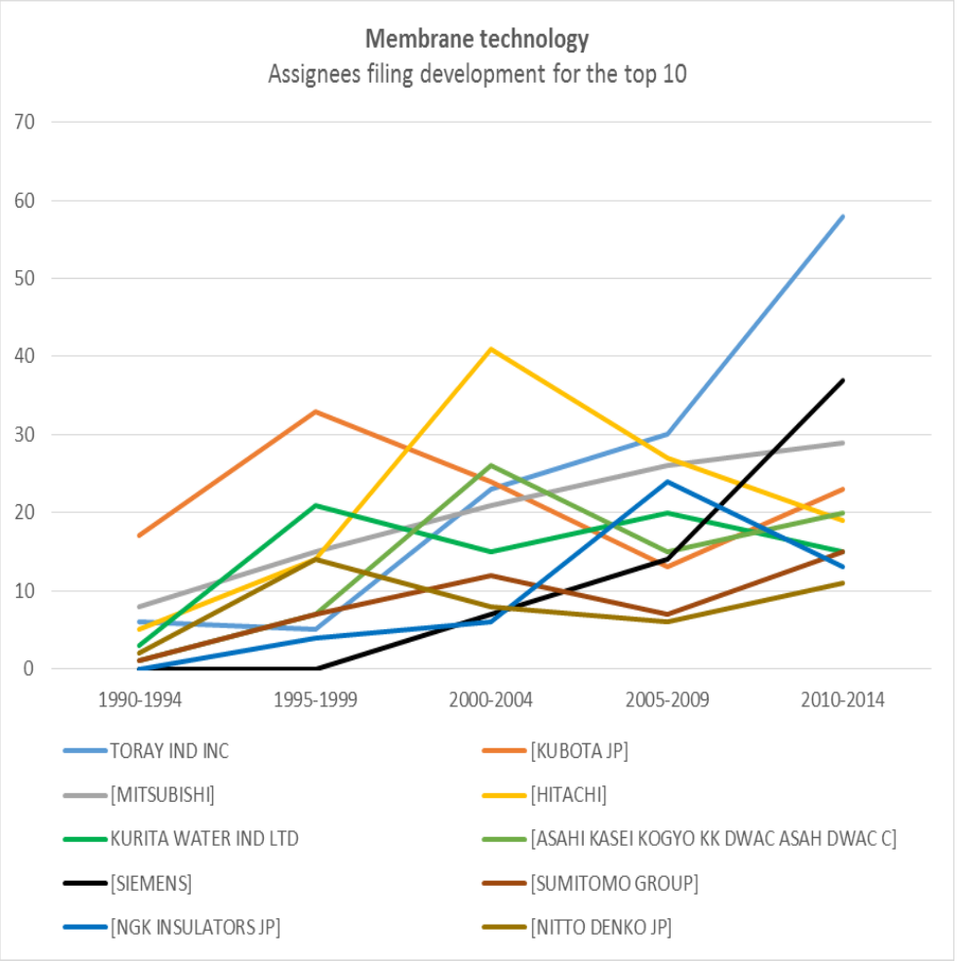


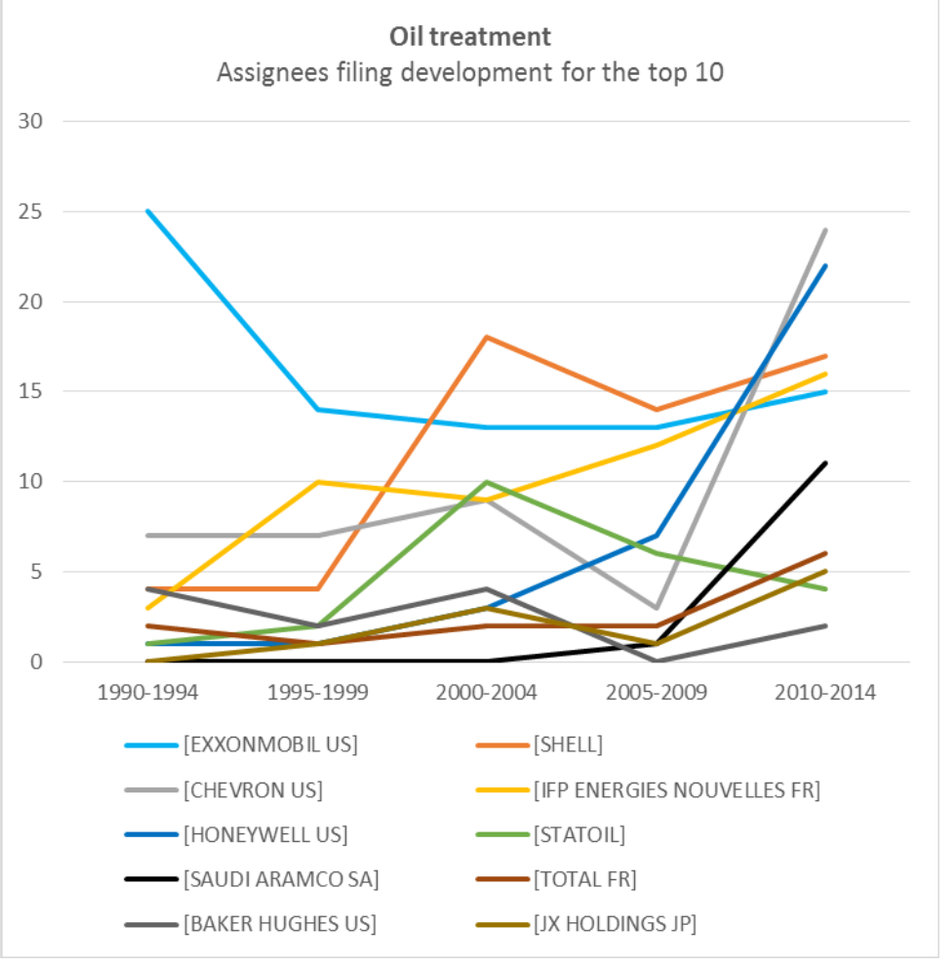
Auxiliary

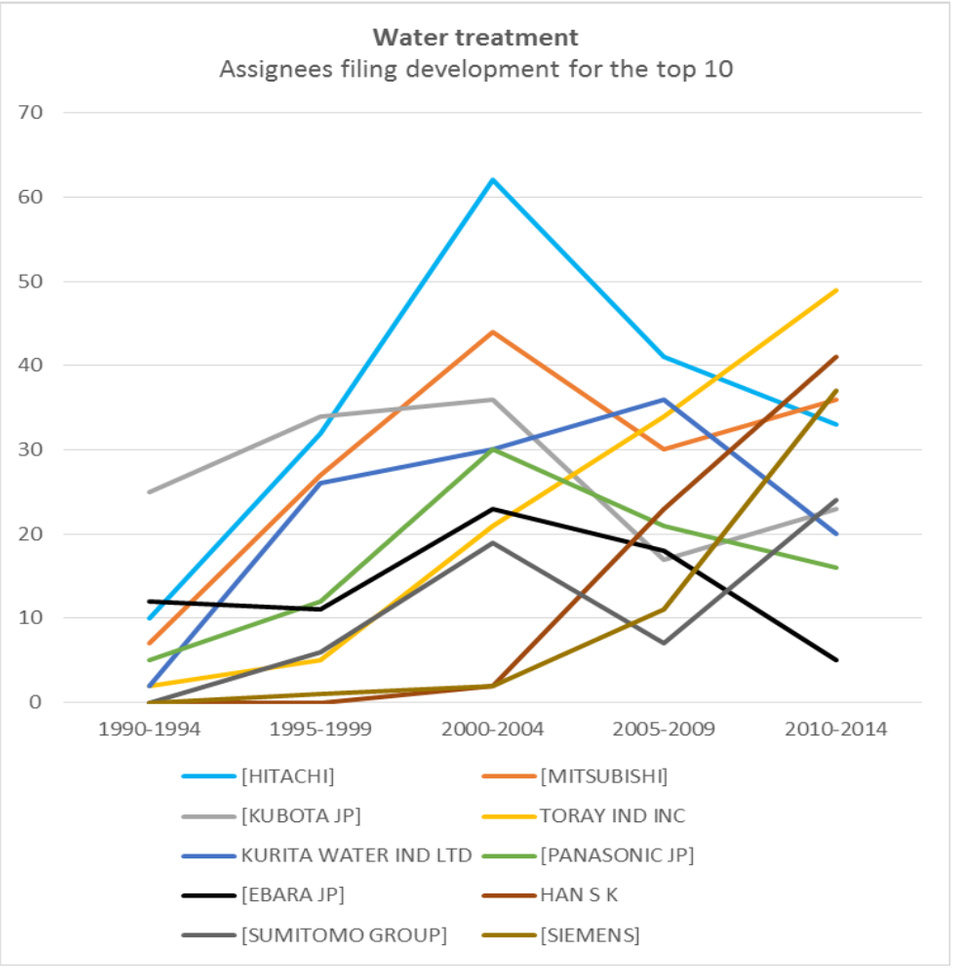
Appendix C

