

Chapter 5

2021 Patent Report Appendix

July 2021



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1. Patent Analysis

1.1. Fuel Cell Patent Activity

1.1.1. Filing and Grant Statistics

Figure A1.1.1 shows the number of published fuel cell patent applications in comparison to the number of total published patent applications according to the geographical split amongst the top 5 patent offices.

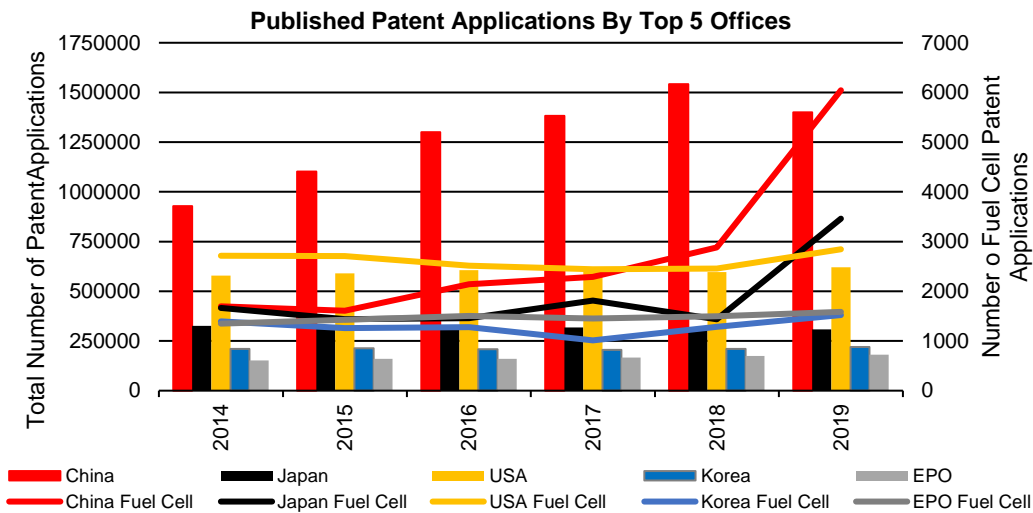


Figure A 1.1.1.1 Published fuel cell patent applications vs. total patent applications for 2014 to 2019 at Top 5 Patent Offices.

In terms of the relative rankings of the top 5 offices, the USPTO has the largest number of published fuel cell patent applications between 2014 and 2017, with China recording the greatest number of filings in 2018 and 2019. China are consistently the leading filer of overall patent applications over the period, with the number of filings increasing annually between 2014 and 2018.

Figures A1.1.2 and A1.1.3 show how the overall number of published fuel cell applications (Figure A1.1.2) and granted fuel cell patents (Figure A1.1.3), at the top 5 offices, is relatively constant year-on-year between 2014 and 2018. A significant incline is observed in the number of fuel cell patent applications published and fuel cell patents granted between 2018 and 2019, with filings in China and Japan recording the biggest increases.

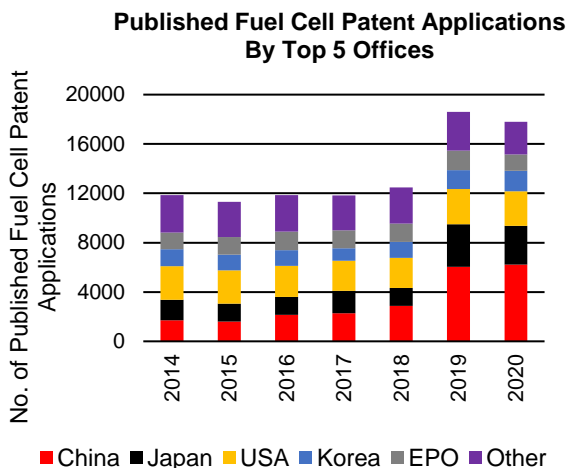


Figure A1.1.2. Annual publications of fuel cell patent applications for 2014 to 2020.

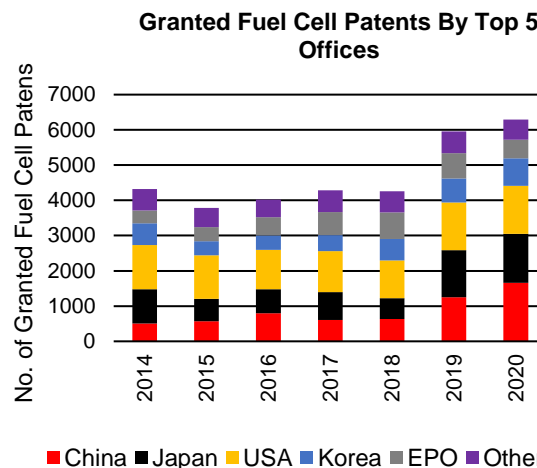


Figure A1.1.3. Annual publications of granted fuel cell for 2014 to 2020.

1.1.2. Assignee Data

The data presented below shows the top 10 filers of patent applications (Figures A1.1.4 to A1.1.10) and granted patents (Figures A1.1.11 to A1.1.18) in the area of fuel cells recorded annually from 2014 to 2020 at the top 5 patent offices. In each case the bars show the absolute number of patent applications associated with a particular entity.

The top 10 filers for both the published fuel cell applications and the granted fuel cell patents predominantly comprise the same entities. The top 10 lists are dominated by large Japanese corporations, with Toyota steadily in the leading position, with second place typically being taken by Hyundai or Nissan. This demonstrates that south east Asian automotive businesses are consistently leading the way in patent filings and, it would be imagined, in fuel cell R&D activity.

