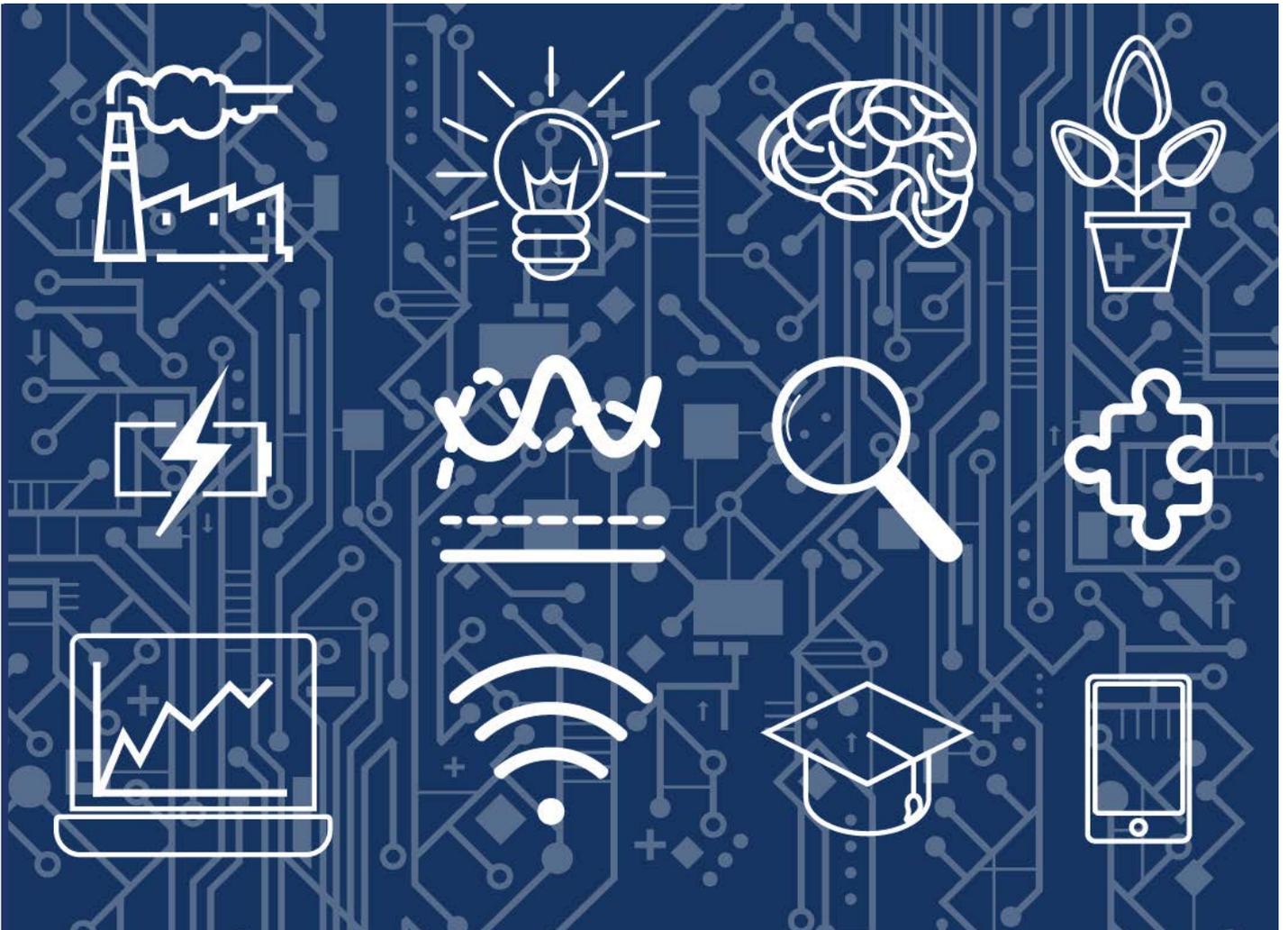




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Flood and coastal defences

A worldwide overview of patenting related to the UK's ten point plan for a Green Industrial Revolution



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Flood and coastal defences

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1. Introduction

1.1 Background

In June 2019, the UK became the first major economy to set a legally binding target to reach net zero greenhouse gas emissions by 2050, in recognition of the transformative change needed to tackle global climate change.¹

The Energy White Paper (EWP)², published in December 2020, and the Industrial Decarbonisation Strategy³, published in March 2021, set out complementary plans for the transformation of our energy system and industries, including actions to fully decarbonise electricity generation by 2050.

On the international stage, the UK has co-assumed⁴ the presidency of COP26 (26th UN Climate Change Conference of the Parties) and is hosting the COP26 UN Climate Change Conference in Glasgow in 2021.^{5,6}

In November 2020 the UK government released a ten point plan for a green industrial revolution,⁷ comprising:

- **Offshore wind:** produce enough offshore wind energy to power every home in the UK, producing up to 40 gigawatts by 2030,
- **Hydrogen:** reach a five gigawatt production capacity of 'low carbon' hydrogen by 2030 – for industry, transport, power and homes – and develop the first town heated by hydrogen by the end of this decade.
- **Nuclear:** provision for a large nuclear plant, as well as for advanced small nuclear reactors.
- **Electric vehicles:** phasing out sales of new petrol and diesel-powered vehicles by 2030, so as to accelerate the transition to electric vehicles and investing in grants to help buy cars and charge point infrastructure.
- **Public transport, cycling and walking:** making cycling and walking more attractive ways to travel and investing in zero-emission public transport for the future.
- **Zero-emission air and greener maritime travel:** supporting research projects for zero-emission planes and ships.
- **Homes and public buildings:** making homes, schools and hospitals greener, warmer and more energy efficient, including a target to install 600,000 heat pumps every year by 2028.

¹ <https://www.gov.uk/government/publications/department-for-business-energy-and-industrial-strategy-outcome-delivery-plan/beis-outcome-delivery-plan-2021-to-2022-b-introduction>

² <https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future>

³ <https://www.gov.uk/government/publications/industrial-decarbonisation-strategy>

⁴ Together with Italy: <https://www.ukcop26.org/ore-cop/>

⁵ The conference was originally scheduled to take place in 2020, but has been postponed to 2021 in view of the COVID-19 pandemic

⁶ UN Climate Change Conference UK 2020 (Conference) <https://www.ukcop26.org/the-conference>

⁷ <https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution>

- **Carbon capture:** developing world-leading technology to capture and store harmful emissions away from the atmosphere, with a target to remove 10 million tonnes of carbon dioxide by 2030.
- **Nature:** Protecting and restoring the natural environment, with plans to include planting 30,000 hectares of trees a year.
- **Innovation and finance:** Developing cutting-edge technologies and making the City of London the global centre of green finance.

Innovation may play a role in helping to achieve carbon net zero⁸ and innovation may be reflected in patenting trends. Hence, this report is part of a series of studies relating to the technologies covered within the UK government's ten point plan for a green industrial revolution. This report analyses the worldwide patent landscape related to flood and coastal defence technologies.

This report is based on the analysis of published patent application data rather than granted patent data. Published patent application data gives more information about technological activity than granted patent data because a number of factors determine whether an application ever proceeds to grant; these include the inherent lag in patent processing at national IP offices worldwide and the patenting strategies of applicants who may file more applications than they ever intend to pursue.

Throughout this report, patents are counted either as single published patent applications or as patent families depending on the context. A 'patent application' refers to a single patent application made in one jurisdiction and published in that jurisdiction. Patent applications are counted once regardless of the number of subsequent publications. A 'patent family' refers to a group of patent applications made and published in different jurisdictions. Each member of a patent family is considered to relate to the same invention. A patent family is counted once regardless of the number of members or publications it contains.

