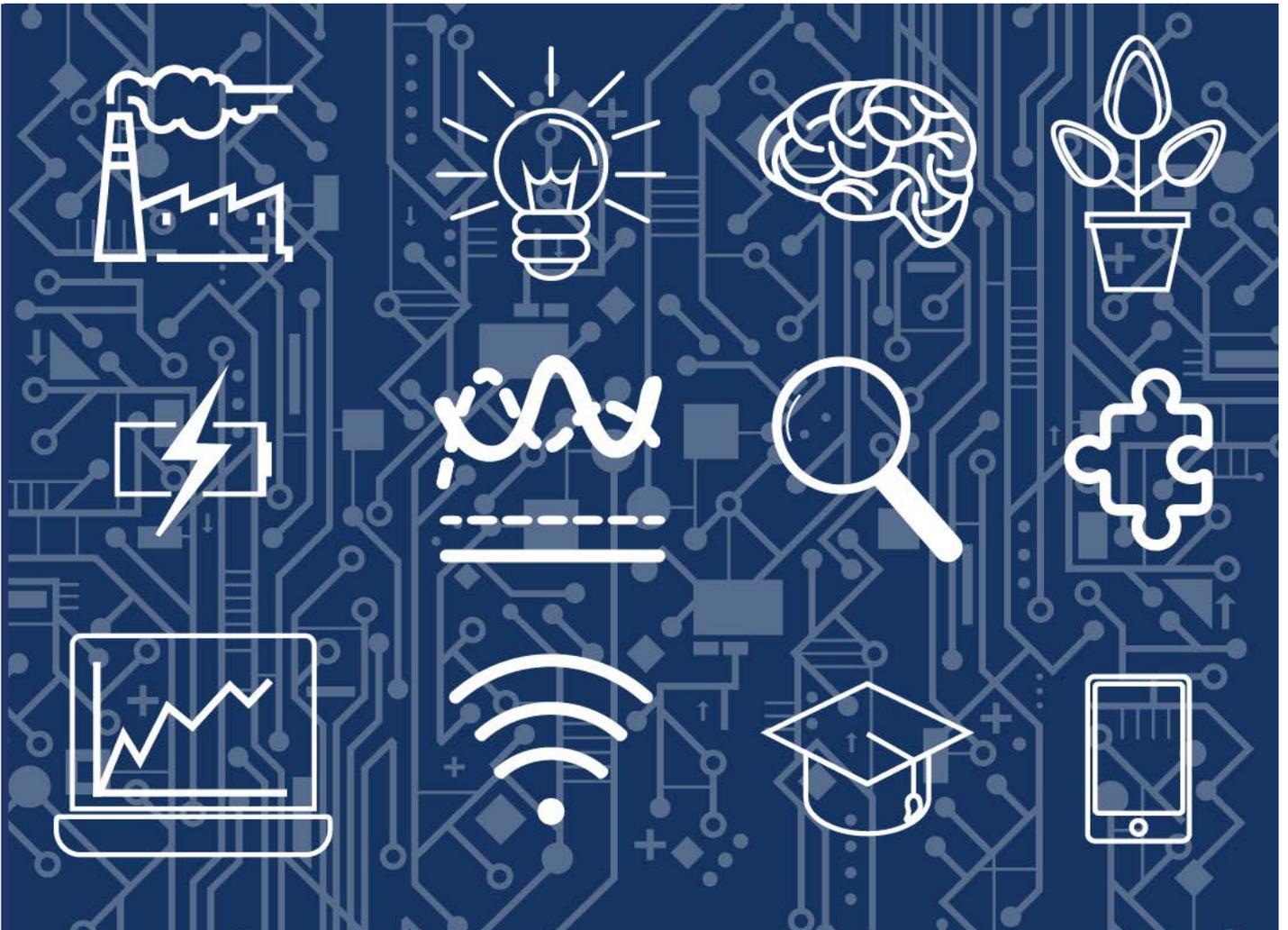




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# Greener buildings and heat pumps

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



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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.<sup>1</sup>

The Energy White Paper (EWP)<sup>2</sup>, published in December 2020, and the Industrial Decarbonisation Strategy<sup>3</sup>, 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-assumed<sup>4</sup> the presidency of COP26 (26<sup>th</sup> UN Climate Change Conference of the Parties) and is hosting the COP26 UN Climate Change Conference in Glasgow in 2021.<sup>5,6</sup>

In November 2020 the UK government released a ten point plan for a green industrial revolution<sup>7</sup>, 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.

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<sup>1</sup> <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>

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

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

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

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

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

<sup>7</sup> <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 zero<sup>8</sup> 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 greener building and heat pump 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<sup>9</sup>. The data coverage of this database is that of DOCDB, the European Patent Office's (EPO) database.<sup>10</sup>

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.

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

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

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

## 1.2 Greener buildings and heat pumps

Point 7 of the government's ten point plan focuses on making buildings more energy efficient, as well as moving away from fossil fuel boilers. Improving the energy efficiency of buildings can be achieved with innovative design of buildings as well as the use of insulation.

Moving away from fossil fuel boilers can be achieved by the use of heat pumps. Heat pumps are devices which heat buildings by transferring thermal energy from a cooler space to a warmer space. These can use various sources, including air, ground (geothermal), and water. Hybrid systems also exist, which can draw heat from various sources. According to the International Energy Agency, nearly 20 million households worldwide purchased heat pumps in 2019, and account for approximately 5% of global building heating demand.<sup>11</sup>

The UK government plans to implement a Future home Standard by 2025 to help future-proof new buildings and ensure high levels of energy efficiency in new buildings.<sup>12</sup> It is also aiming for 600,000 heat pump installations per year by 2028.

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<sup>11</sup> <https://www.iea.org/reports/heat-pumps>

<sup>12</sup> <https://www.gov.uk/government/groups/heat-in-buildings>

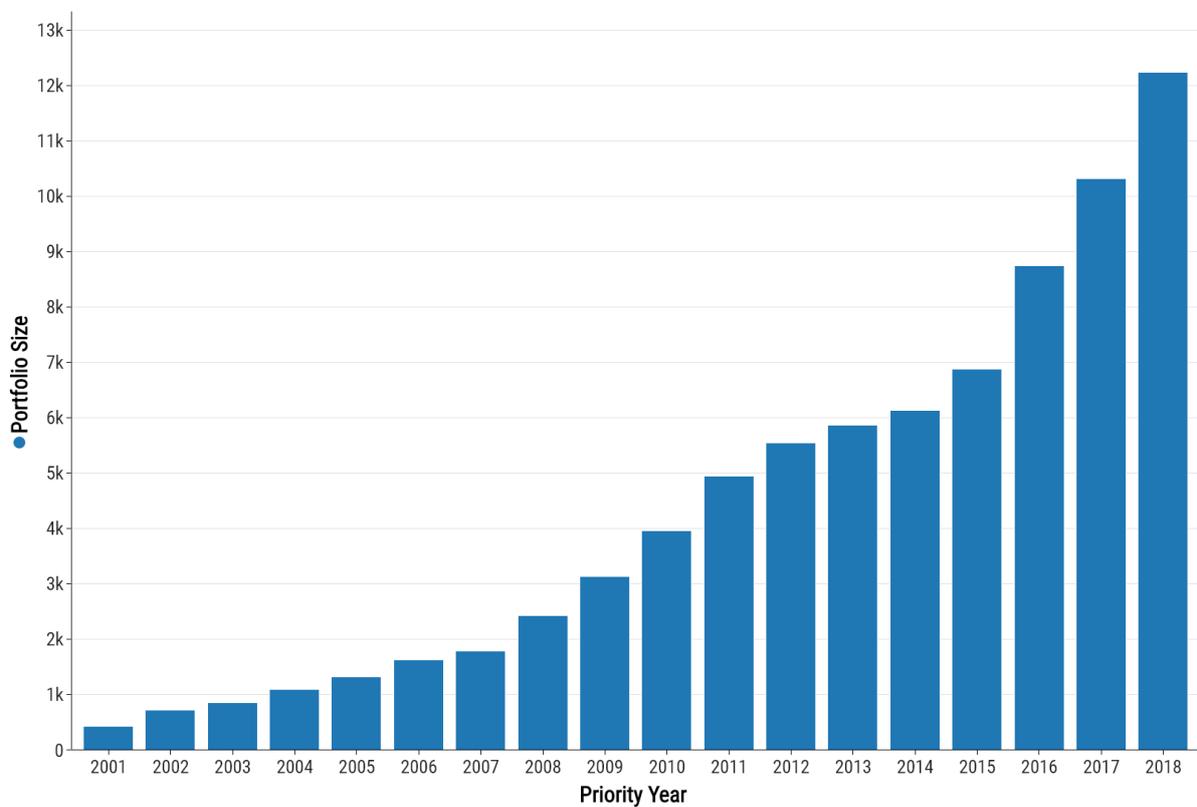
## 2. Greener buildings

This section focuses on patents whose subject matter relates to improving the energy efficiency of buildings in general. It firstly looks at the worldwide landscape before looking at the landscape in the UK.