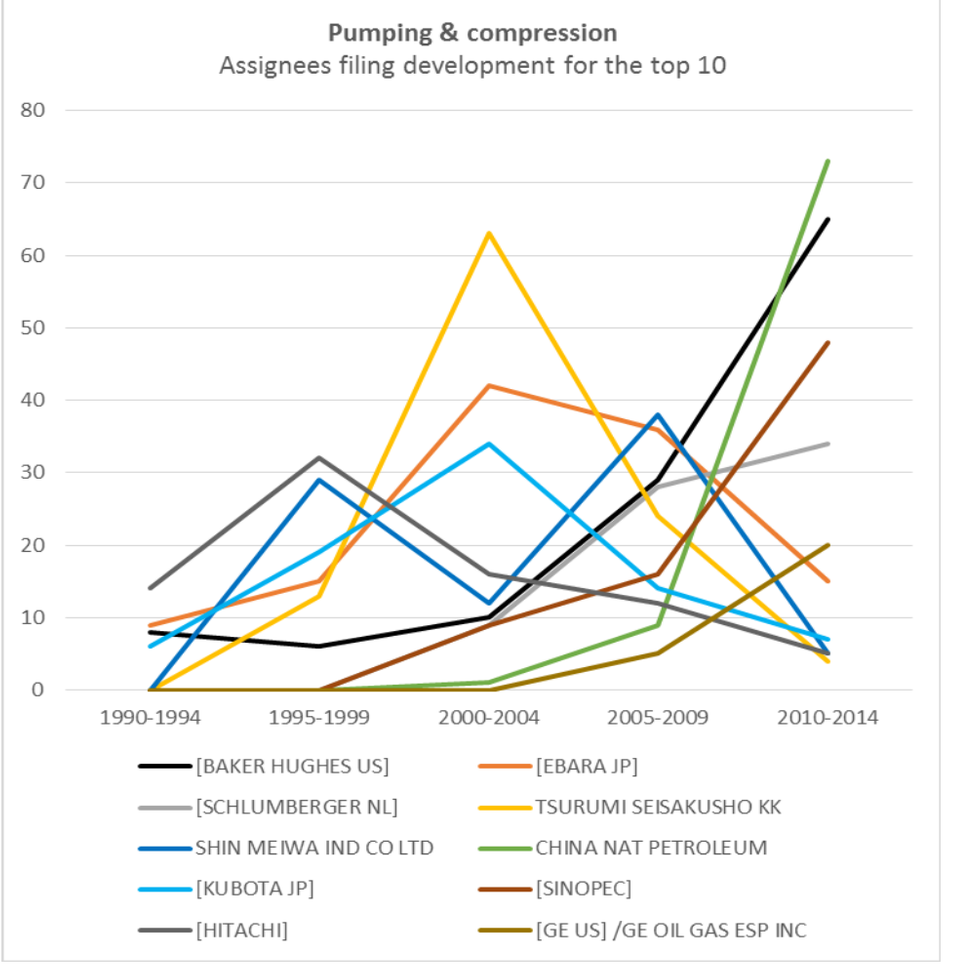

Bulk separation
Assignees filing development for the top 10
30
25
20
15
10
5
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[EXXONMOBIL US]
[SHELL]
[IFP ENERGIES NOUVELLES FR]
[CHEVRON US]
[MITSUBISHI]
[HONEYWELL US]
[GENERAL ELECTRIC CO]
[BASF]
[HITACHI]
[TOTAL FR]