For this study, the LexisNexis worldwide patent database was interrogated using PatentSight.⁹ The data coverage of this database is that of DOCDB, the European Patent Office's (EPO) database.¹⁰

Throughout this report, reference is made to 'active' patent families. A patent family in PatentSight is defined as active when at least one patent family member is either in the pending stage or 'in force' state. PatentSight updates the legal status of documents held within its database weekly.

⁸ <https://www.gov.uk/government/publications/promoting-innovation-and-growth-the-ipo-at-work-2020-21/innovation-and-growth-report-2020-21>

⁹ <https://go.patentsight.com/BI2.0/bi/secure/src/resources/documentation/syntax-cheat-sheet/SyntaxCheatSheet.pdf?45be120476a49463f31ebcd79b10b19e>

¹⁰ <https://www.epo.org/searching-for-patents/data/coverage/weekly.html>

1.2 Protecting the natural environment

Point 9 of the ten point plan looks at protecting the natural environment. The UK government aims to do so through the creation of new National Parks and Areas of Outstanding Natural Beauty (AONB). In addition to this, the government will look at investing up to £40 million in a second round of the Green Recovery Challenge fund to help create and retain jobs within nature conservation and restoration projects.

These aspects of the ten-point plan do not directly relate to technological innovation that may be covered by patenting activity. One aspect of point 9, however, is a commitment to invest up to £5.2 billion in flood and coastal defences. This area within point 9 may potentially relate to patentable technologies, so this report focuses on patents relating to flood and coastal defences.

Flood and coastal defence methods have been used since ancient times, and there are a variety of methods used to defend against flooding. These include dams, levees, weirs, sea walls and diversion canals. The Thames Barrier is an example of flood defence technology that is deployed in the UK.

2. Flood and coastal defences

This sector looks at patents relating to flood and coastal defences in general, both worldwide and specific to the UK.

2.1 Worldwide patent landscape

Figure 1 shows how the number of active patent families being filed each year worldwide (23,840) relating to flood and coastal defences have increased year-on-year. In the ten years from 2008 to 2018, the number of active patent families filed each year increased nearly six-fold. There also appears to have been a marked increase from 2017-2018, where the number of active patent families being filed increased by over 700, suggesting continued and increasing development in this area of technology.

Figure 1: Number of active flood and coastal defence patent families worldwide per priority (first filing) year, 2001-2018

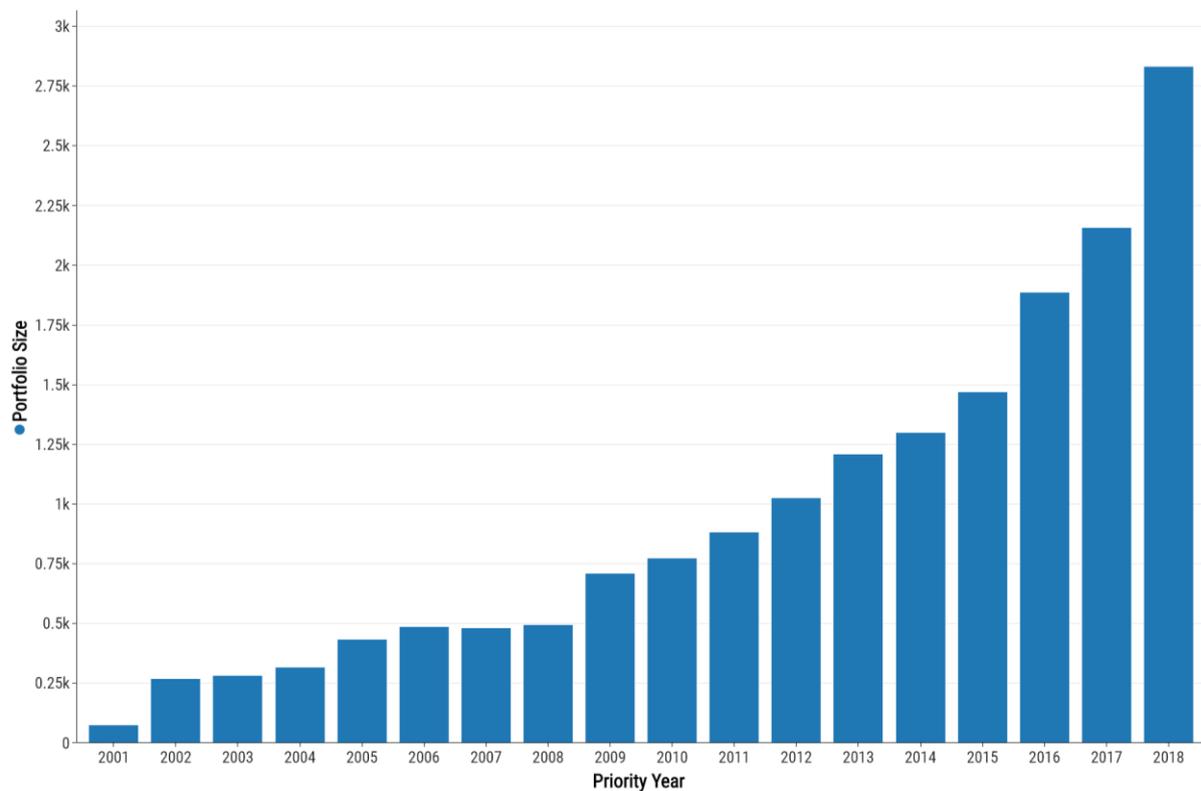


Figure 2 shows that there are significantly more patent families active in China compared to the rest of the world, where over half of all patent families relating to flood and coastal defences are protected in China. South Korea and Japan also feature more prominently than other countries. Somewhat surprisingly, the US does not feature as prominently on this chart as may be expected given the absolute levels of patenting in the US.

Figure 2: World map showing where flood and coastal defence patents are being protected, 2001-2018