### 2.1 Worldwide patent landscape

Figure 1 shows that there has been a continuing year-on-year increase in the number of active patent families filed each year relating to greener buildings from 2001-2018. Data are grouped by the earliest priority (first filing) year for each patent family. In total, there are 99,857 active patent families in this time period. There was over a 400% increase in the number of active patent families filed each year from 2008 to 2018. This shows that this is a growing sector of technology.

Figure 1: Number of active greener building patent families, grouped by priority (first filing) year, 2001-2018



China stands out clearly in Figure 2 showing that there are 52,581 active patent families in this country. Following China, the US is the next most prominent country. There also appears to be more activity in Japan and South Korea, followed by European nations and Canada.

Figure 2: World map showing where greener building patents are being protected, 2001-2018

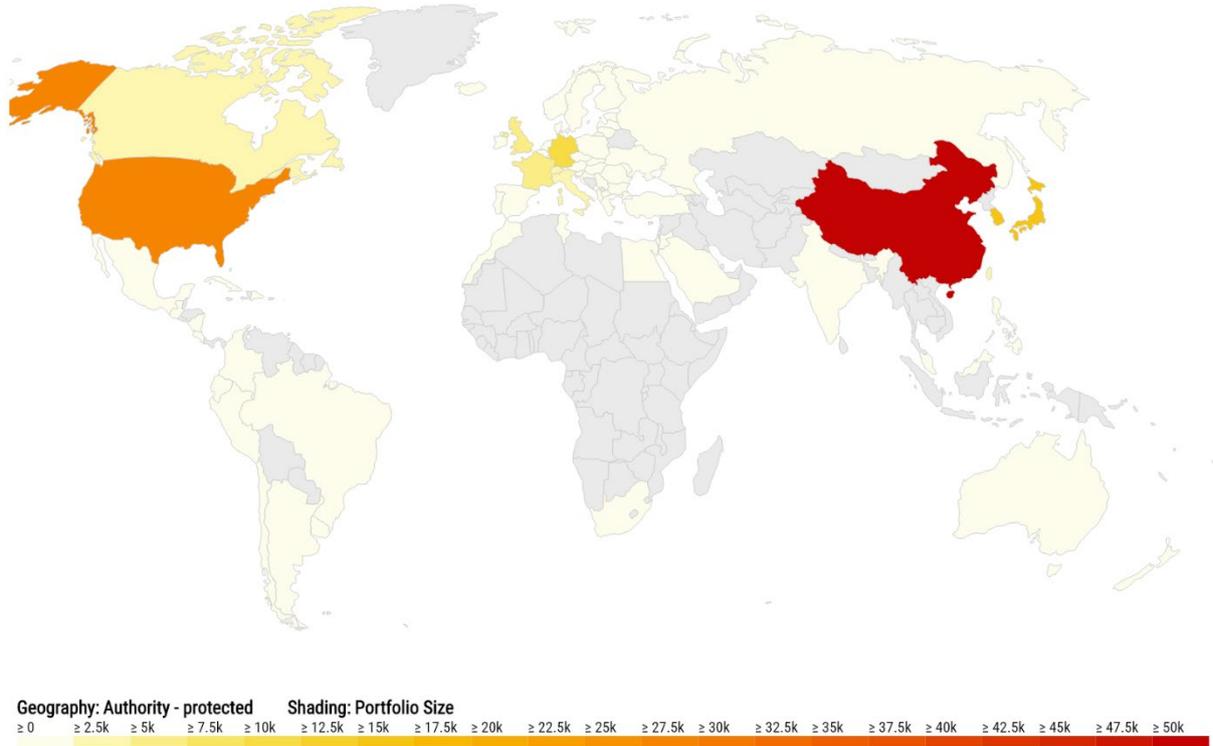


Figure 3: World map showing where greener building patents are being invented, 2001-2018

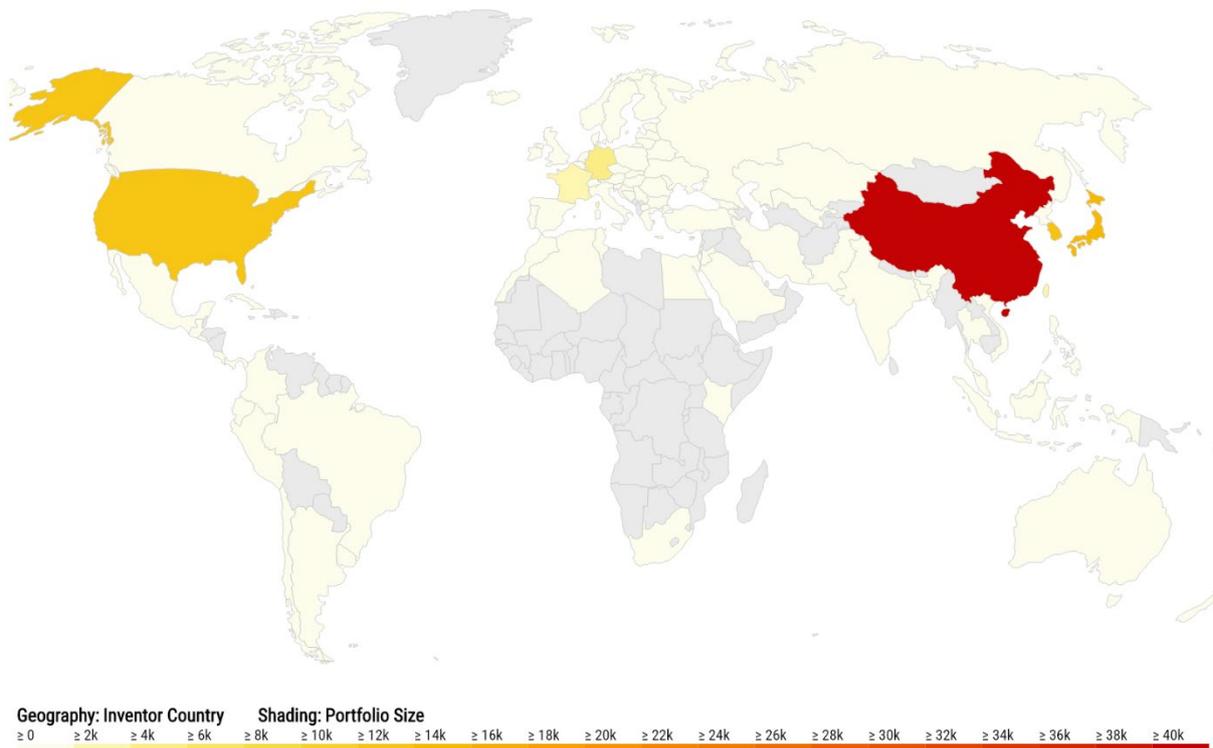


Figure 3 broadly follows the same pattern as shown in Figure 2. This means that a significant proportion of patents relating to greener buildings are being invented in China, followed by Japan and the US.