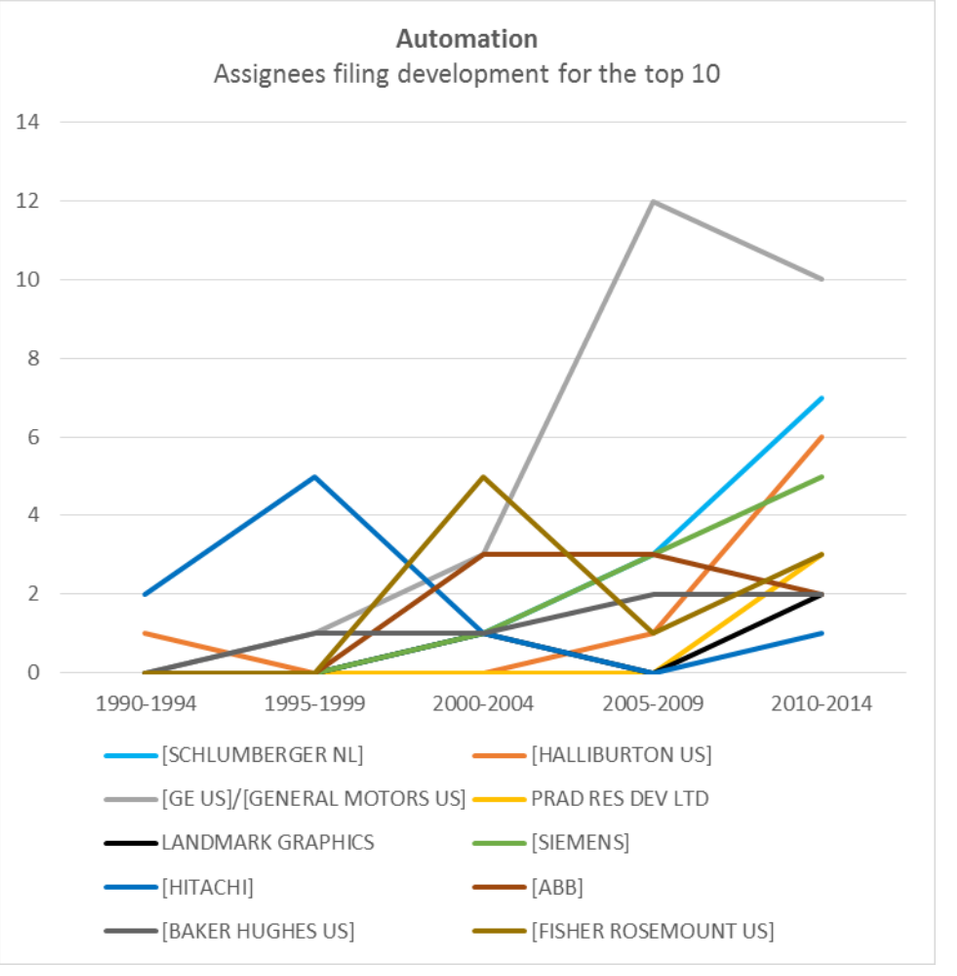

Gas treatment
Assignees filing development for the top 10
40
35
30
25
20
15
10
5
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[MITSUBISHI]
[TOYOTA]
[HITACHI]
[HONEYWELL US]
[EXXONMOBIL US]
[SHELL]
[IFP ENERGIES NOUVELLES FR]
[BASF]
[SUMITOMO GROUP]
[NGK INSULATORS JP]