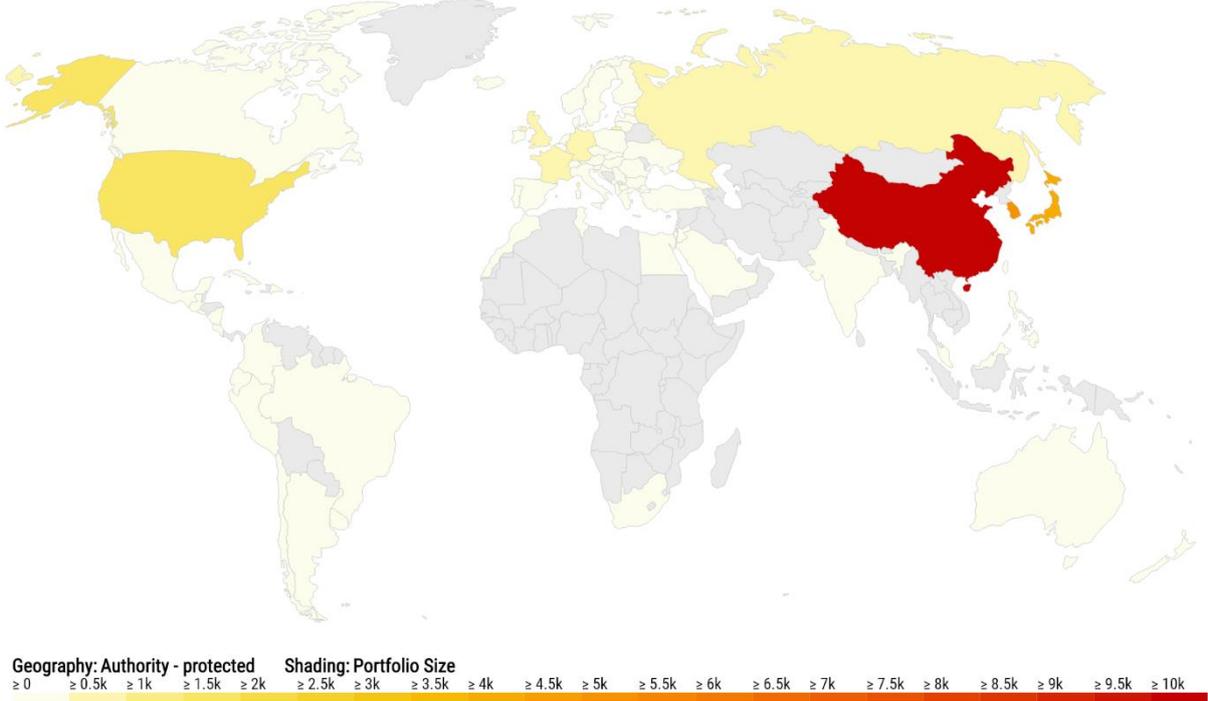
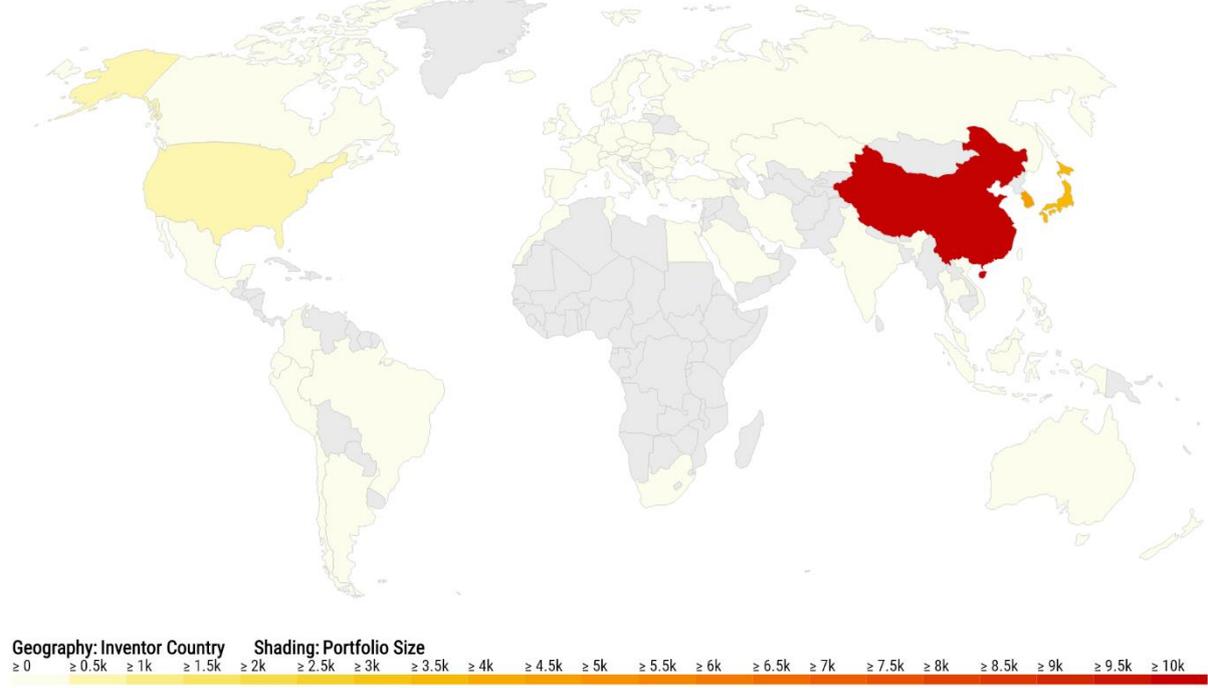


Figure 3: World map showing where flood and coastal defence patents are being invented, 2001-2018



The map depicted in Figure 3 follows the same pattern as is seen in Figure 2, signifying that patents protected in China are also being invented in the same country, and that South Korea and Japan are the next most popular invention locations for patents relating to flood and coastal defences. The scale of patents being invented in China somewhat hides the smaller scale differences seen across many other parts of the world, including within Europe.

Using the Relative Specialisation Index (RSI) can help to account for the fact that some countries file more patent applications than others in all fields of technology. The RSI compares the fraction of a country's technology-specific patents, out of all of its patents across all fields of technology, with the corresponding fraction of technology-specific patents worldwide.

Table 1: Relative Specialisation Index (RSI) of selected nations for flood and coastal defence patents, 2001-2018

Country	Relative Specialisation Index
South Korea	0.398
Australia	0.189
Canada	0.134
Japan	0.050
China	0.008
France	-0.058
United Kingdom	-0.077
India	-0.376
USA	-0.519
Germany	-0.797

Table 1 shows the Relative Specialisation Index (RSI)¹¹ of the top 10 patenting countries for flood and coastal defence patents. From this, it shows that South Korea has the highest RSI value, meaning it is most specialised in this area. A value near zero for the UK indicates that the UK is not a specialist in this field but it is producing as many flood and coastal defence patents as you would expect given the absolute levels of patenting within the UK.

¹¹ See Appendix C for details of how the Relative Specialisation Index (RSI) is calculated

Figure 4: Top 20 owners of flood and coastal defence patents, 2001-2018

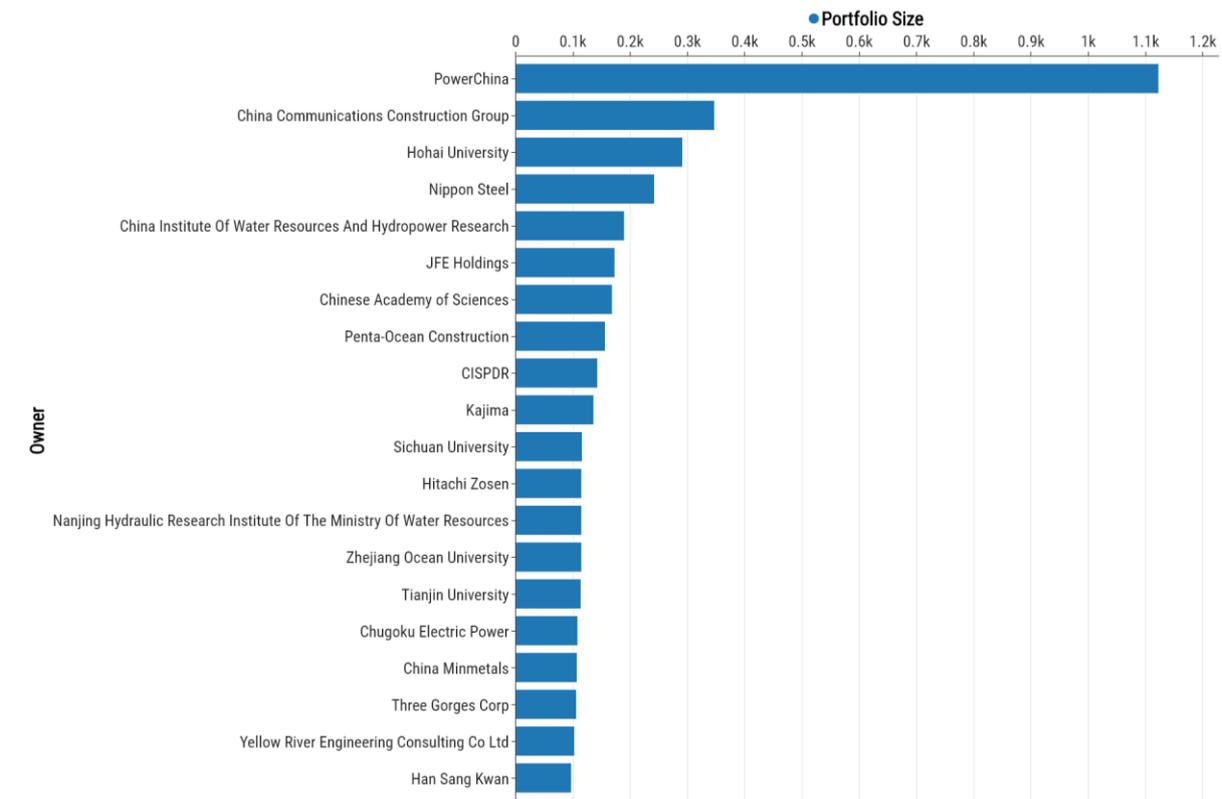


Figure 4 demonstrates how this area of patenting appears to be almost entirely dominated by companies based in China. PowerChina, a state-owned heavy and civil engineering company,¹² owns nearly 800 active patent families more than the next patent owner. From a patenting perspective this company is therefore somewhat dominant in this technology area. PowerChina are active in the hydropower market, and a substantial proportion of their patents in this area appear to relate to hydropower and damming technologies. The dominance of Chinese companies in this area may be related to China being the world's largest producer of hydroelectricity, contributing 28.5% of the world's total in 2020.¹³