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 greener building patents, 2001-2018

Country	Relative Specialisation Index
United Kingdom	0.788
France	0.667
Australia	0.397
Canada	0.320
Germany	0.233
India	0.162
USA	-0.127
South Korea	-0.184
China	-0.220
Japan	-0.348

Table 1 shows the Relative Specialisation Index (RSI)<sup>13</sup> of the top 10 patenting countries for green building technologies. From this, we can see that the UK has a value well above zero, meaning that UK based inventors are producing more patents in this field than would be expected given the absolute levels of patenting within the UK. This value is also suggesting that out of the nations shown above, the UK is the most specialised in relation to technologies related to greener buildings.

<sup>13</sup> See Appendix C for details of how the Relative Specialisation Index (RSI) is calculated

Figure 4: Top 20 owners of greener building patents, 2001-2018

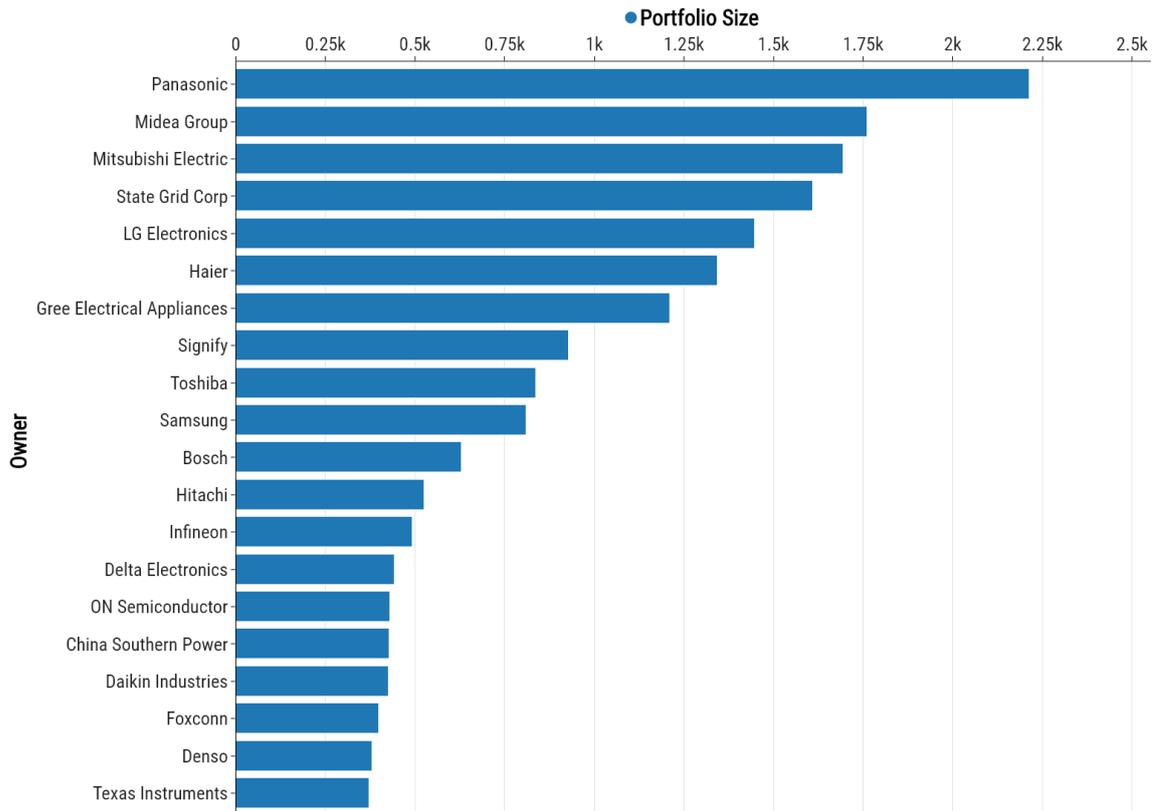


Figure 4 shows that Panasonic owns the most patent families in this area, with over 450 patent families more than the next owner, Midea Group. Most owners appear to be companies that operate in the electrical sector, suggesting that areas such as ‘smart home’ technologies may be an area of focus for technology relating to greener buildings. These top 20 owners own around 18% of patents relating to greener buildings.

Figure 5: Number of active greener building patent families per owner, grouped by priority (first filing) year, 2001-2018

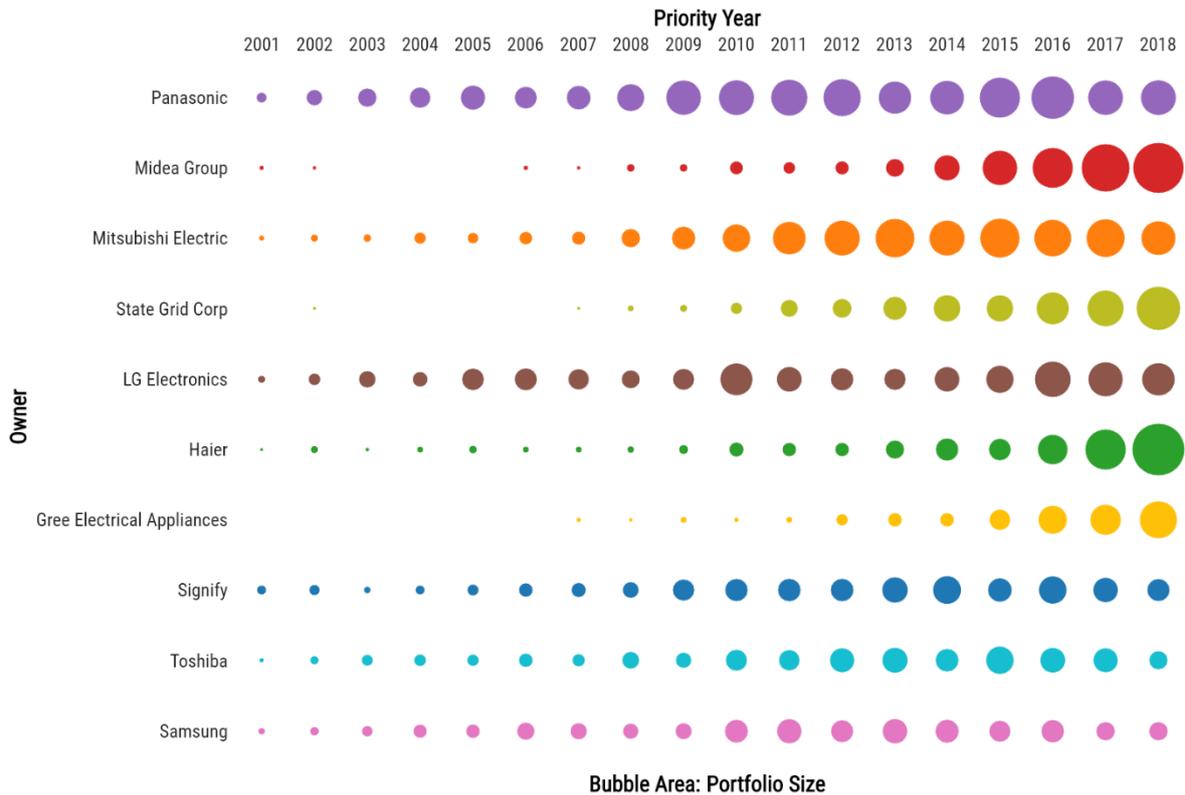
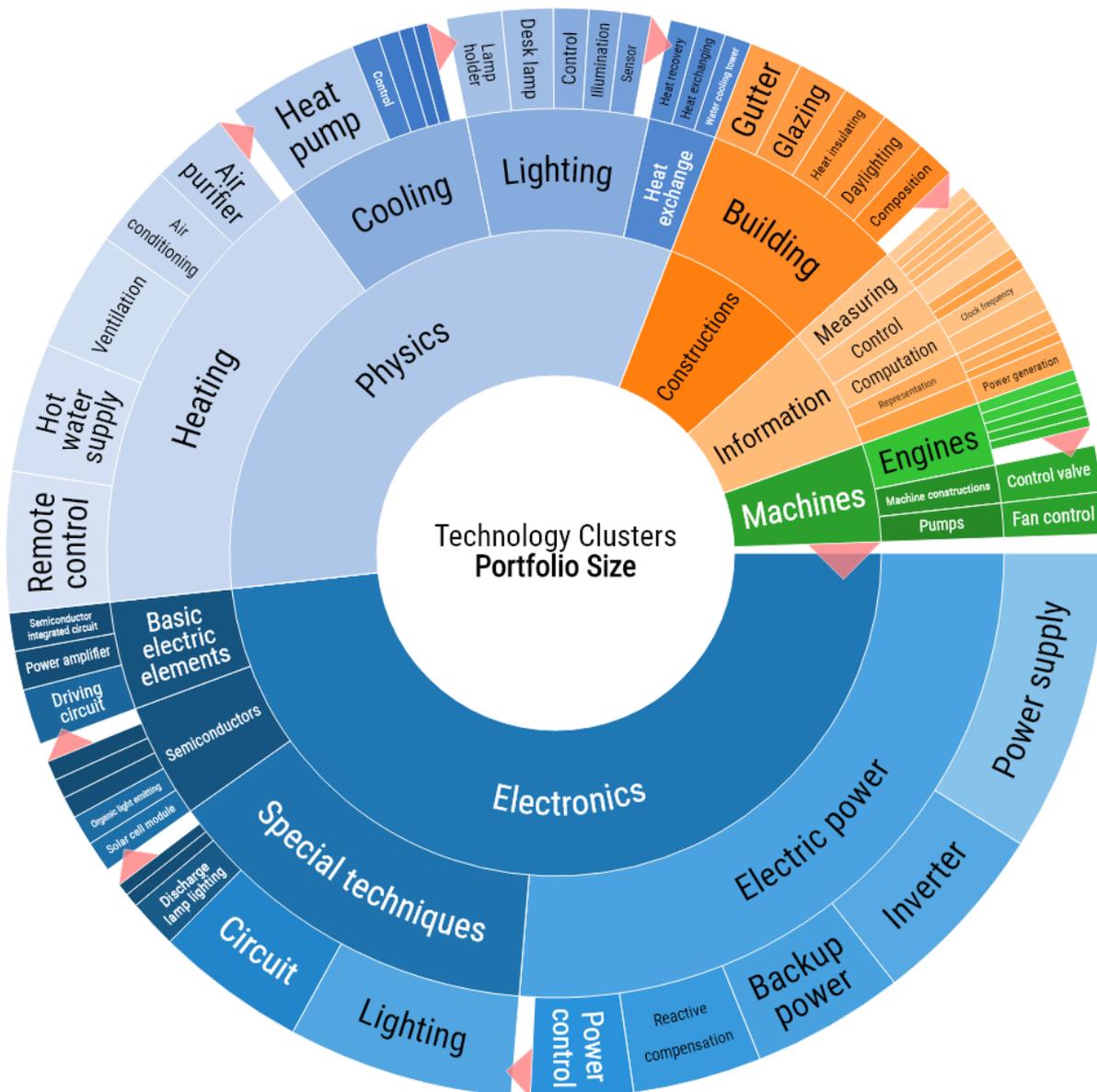