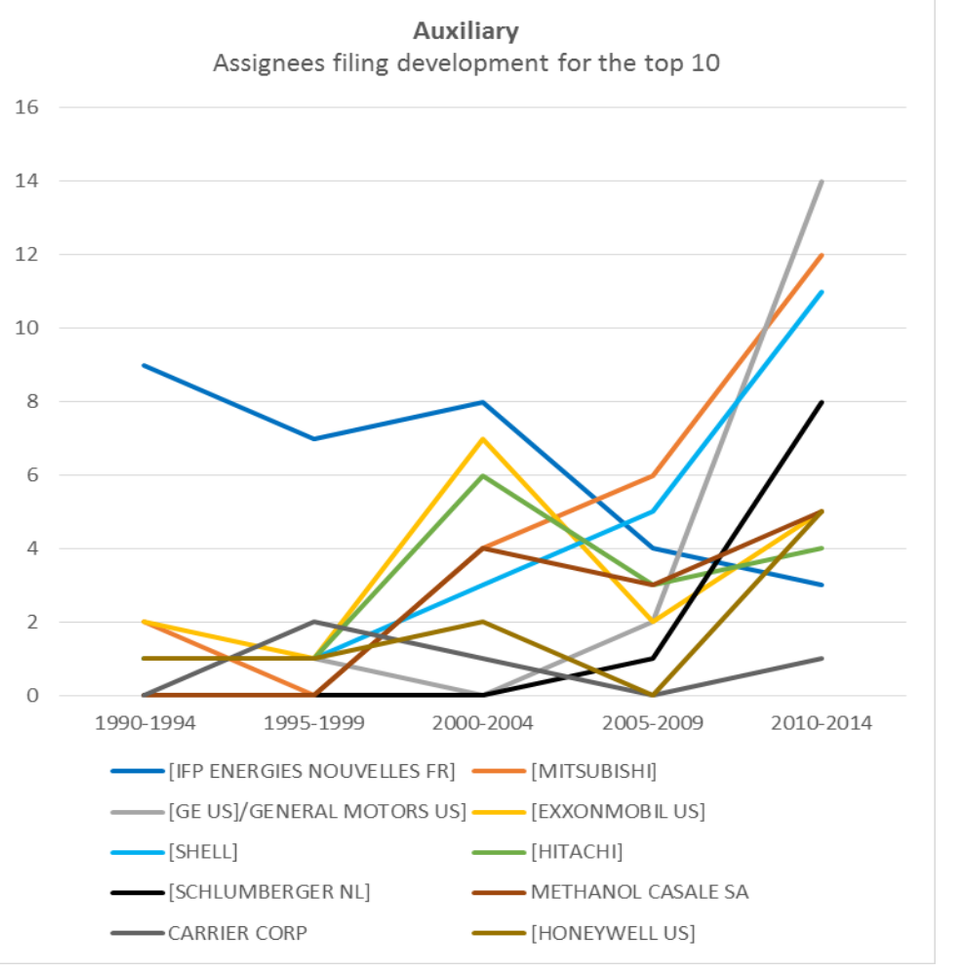

Membrane technology
Assignees filing development for the top 10
70
60
50
40
30
20
10
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
TORAY IND INC
[KUBOTA JP]
[MITSUBISHI]
[HITACHI]
KURITA WATER IND LTD
[ASAHI KASEI KOGYO KK DWAC ASAH DWAC C]
[SIEMENS]
[SUMITOMO GROUP]
[NGK INSULATORS JP]
[NITTO DENKO JP]


Oil treatment
Assignees filing development for the top 10
30
25
20
15
10
5
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[EXXONMOBIL US]
[SHELL]
[CHEVRON US]
[IFP ENERGIES NOUVELLES FR]
[HONEYWELL US]
[STATOIL]
[SAUDI ARAMCO SA]
[TOTAL FR]
[BAKER HUGHES US]
[JX HOLDINGS JP]