¹² en.powerchina.cn

¹³ <https://www.iea.org/reports/key-world-energy-statistics-2020>

Figure 5: Bubble chart matrix showing patent portfolio size per year, grouped by the top 10 owners of flood and coastal defence patents, 2001-2018

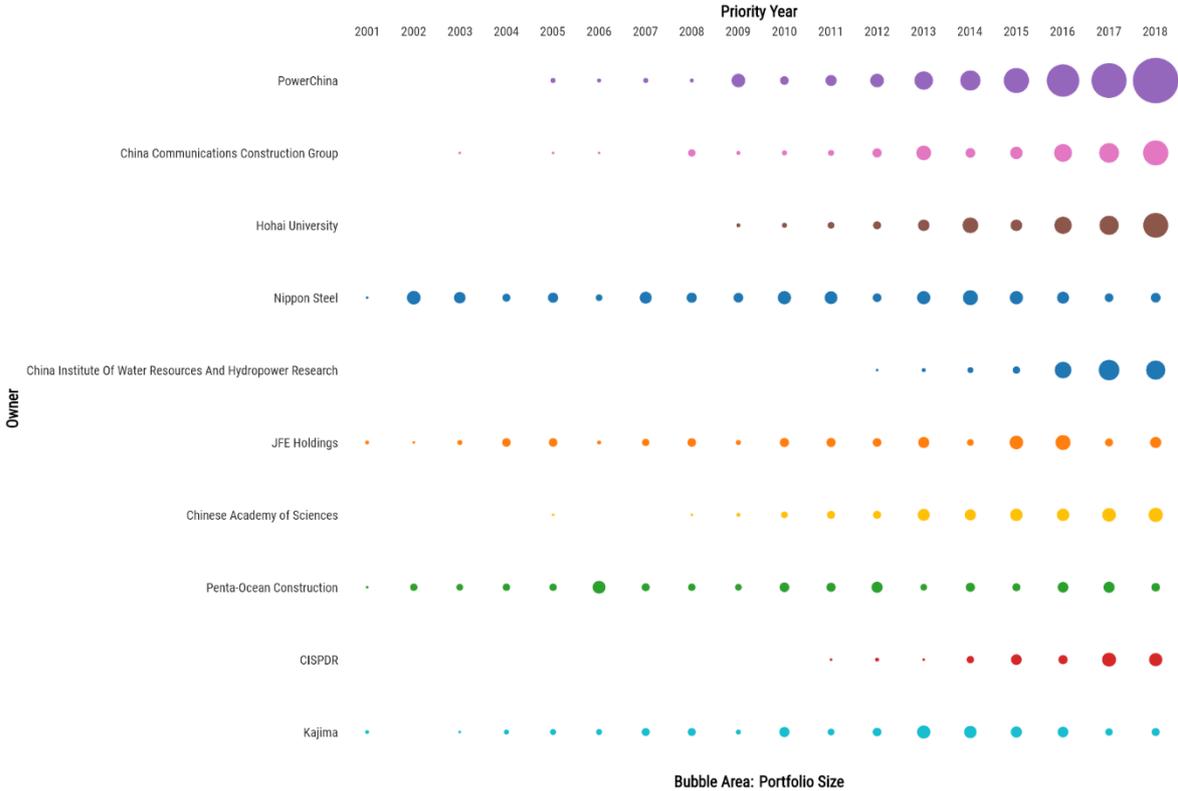
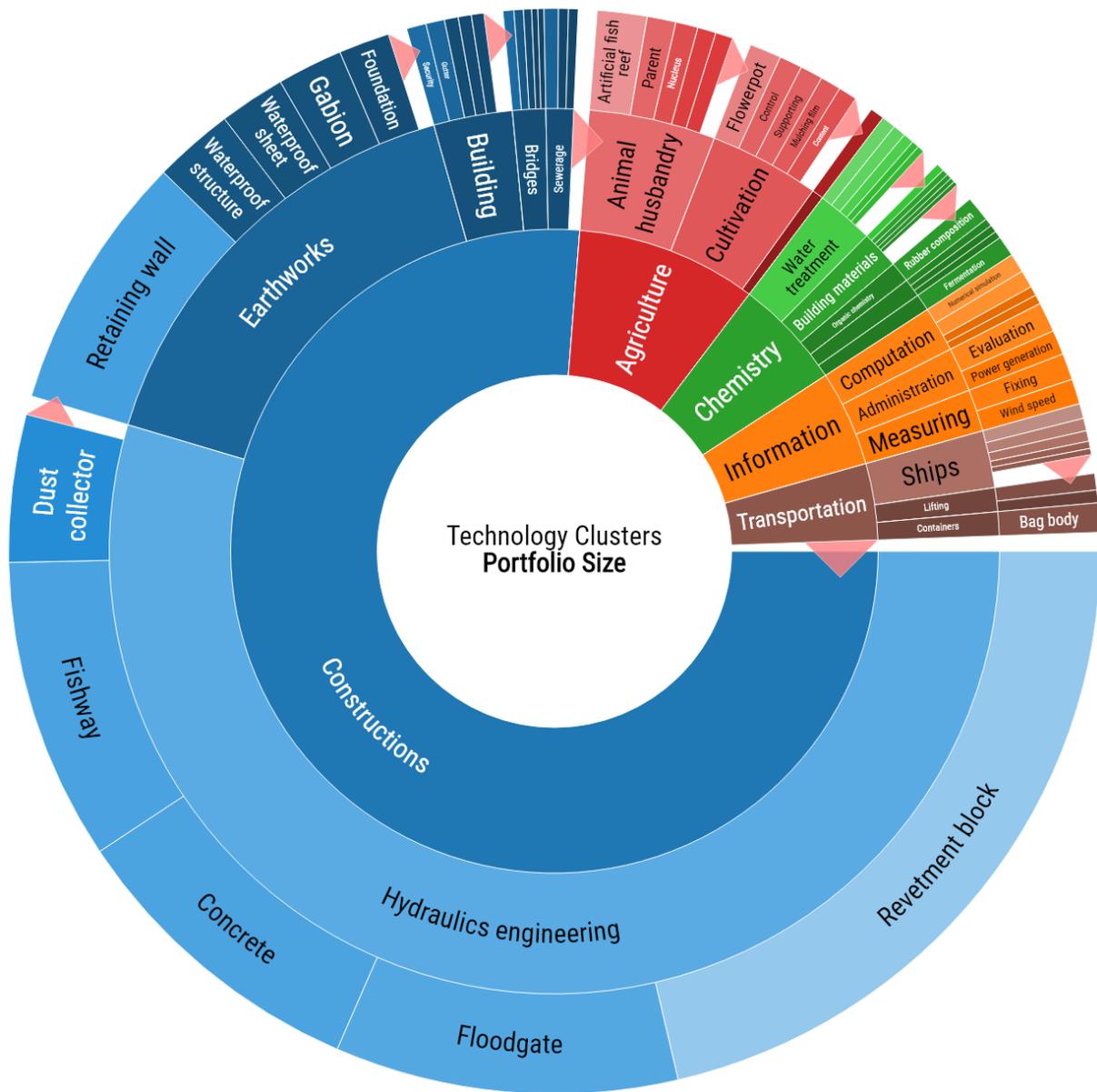


Figure 5 shows that the dominance of PowerChina in flood and coastal defence patents has only occurred in recent years with increasing filings each year. Other owners, such as Nippon Steel, have maintained a more consistent level of annual filings, and companies such as the China Institute of Water Resources and Hydropower Research appear to have increased their filing activity in most recent years.