Figure 5 shows how the top 10 owners of patents relating to greener buildings have been increasing over this time period. Panasonic have been relatively consistent in their number of annual filings over the past decade. In comparison, Midea Group appear to have significantly increased their patenting activity in more recent years from 2014-2018. Haier and Gree Electrical Appliances both appear to have increased their patenting activity from 2016 onwards.

Figure 6: Sunburst chart of the technology clusters covered by greener building patents, 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. Figure 6 shows that 46% of greener building patents relate to electronics. From this sunburst chart, only 5.4% of patents relate directly to buildings. This suggests that greener building development is more focused on technological advancements and uses of electronics rather than relating specifically on construction. 17% of patents relate to heating, suggesting that the heating of homes is a significant focus within greener building patents (e.g. smart home heating technologies).

## 2.2 UK patent landscape

This section focuses specifically on the UK landscape for patents relating to green buildings.

Figure 7: Number of greener building patents active in the UK, 2001-2018

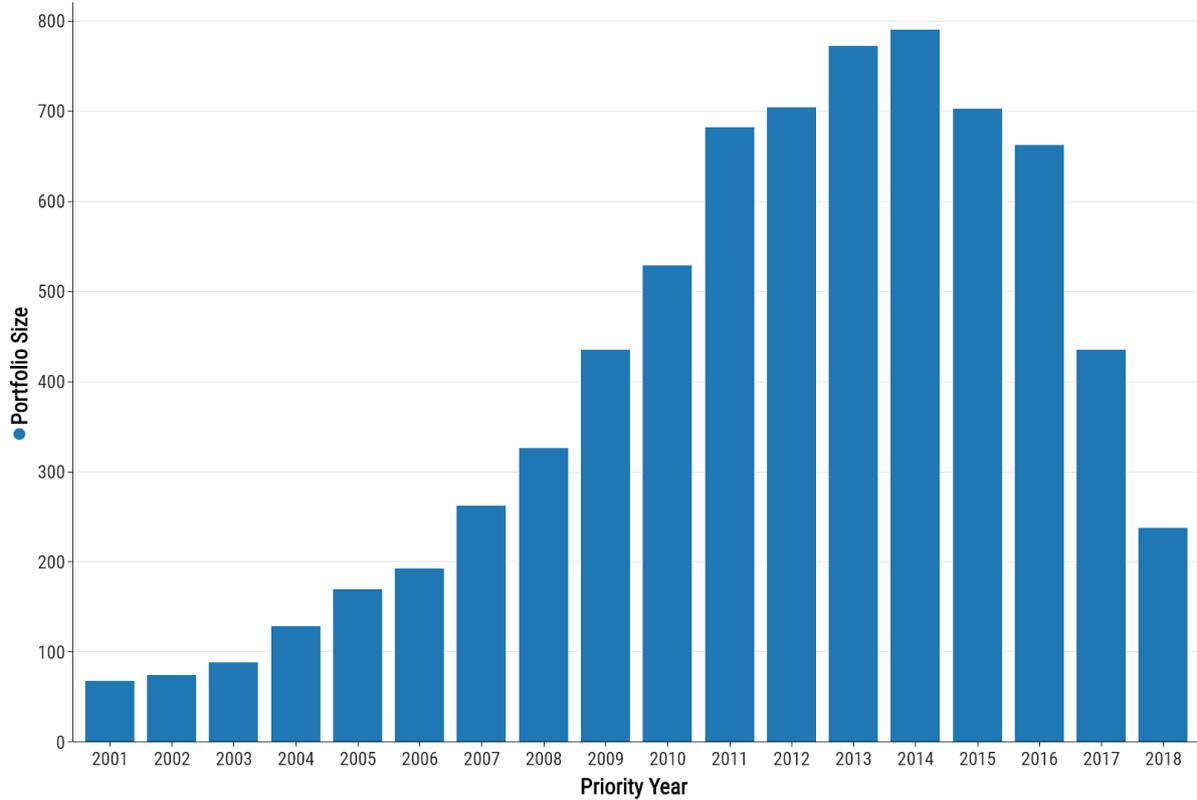


Figure 7 shows how the number of greener building related patents filed each year increased significantly from 2001-2015, with large annual increases over this time. In total, there are 7,271 patent families in the UK.