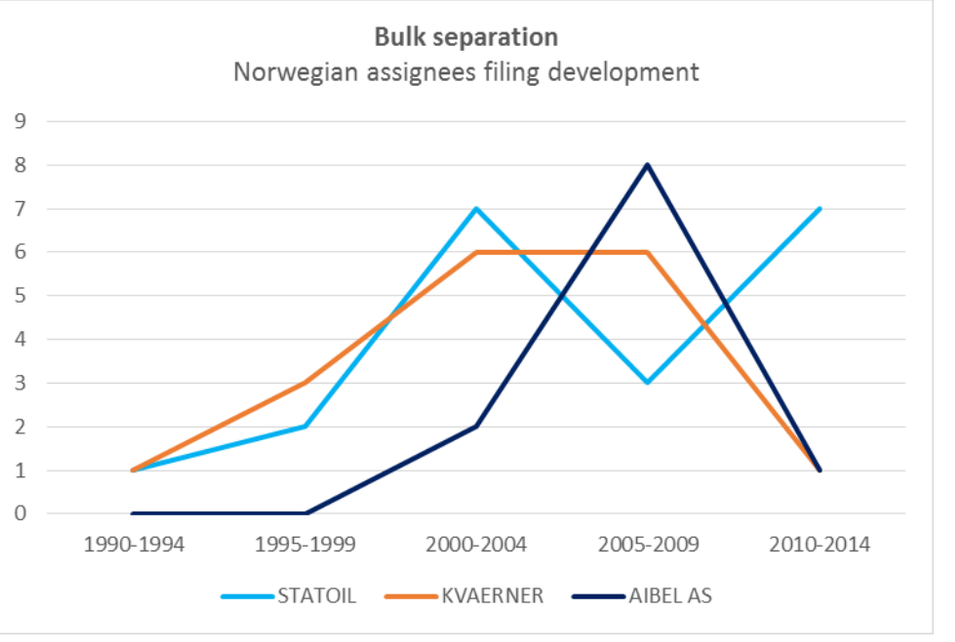

Water treatment
Assignees filing development for the top 10
70
60
50
40
30
20
10
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[HITACHI]
[MITSUBISHI]
[KUBOTA JP]
TORAY IND INC
KURITA WATER IND LTD
[PANASONIC JP]
[EBARA JP]
HAN S K
[SUMITOMO GROUP]
[SIEMENS]

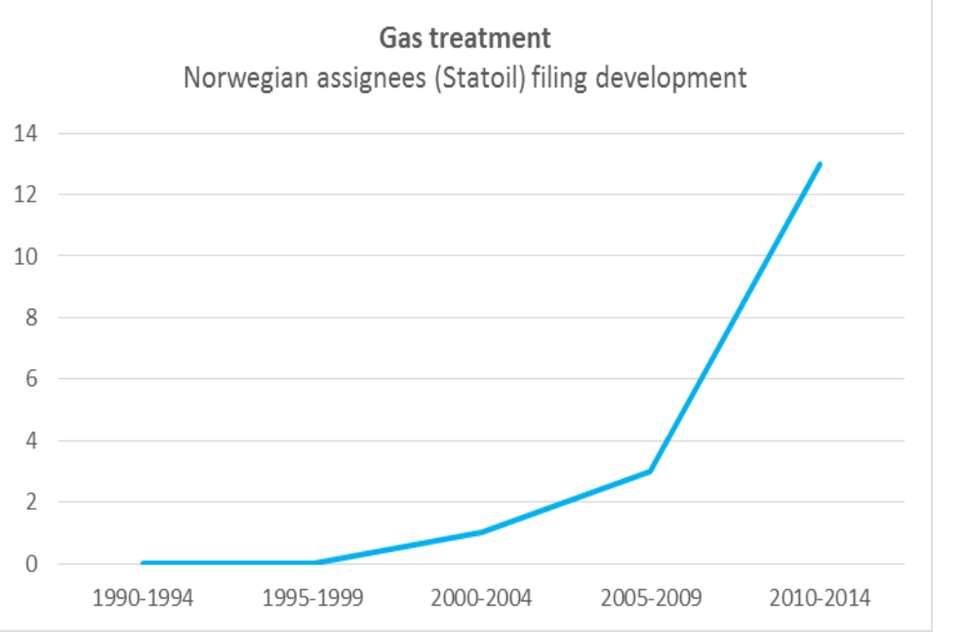

Pumping & compression
Assignees filing development for the top 10
80
70
60
50
40
30
20
10
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[BAKER HUGHES US]
[EBARA JP]
[SCHLUMBERGER NL]
TSURUMI SEISAKUSHO KK
SHIN MEIWA IND CO LTD
CHINA NAT PETROLEUM
[KUBOTA JP]
[SINOPEC]
[HITACHI]
[GE US] /GE OIL GAS ESP INC