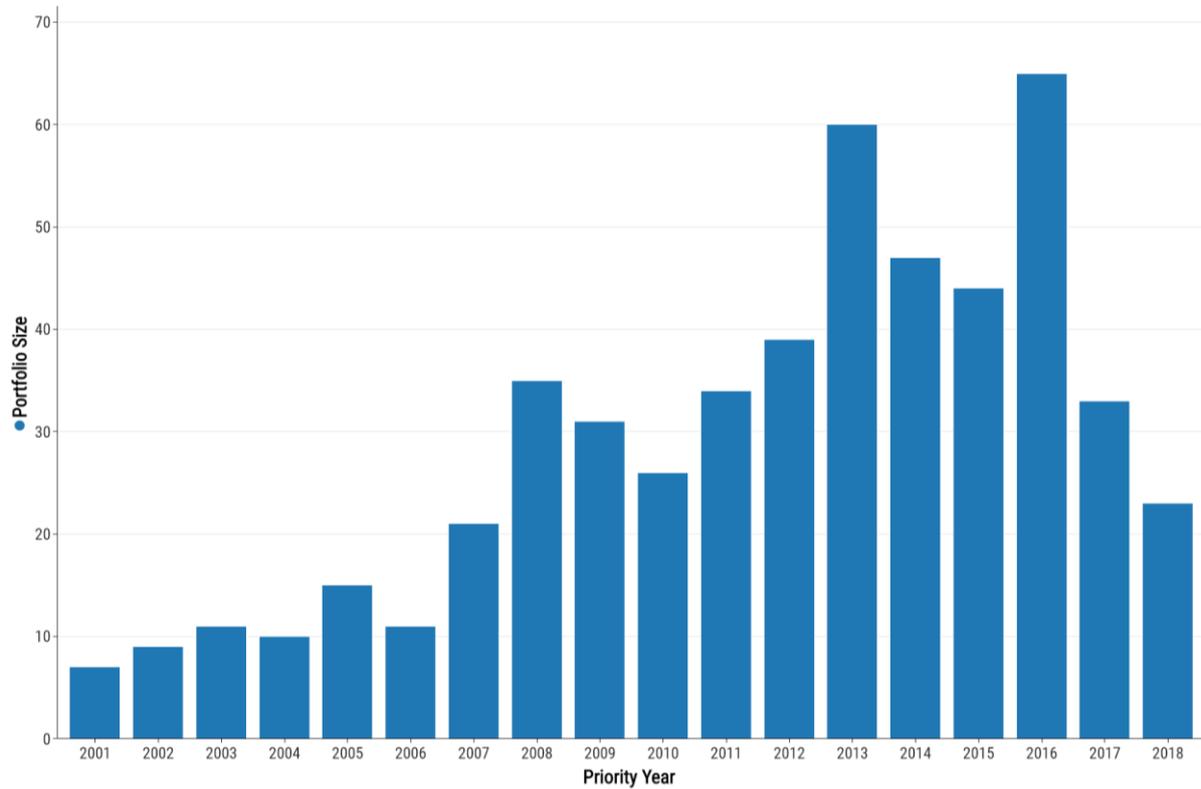
Figure 6: Sunburst chart of the technology clusters covered by flood and coastal defence patent families, 2001-2018



Sunburst charts provide a quick and intuitive understanding of a technology area, including the categories of inventions that are protected and in what proportions. The sunburst chart in Figure 6 shows that nearly three quarters of patents in this sector relate to constructions, with 7% being devoted to floodgates, and 15.5% being related to earthworks.

2.2 UK patent landscape

Figure 7: Number of flood and coastal defence patent families active in the UK, grouped by priority (first filing) year, 2001-2018



Looking at Figure 7, it is clear that the number of active patent families filed each year relating to flood and coastal defences (512) was relatively low from 2001-2006. This was followed by a general increasing trend as far as 2016, where there was approximately a six-fold increase in annual patenting activity in the ten years between 2006 and 2016.

Figure 8: Number of active flood and coastal defence patent families invented in the UK, 2001-2018

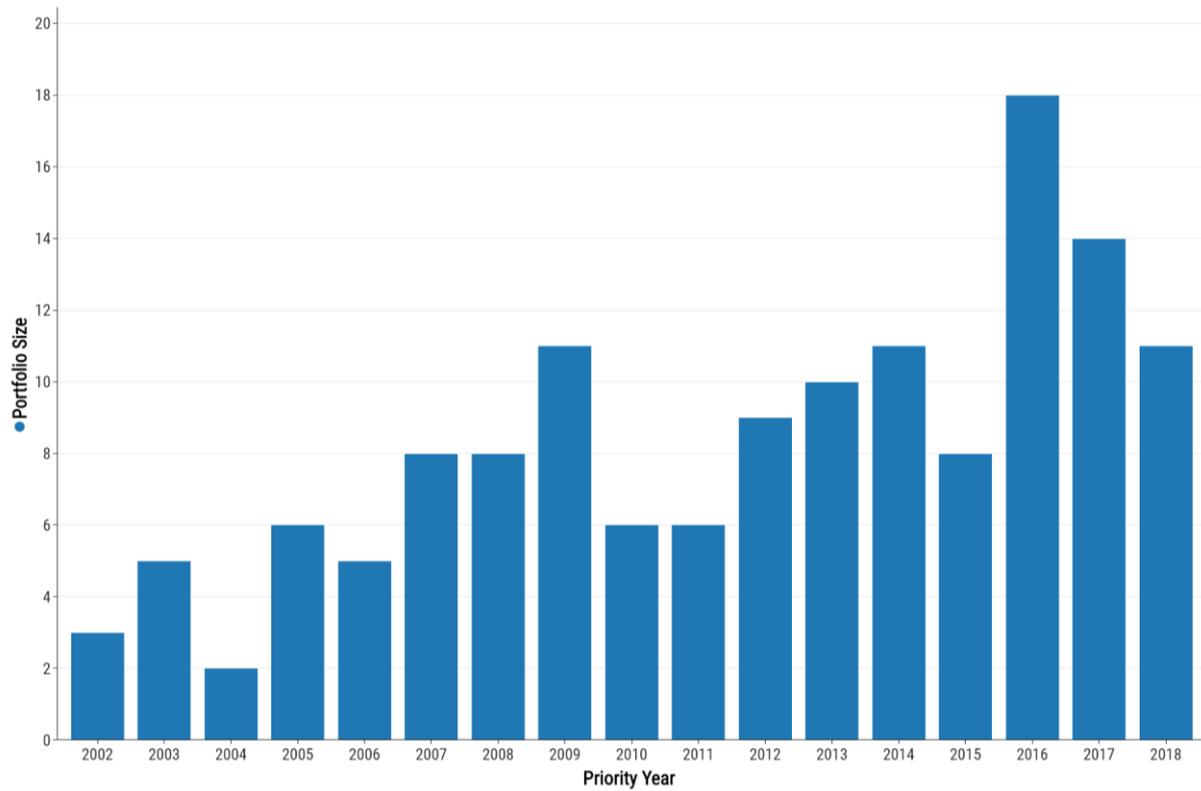


Figure 8 shows the number of patent families filed each year relating to flood and coastal defence which were invented in the UK from 2001-2018 (141 in total). This is a relatively modest figure compared to the global figures, but the numbers remain fairly consistent for most years, with a peak in 2016 which appears to correlate with the peak also seen in Figure 7. An investigation into the patents contained within this peak show a range of different owners with no particular pattern in terms of specific subject matter.