Figure 8: Number of greener building patent families invented in the UK, 2001-2018

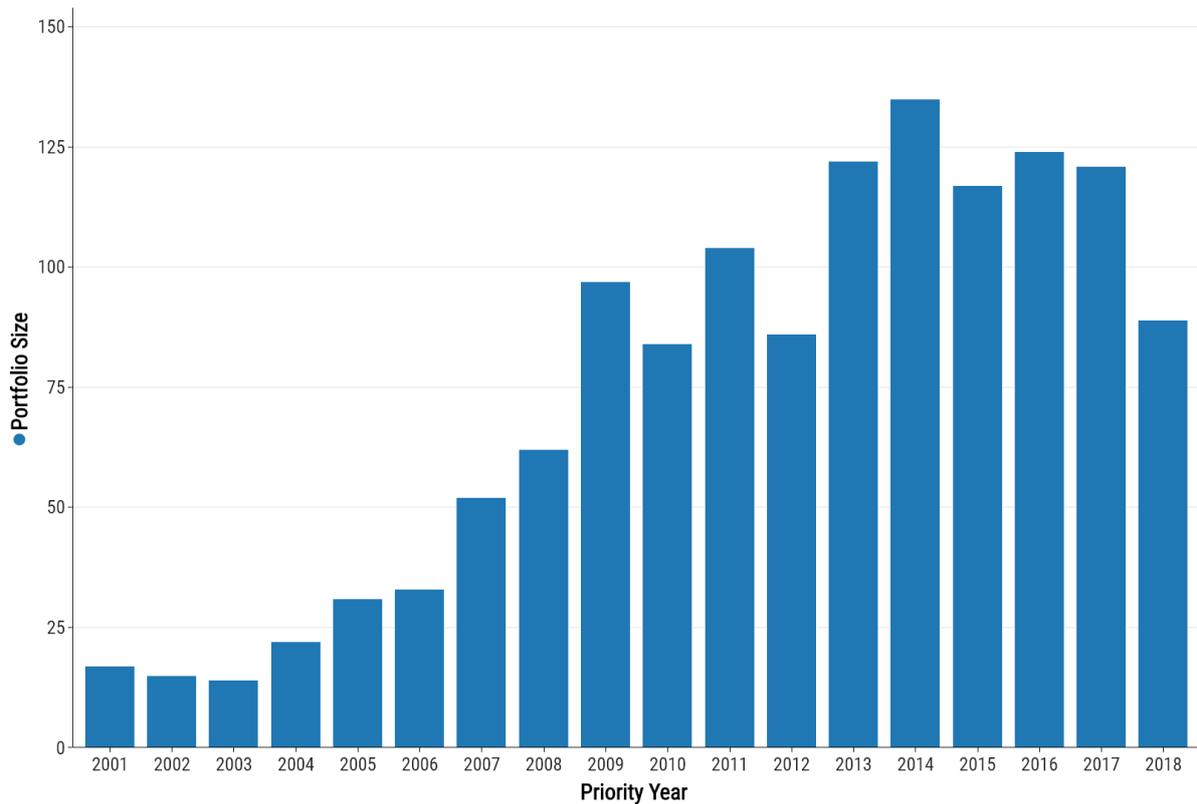


Figure 8 shows that the number of patents filed each year invented in the UK (1325), has been increasing over time. There was a significant increase from 2004-2009, where the number of active patent families filed each year increased four-fold. The growth rate of active patent families continued to increase until 2013, where it appears to level off for some years prior to a decrease in 2018. This decrease may be mirroring the decrease seen in Figure 7.

Figure 9: World map showing where greener building patents active in the UK are being invented, 2001-2018

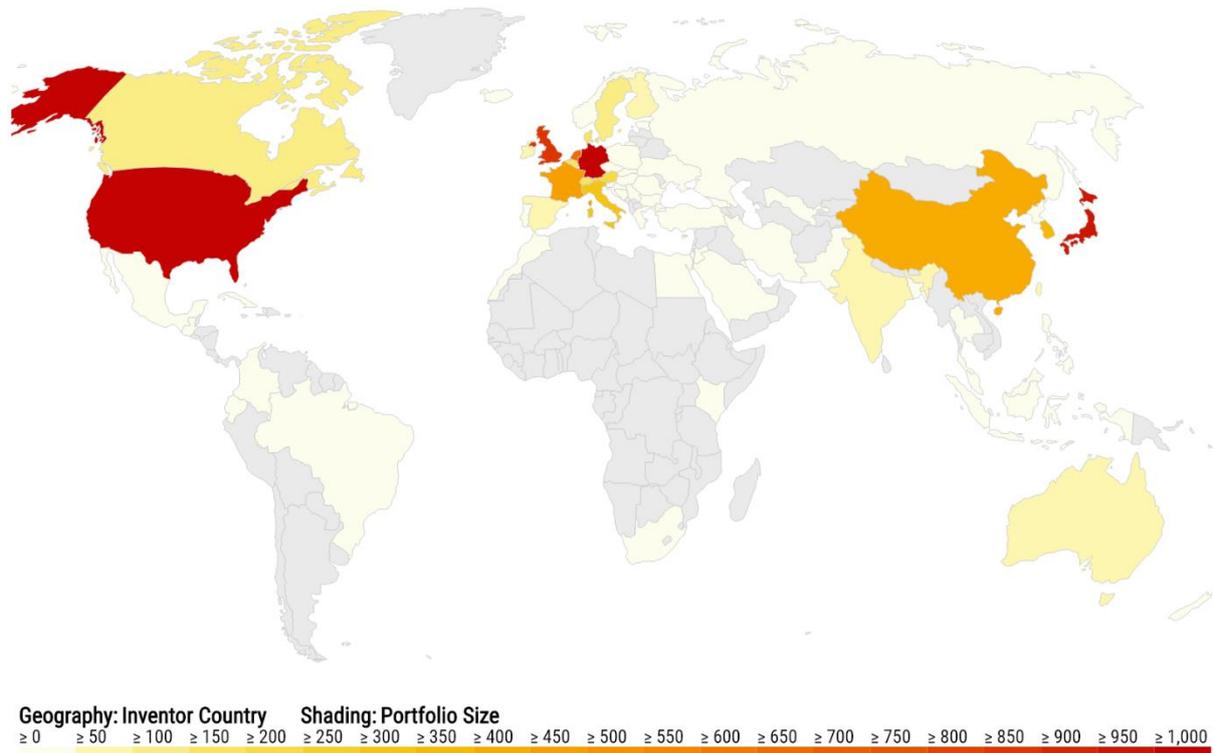
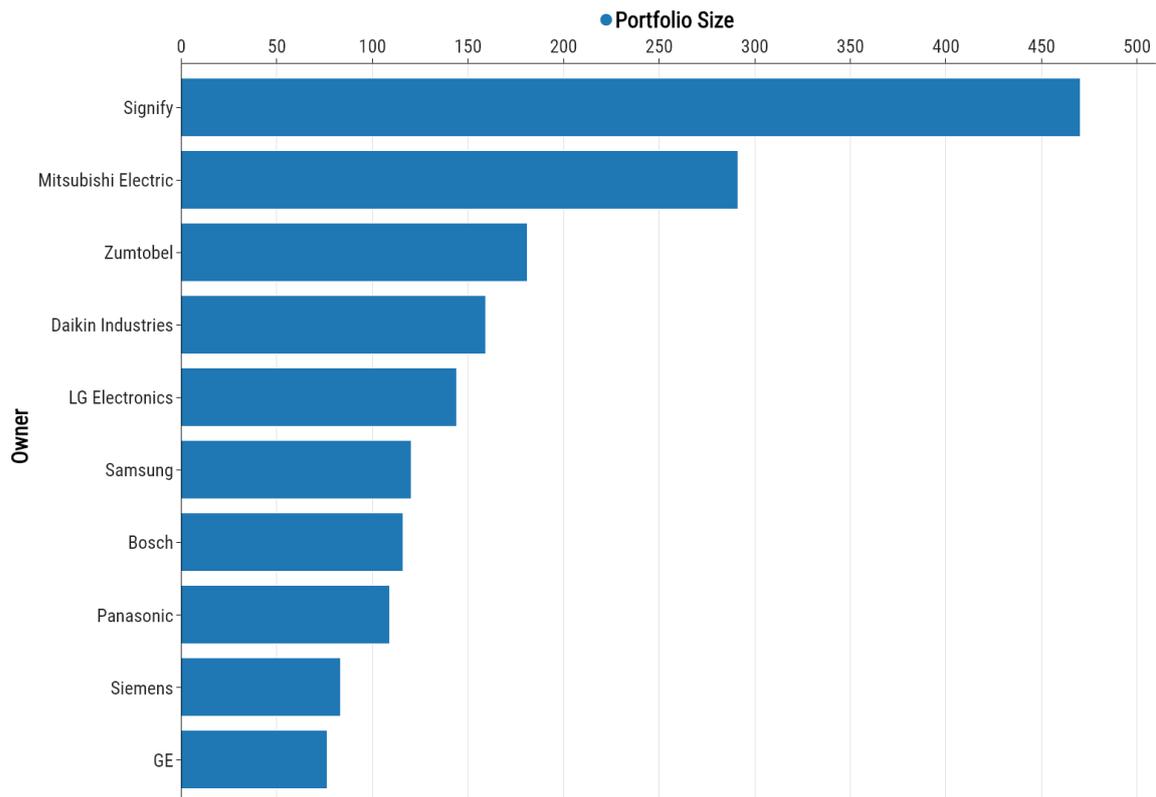


Figure 9 shows that most of the greener building patents active in the UK appear to be invented in the US, Japan, Germany, and the UK itself. China does not feature as prominently here compared to the worldwide landscape, suggesting that a substantial proportion of Chinese inventors in this field do not seek patent protection in the UK, especially compared to inventors from other nations. Of the 7,271 patents active in the UK, only 400 or so were invented in China, compared to 1,425 having been invented in the US.