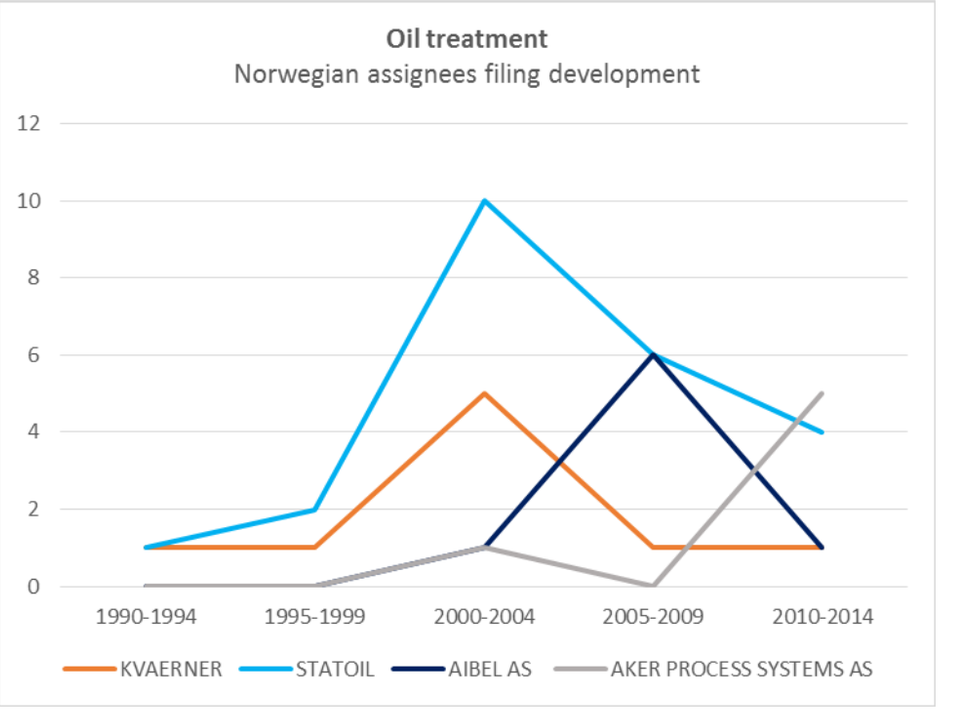

Automation
Assignees filing development for the top 10
14
12
10
8
6
4
2
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[SCHLUMBERGER NL]
[HALLIBURTON US]
[GE US]/[GENERAL MOTORS US]
PRAD RES DEV LTD
LANDMARK GRAPHICS
[SIEMENS]
[HITACHI]
[ABB]
[BAKER HUGHES US]
[FISHER ROSEMOUNT US]