Figure 9: World map showing where flood and coastal defence patents invented in the UK are being protected, 2001-2018

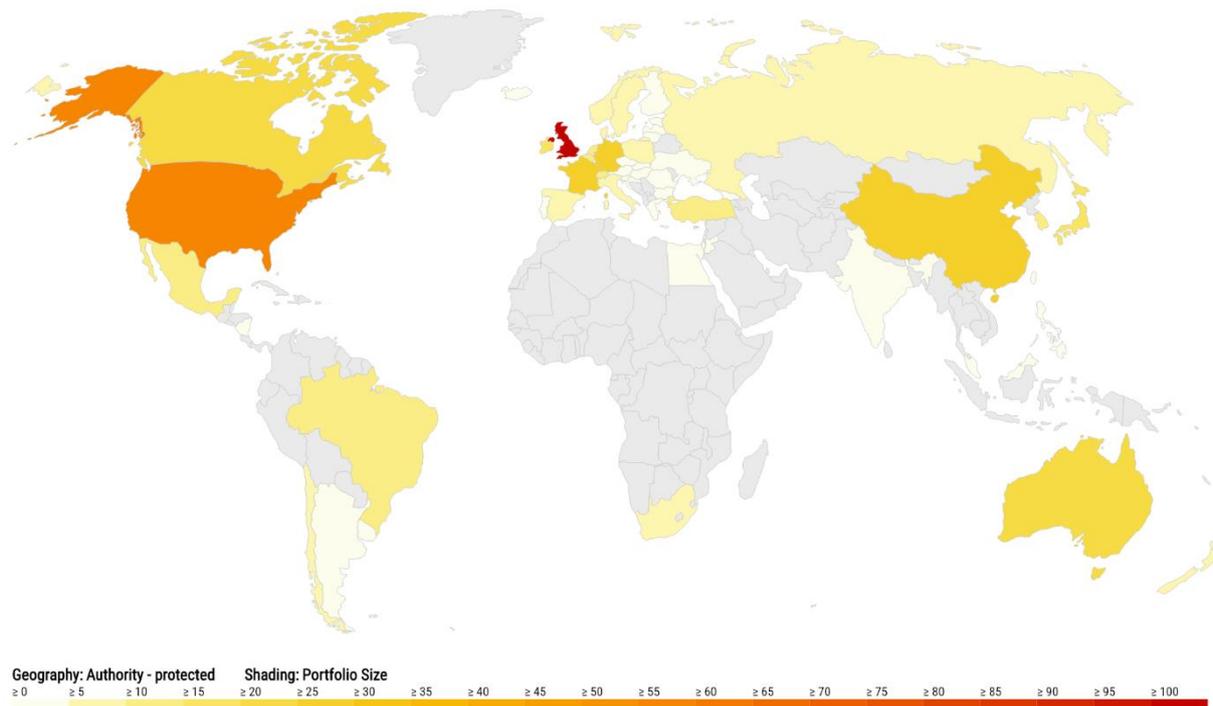


Figure 9 shows that patents invented in the UK are mostly also being protected in the UK. This is followed by the US being the next most popular country for patent protection, and then lower numbers of patents being protected in Australia, Canada, China, France and Germany. This varies somewhat to what has been seen in other reports in this series of reports on the patenting of technologies in the ten point plan; in some of the other reports, UK inventors generally appear to seek protection in multiple countries. The reasons for an apparently more insular protection strategy in this sector may warrant further investigation.

Figure 10: Top 10 owners of flood and coastal defence patent families which are active in the UK, 2001-2018

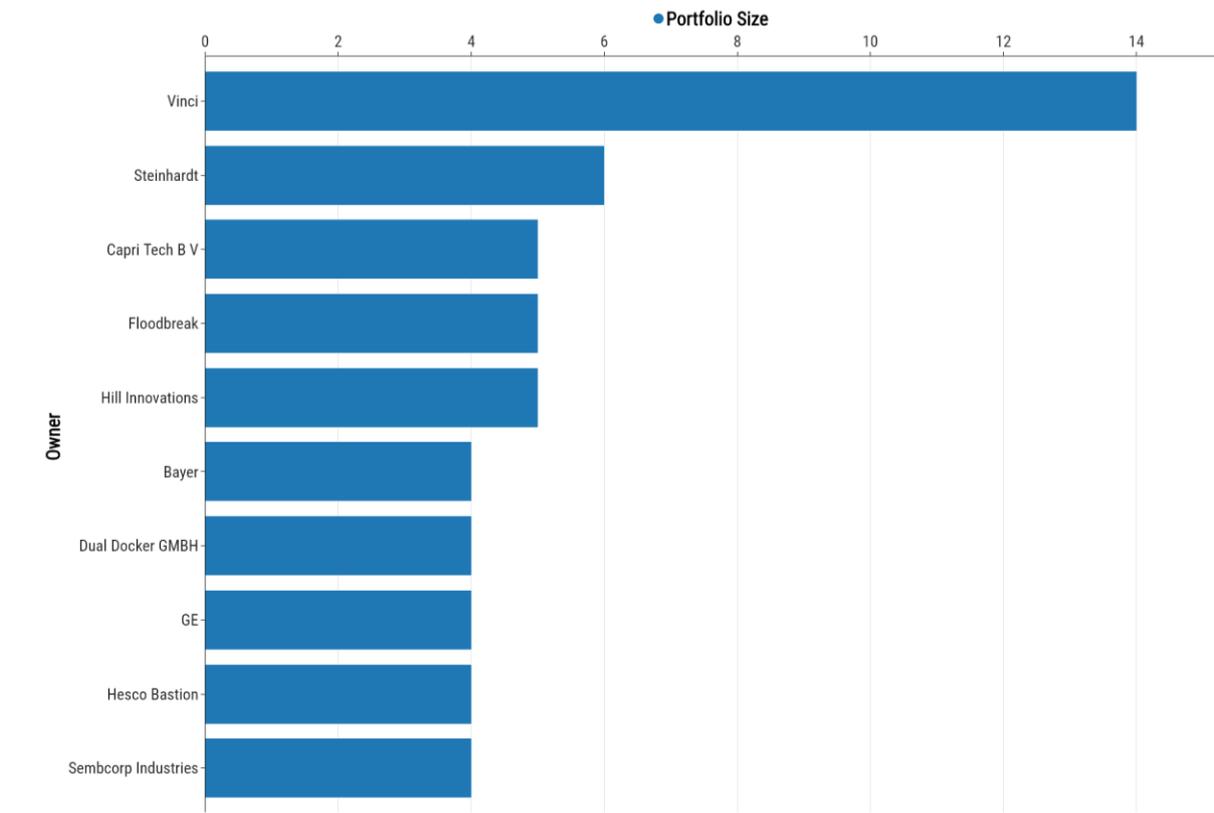


Figure 10 shows that Vinci own the most patents in this area which are active in the UK. Around 11% of patents relating to flood and coastal defences are owned by these top 10 owners. Vinci appear to have more than double the number of active patent families active in the UK compared to other owners. Vinci are a French concessions and constructions company, and an investigation into their patents shows they own a number relating to constructional features which could be used within reinforced soil structures as well as dams, dykes and the like.