Figure 10: Top 10 owners of greener building patents active in the UK, 2001-2018



From Figure 10 it is clear that Signify has significantly more patent families active in the UK compared to other companies. Signify, formally known as Philips Lighting, is a spin-off of the Dutch multinational company Philips, and focuses on energy-efficient lighting products.<sup>14</sup> Zumtobel is another company which focuses on lighting technology, suggesting that lighting technology is an important aspect within greener building patents active in the UK.<sup>15</sup> 24% of patents active in the UK relating to greener buildings are owned by these top 10 owners.

<sup>14</sup> <https://www.signify.com/en-gb>

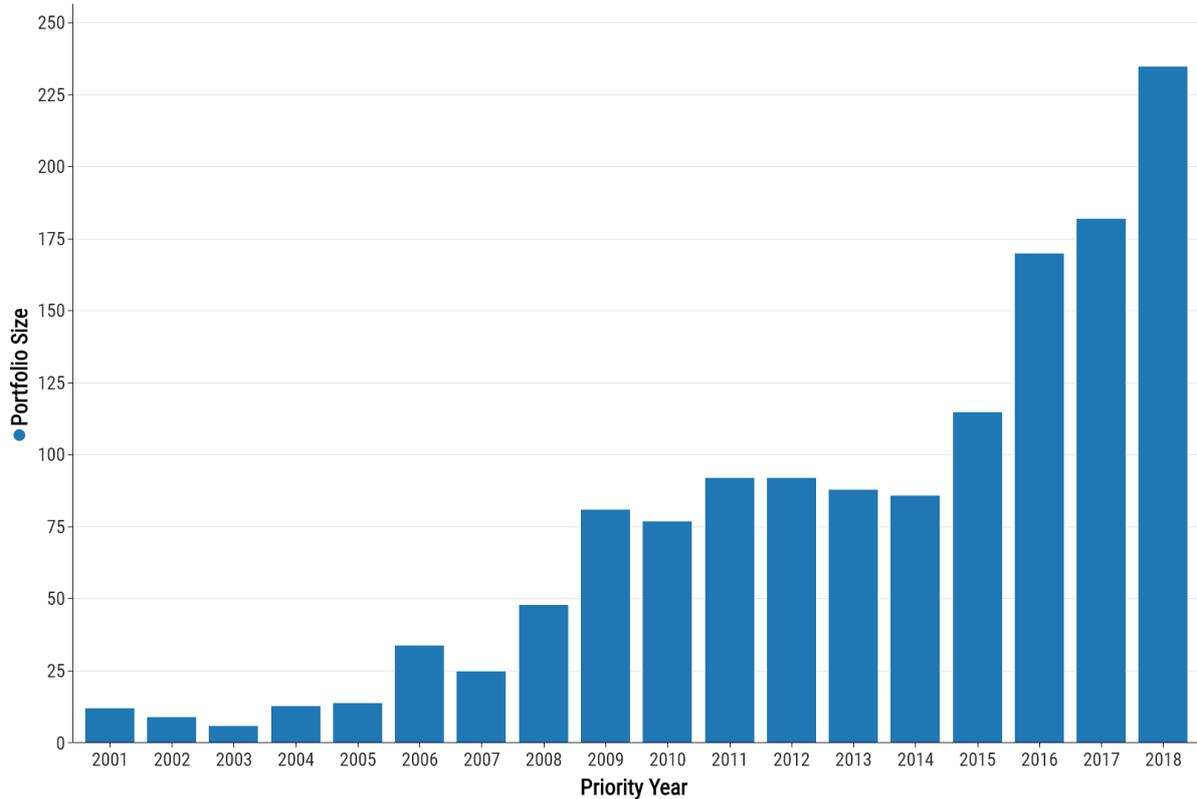
<sup>15</sup> <https://www.zumtobel.com/gb-en/index.html>

### 3. Heat pumps

This section focuses specifically on heat pumps, since this technology area is expected to be of increasing importance in future years as part of point 7 of the government's ten point plan.

#### 3.1 Worldwide patent landscape

Figure 11: Number of active heat pump patent families, grouped by priority (first filing) year, 2001-2018



It can be seen from Figure 11 that there was relatively little patent activity in heat pump technologies from 2001-2007. This period was followed by a period of moderate activity from 2008-2015, followed by a substantial increase from 2015 onwards, where the number of active patent families filed each year doubled from 2015-2018. The total number of active patents relating to heat pumps in this time period is 1379.

Figure 12: World map showing where heat pump patents are being invented, 2001-2018

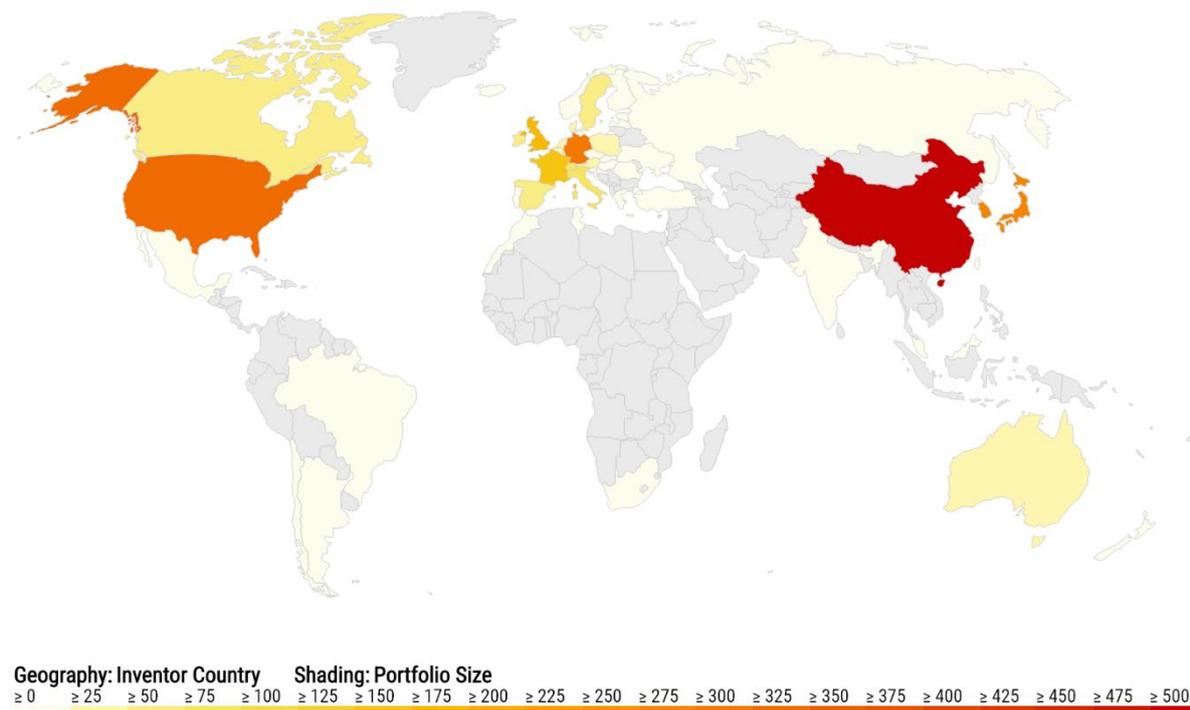


Figure 12 shows that the bulk of heat pump patents appear to have been invented in China. Following this, the US, Japan, South Korea and Germany appear next most prominently.