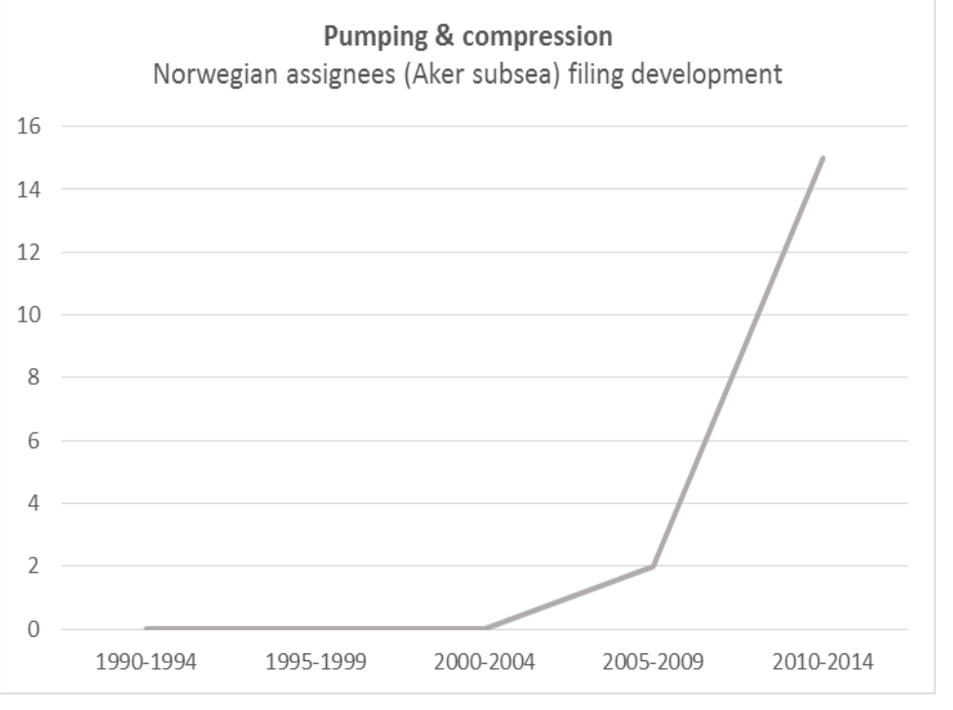

Auxiliary
Assignees filing development for the top 10
16
14
12
10
8
6
4
2
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
[IFP ENERGIES NOUVELLES FR]
[MITSUBISHI]
[GE US]/GENERAL MOTORS US]
[EXXONMOBIL US]
[SHELL]
[HITACHI]
[SCHLUMBERGER NL]
METHANOL CASALE SA
CARRIER CORP
[HONEYWELL US]

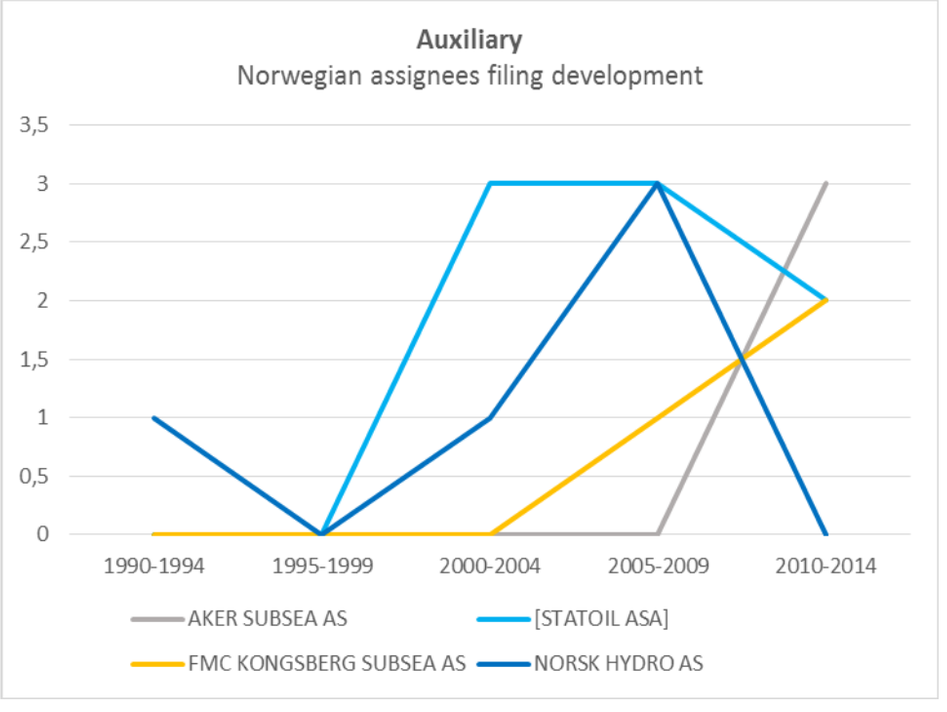
Appendix D


Bulk separation
Norwegian assignees filing development
9
8
7
6
5
4
3
2
1
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
STATOIL
KVAERNER
AIBEL AS


Gas treatment
Norwegian assignees (Statoil) filing development
14
12
10
8
6
4
2
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014


Oil treatment
Norwegian assignees filing development
12
10
8
6
4
2
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
KVAERNER
STATOIL
AIBEL AS
AKER PROCESS SYSTEMS AS


Pumping & compression
Norwegian assignees (Aker subsea) filing development
16
14
12
10
8
6
4
2
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014


Auxiliary
Norwegian assignees filing development
3,5
3
2,5
2
1,5
1
0,5
0
1990-1994
1995-1999
2000-2004
2005-2009
2010-2014
AKER SUBSEA AS
[STATOIL ASA]
FMC KONGSBERG SUBSEA AS
NORSK HYDRO AS

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