Hesco Bastion appear to be the most prominent company for patents in this area which were invented in the UK. Hesco Bastion are a company with offices in the UK and the US, and produce earth-filled barriers known as gabions, which may be used for flood defences as well as within military fortifications.

3. Flood and coastal defences specifically for adaption to climate change

This section looks specifically at patents contained within Cooperative Patent Classification (CPC) Y02A10, which specifically focuses on technologies for adaption to climate change at coastal zones and at river basins. This is in order to focus more specifically at areas relating to point 9 of the UK government's ten point plan.

3.1 Worldwide patent landscape

Figure 11: Number of active patent families worldwide per priority (first filing) year for flood and coastal defence patents specifically adapted for climate change, 2001-2018

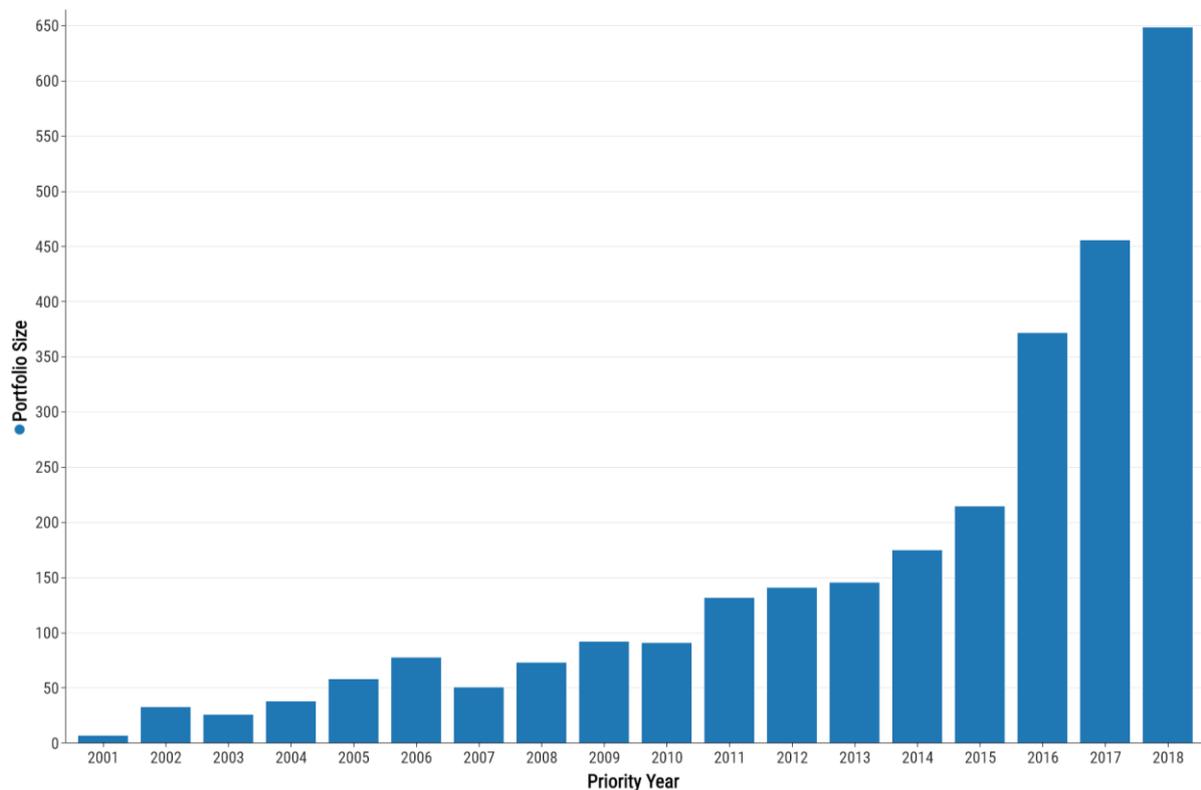


Figure 11 above shows how the number of active patent families filed each year relating to CPC Y02A10 (2,833) has significantly increased from 2001-2018. There appears to have been a gradual increase from 2001 to around 2010, where the number of active patent families filed each year then increase fairly dramatically from 2015 onwards. The trend seen here broadly follows trends seen for flood and coastal defence patents in general, showing the same increase in the most recent years.

Figure 12: Top 10 owners of for flood and coastal defence patents specifically adapted for climate change, 2001-2018

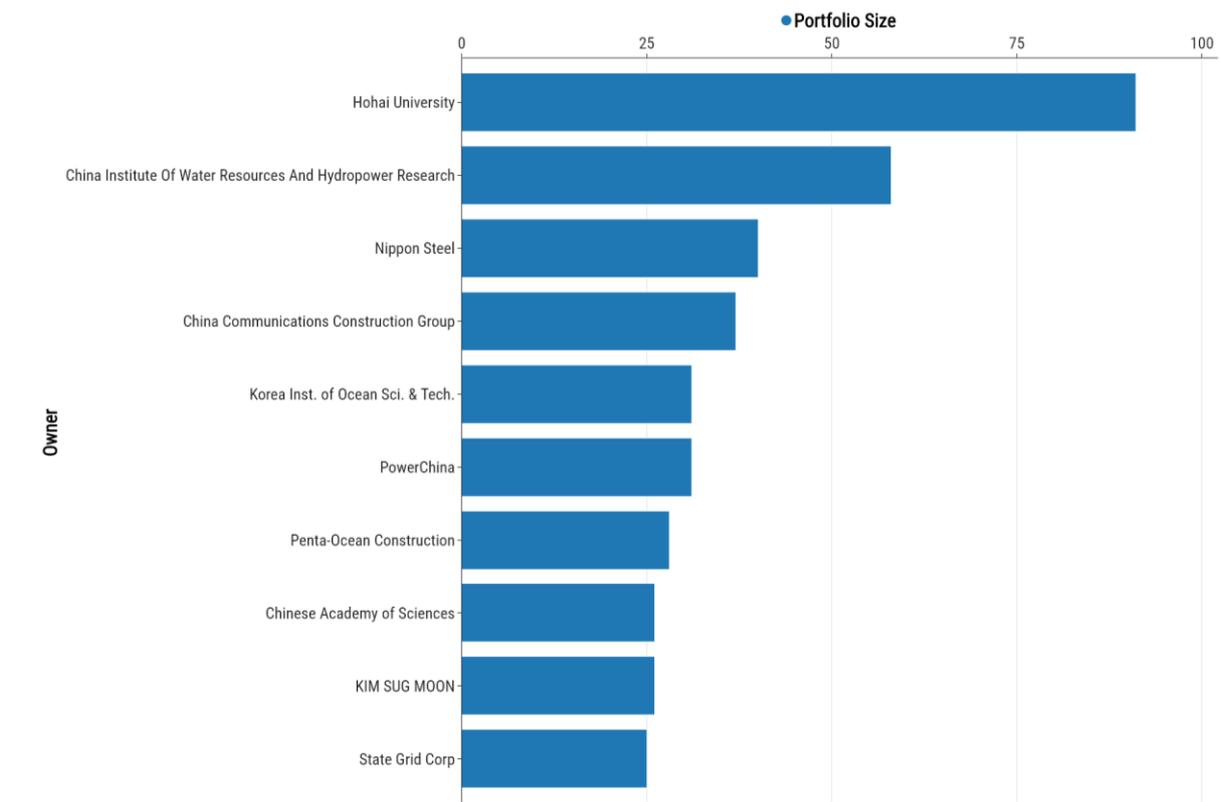


Figure 12 shows how the owners of patents in this area are broadly similar to those who own patents relating to flood and coastal defences in general. Again there is a similar prevalence of Chinese-based companies that appear to be very active in this sector. Around 14% of patents in this sector are owned by these top 10 owners.