Table 2: Relative Specialisation Index of selected nations for heat pump patents, 2001-2018

Country	Relative Specialisation Index
Austria	0.879
Germany	0.322
Canada	0.294
South Korea	0.216
<b>United Kingdom</b>	<b>0.155</b>
China	0.030
Australia	0.009
France	-0.157
Japan	-0.177
USA	-0.180

Table 2 shows that a number of countries, notably Austria and Germany, are more specialised in relation to heat pump technology compared to other nations. The UK appears to be less specialised in this area compared to greener building technology in general. This is shown by a value closer to 0 in Table 2 compared to Table 1.

Figure 13: Top 20 owners of heat pump patents, 2001-2018

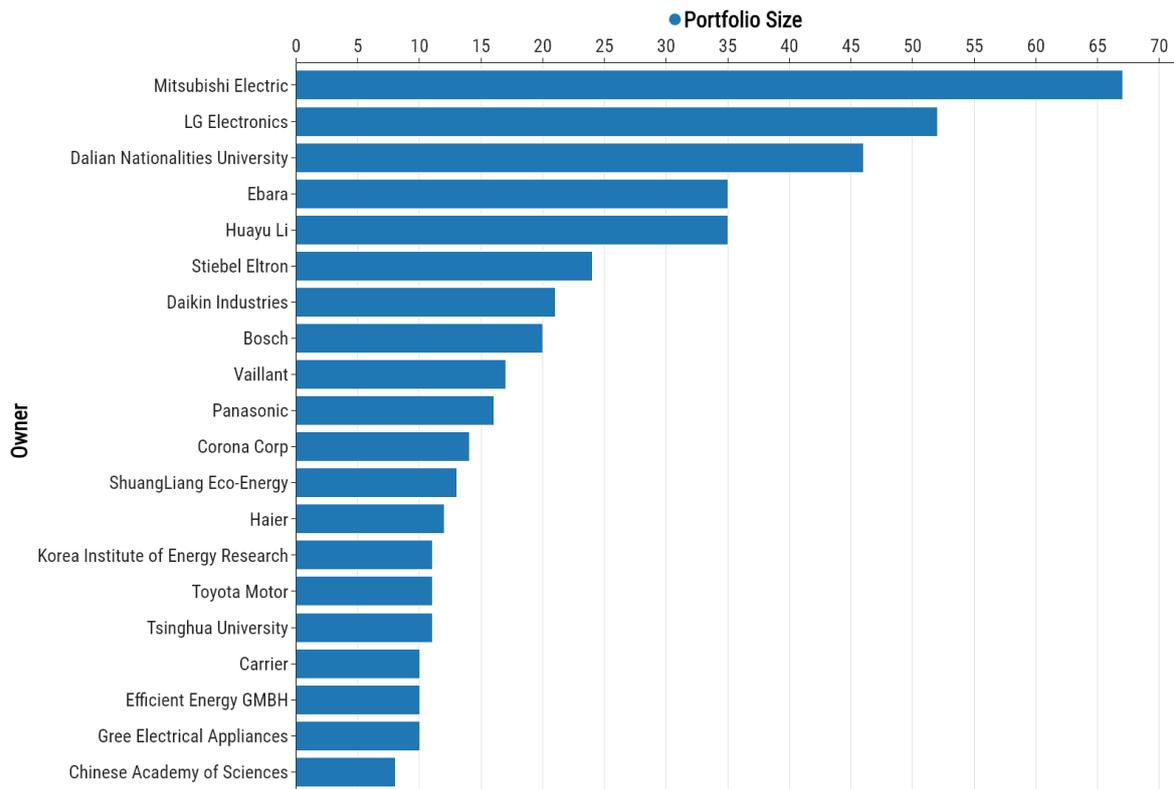


Figure 13 shows that most owners of patents relating to greener buildings (as shown in Figure 4) are on the most part also most prevalent owners of patents relating specifically to heat pumps. Also appearing here are some educational institutions, which may be reflective of this emerging technology area since these universities may be engaged in research that may result in patentable inventions being developed. 32% of heat pump related patents are owned by these top 20 owners.

## 3.2 UK patent landscape

Figure 14: Number of heat pump patents active in the UK, grouped by priority (first filing) year, 2001-2018

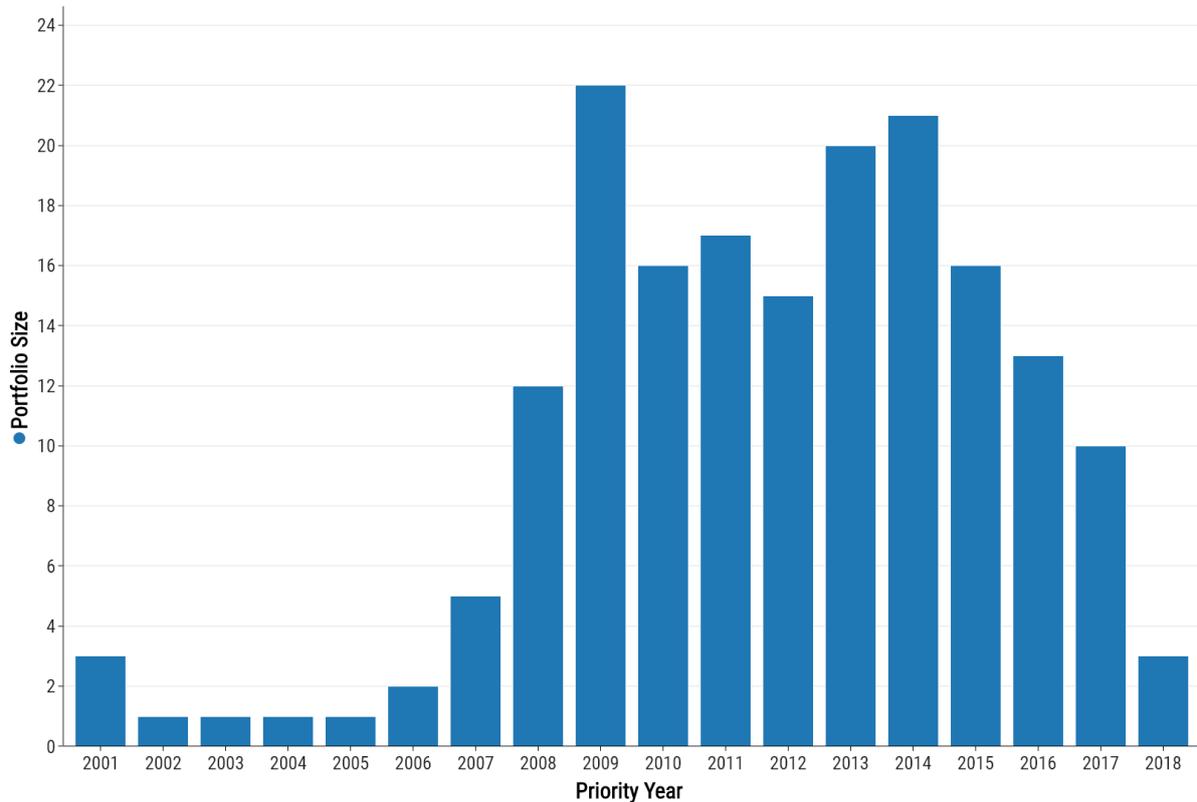
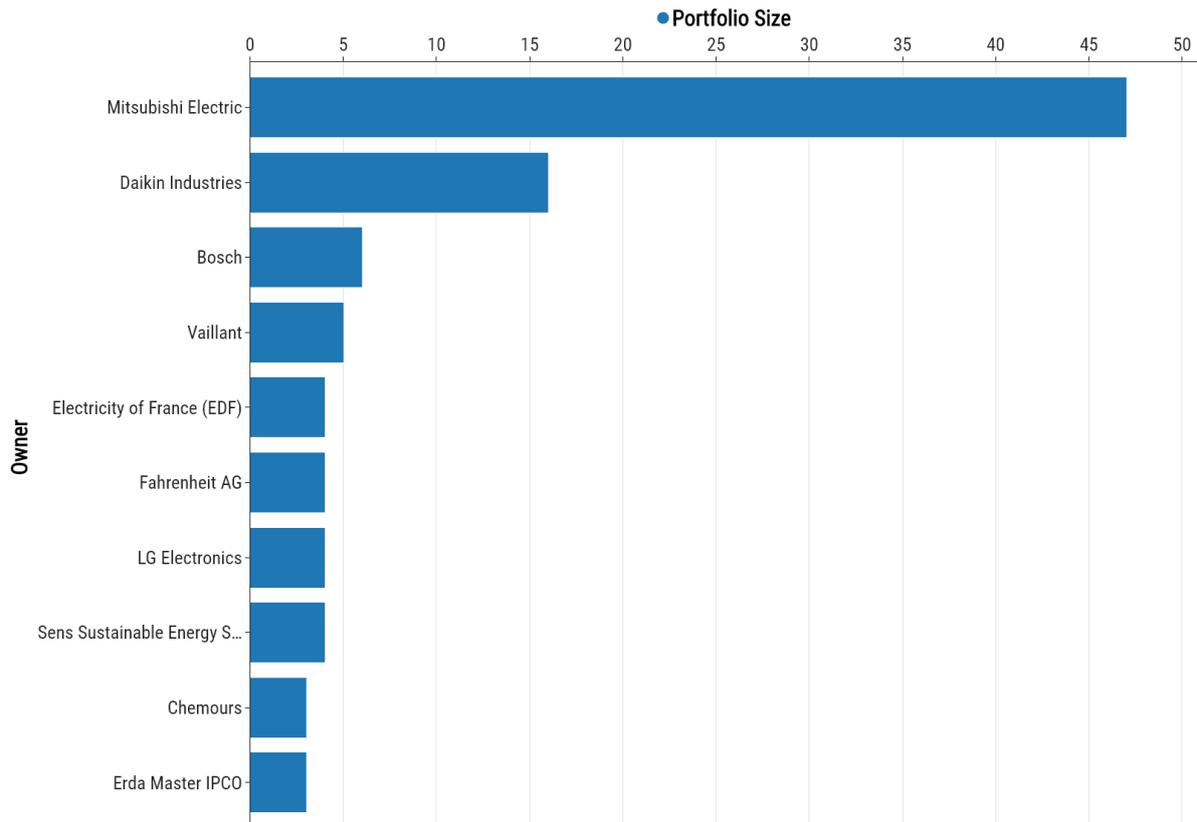