In broad terms, worldwide trends looking at flood and coastal defences specifically for adaption to climate change follow the same trends as those seen for flood and coastal defence patterns in general, but on a smaller scale. As such, similar charts have been excluded from this point in the report to avoid repetition of the same trends.

3.2 UK patent landscape

Figure 13: Number of patent families active in the UK per priority (first filing) year for flood and coastal defence patents specifically adapted for climate change, 2001-2018

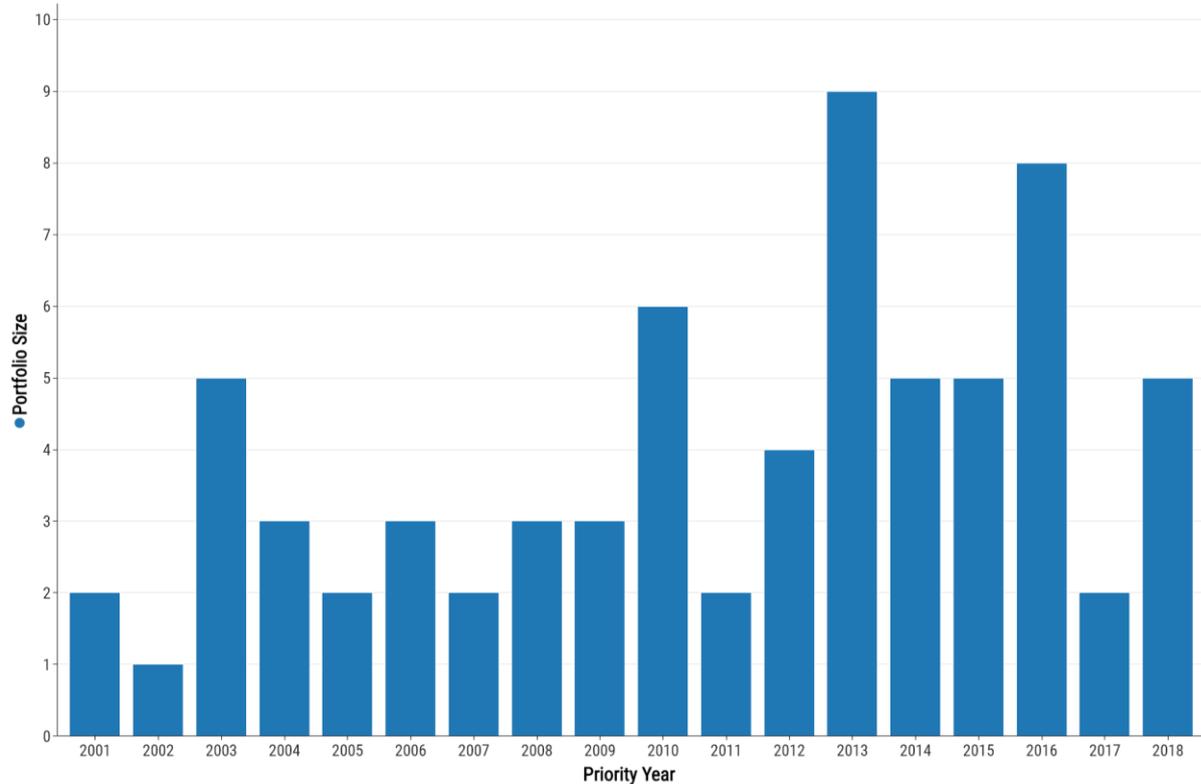


Figure 13 shows the number of patents relating specifically to CPC Y02A10, and active in the UK (70). This is a fairly small number compared to flood and coastal patents in general, and due to the small order of magnitude it is difficult to establish a clear pattern from the above chart. It can be said, however, that there is continuing activity in this technological field in the UK, and owners are maintaining at least some patenting activity in the UK.

Only 20 patent families relating to CPC Y02A10 were invented in the UK from 2001-2018. A chart showing this grouped by priority year has not been included since it does not provide any meaningful insights into trends in this technological area. UK companies appear to be continuing to file for patents in this area, but on a substantially smaller scale compared to flood and coastal defence patents in general.

4. Conclusions

Flood and coastal defences in general are relatively well-known and established technology areas, therefore one may expect that activity in this area would be relatively stable. The worldwide patenting trends however shows that innovation in this area is still ongoing and patenting activity is in fact continuing to increase in recent years.

China appears to be a key country in the area of flood and coastal defences, and over half of all patents in this technological area appear to be invented in China. This may be a result of the country's focus on hydroelectric power, where dams are used as part of hydroelectric power generation as well as for flood defence purposes.

Most patents relating to flood and coastal defences fall within the construction sector, emphasising how the construction of physical structures is a key aspect of technological development of flood and coastal defences.

In terms of the UK landscape, patenting activity is on a much smaller scale compared to the worldwide picture. In general, patenting activity in the UK has moderately increased over time, showing that there is continuing innovation in the flood and coastal defences area. There are relatively low levels of patenting being invented in the UK in this sector, with some owners such as Hesco Bastion filling for patents that could be used within flood defences, but may also have other purposes.

Appendices

Appendix A: Search strategy

For this study, the LexisNexis worldwide patent database was interrogated using PatentSight¹⁴.

A.1 Flood and coastal defences in general

IPC=(E02B 3, E02B 7, E02B 8, E02D 17/18) OR CPC=(E02B 3, E02B 7, E02B 8, E02D 17/18, E04H 9/145, Y02A 10, Y02A 40) AND TAC=((prevent* or reduc* or control* or limit* or regul* or manag* or protect* or defen* or guard*) AND (flood* or wave* or tide* or coast* or tsunami*)) AND PriorityDate=(2001-01-01 TO 2018-12-31)

A.2 Flood and costal defences specifically for adaption to climate change

CPC=(Y02A 10) AND PriorityDate=(2001-01-01 TO 2018-12-31)

Appendix B: Cooperative Patent Classification (CPC) definitions

E02B3/00 Engineering works in connection with control or use of streams, rivers, coasts, or other marine sites (barrages or weirs E02B7/00); Sealings or joints for engineering works in general

E02B7/00 Barrages or weirs; Layout, construction, methods of, or devices for, making same

E02B8/00 Details of barrages or weirs

E02D17/18 Making embankments, e.g. dikes, dams

E04H9/145 Floods

Y02A10/00 at coastal zones; at river basins

Y02A40/00 Adaptation technologies in agriculture, forestry, livestock or agroalimentary production

¹⁴ <https://go.patentsight.com/BI2.0/bi/secure/src/resources/documentation/syntax-cheat-sheet/SyntaxCheatSheet.pdf?245be120476a49463f31ebcd79b10b19e>

Appendix C: Relative Specialisation Index (RSI)

Relative Specialisation Index (RSI) was calculated to account for the fact that some countries file more patent applications than others in all fields of technology. In particular US, Chinese and Japanese applicants and inventors are prolific patentees.

The RSI compares the fraction of a country's technology-specific patents, out of all of its patents across all fields of technology, with the corresponding fraction of technology-specific patents worldwide.

A logarithm is applied to scale the fractions more suitably; an RSI of zero then represents a country that is no more or less specialised than the worldwide average.

The Relative Specialisation Index (RSI) for country c in technology t is defined as:

$$RSI_{c,t} = \ln \left(\frac{n_{c,t}/n_t}{N_c/N} \right)$$

where:

$n_{c,t}$ = number of patents for country c in technology t

n_t = sum of patents in all countries in technology t

N_c = number of patents for country c

N = sum of patents for all countries.

A value above positive indicates that a country has a higher specialisation in this field than would be expected, whilst a negative value indicates a lower specialisation than expected for that country.

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