Figure 14 shows the number of heat pump patents active in the UK (179). The relatively low number of active patent families may cause some fluctuations in numbers to appear more pronounced. There was limited patenting activity in this area from 2001-2007. This was followed in an increase in patenting activity from 2008-2015. After this, there appears to have been a decline in the growth rate from 2016-2018. This broadly mirrors the trend seen in the UK for greener buildings in general, but does not appear to be reflecting worldwide activity in relation to heat pumps.

Figure 15: Top 10 owners of heat pump patents active in the UK, 2001-2018



Looking at Figure 15, Mitsubishi Electric have a much larger portfolio of patents active in the UK compared to other owners, owning 26% of heat pump patents active in the UK. This company produces a substantial number of air conditioning and building systems, which include low-carbon products as well as heat pumps, going some way into explaining their large portfolio in this area.<sup>16</sup> These 10 owners own 53% of patents relating to heat pumps in the UK.

<sup>16</sup> <https://gb.mitsubishielectric.com/en/products-solutions/air-conditioning/index.html>

The most prominent owner of heat pump patents invented in the UK is Erda Energy.<sup>17</sup>

Table 3: Details of patents owned by Erda Energy

Patent family	Priority year	Title	Current owners	Active authorities (today)
EP2176548.A1	2007	Geothermal energy system and method of operation	ERDA MASTER IPCO	BE, CA, CH, CN, DE, DK, FI, FR, GB, NL, NO, SE, US
EP2179174.A1	2007	Geothermal energy system and method of operation	ERDA MASTER IPCO	BE, CA, CH, DE, DK, FI, FR, NL, NO, SE, US
EP2310678.A2	2008	Thermal energy system and method of operation	ERDA MASTER IPCO	BE, CA, CH, DE, DK, FI, FR, GB, NL, NO, SE, US
EP2683993.A2	2011	Thermal energy system and method of operation	ERDA MASTER IPCO	CA, EP, US
EP2893264.A2	2012	Thermal energy system and method of operation	ERDA MASTER IPCO	BE, CH, DE, DK, FI, FR, GB, NL, NO, SE, US
EP3084318.A1	2013	Controlling heat exchange from refrigeration system to geothermal system	ERDA MASTER IPCO	CA, EP, GB, US
EP3092445.A2	2014	Thermal energy network	ERDA MASTER IPCO	CA, EP, GB, US

Table 3 shows the relatively small patent portfolio of Erda Energy, who are a UK company with patents in the area of heat pumps.

<sup>17</sup> <https://www.erdaenergy.com/>

## 4. Conclusions

At present, there are relatively few patents directly relating to heat pumps being invented in the UK. There are more patents active in the UK in this area, but these are also small compared to patents relating to greener building technologies in general.

When looking at the worldwide picture, the growth in the number of greener building patents has been steadily increasing from 2001-2018. This suggests that technological development in this area has been ongoing for some time and is continuing to develop.

Considering the worldwide landscape of patents relating to heat pumps, this area has shown a significant increase in patenting technology in recent years compared to the early 2000s. This suggests that there may have been an increase in R&D relating to heat pump technology in recent years, which is being reflected in patenting activity.

In coming years, one could expect heat pump patenting trends to continue increasing as the technology continues to develop. In the UK, consumers may seek to pursue more environmentally friendly means of heating their homes. As a result, consumer use of heat pumps could be expected to increase in the near future. Such an increase could cause an increase in patenting activity relating to heat pumps in the UK, as companies will seek IP protection prior to commercialisation of products.

The UK government is seeking to develop low-carbon buildings in coming years, and increasing the use of low-carbon technologies such as heat pumps may be a means to help achieve this. The Green Heat Network Fund (GHNF) is a £270 million scheme which supports the commercialisation of low carbon heat network projects, and may support the use of more low-carbon technologies in the rollout of heat networks that supply heat from a central source from 2022 onwards.<sup>18</sup>

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<sup>18</sup> <https://www.gov.uk/government/news/next-generation-of-heat-networks-to-power-uks-green-revolution>

## Appendices

### Appendix A: Search strategy

For this study, the LexisNexis worldwide patent database was interrogated using PatentSight<sup>19</sup>.

#### A.1 Greener buildings

(CPC=(Y02B) OR (IPC=(E04B) AND tac=(green\* or (low NEAR 3 carbon\*) or (climat\* NEAR3 chang\*) or ((reduc\* or lower\* or lessen\*) NEAR5 (emission\* or releas\* or loss\*)))) AND PriorityDate=(2001-01-01 TO 2018-12-31)

#### A.2 Heat pumps

(CPC=(Y02B) OR (IPC=(E04B) AND tac=(green\* or (low NEAR 3 carbon\*) or (climat\* NEAR3 chang\*) or ((reduc\* or lower\* or lessen\*) NEAR5 (emission\* or releas\* or loss\*)))) AND IPC=(F25B 30)

### Appendix B: Cooperative Patent Classification (CPC) definitions

E04B General building constructions; walls, e.g. partitions; roofs; floors; ceilings; insulation or other protection of buildings

F25B30/00 Heat pumps

Y02B Climate change mitigation technologies related to buildings, e.g. housing, house appliances or related end-user applications

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<sup>19</sup> <https://go.patentsight.com/BI2.0/bi/secure/src/resources/documentation/syntax-cheat-sheet/SyntaxCheatSheet.pdf?45be120476a49463f31ebcd79b10b19e>

## 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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