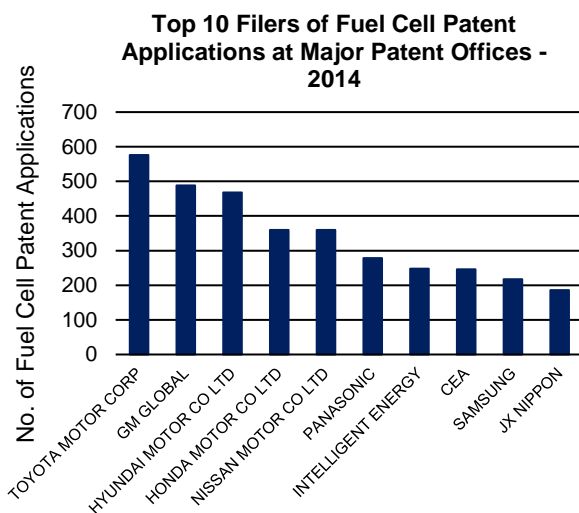


Figure A1.1.4. Top ten filers of fuel cell patent applications at the Top 5 Patent Offices for 2014.

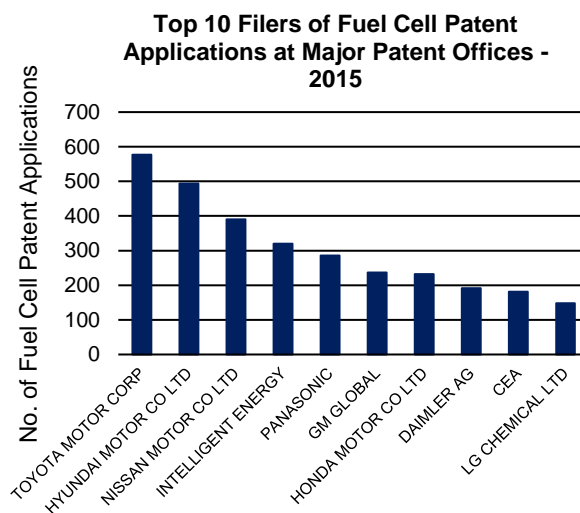


Figure A1.1.5. Top 10 filers of fuel cell patent applications at the Top 5 Offices for 2015.

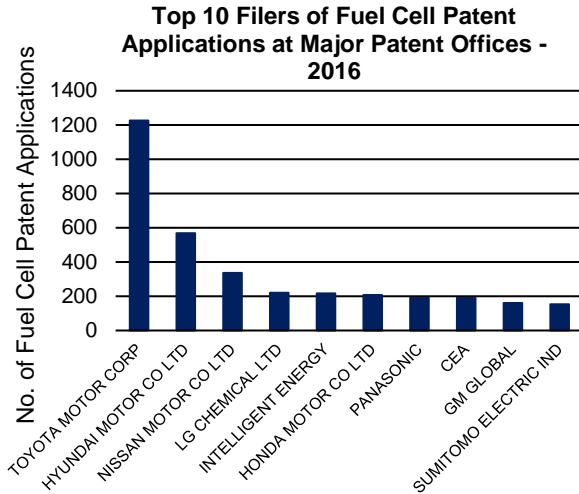


Figure A1.1.6. Top ten filers of fuel cell patent applications at the Top 5 Patent Offices for 2016.

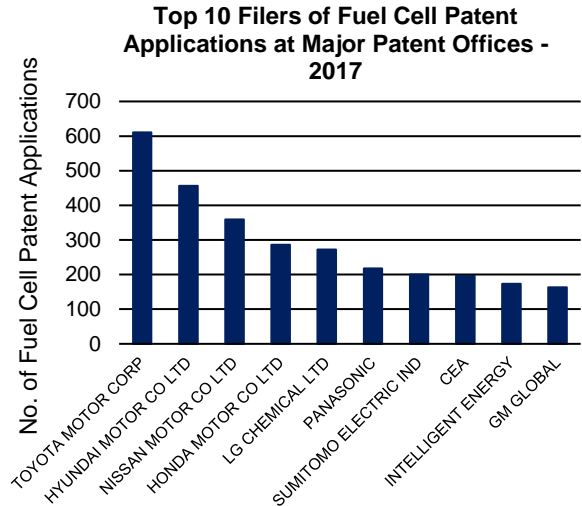


Figure A1.1.7. Top 10 filers of fuel cell patent applications at the Top 5 Offices for 2017.

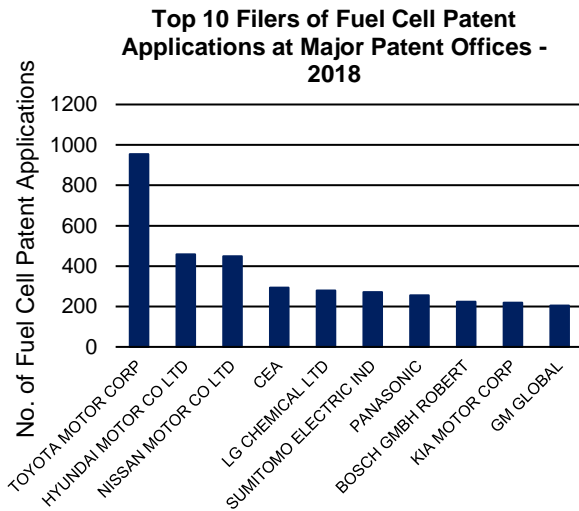


Figure A1.1.8. Top ten filers of fuel cell patent applications at the Top 5 Patent Offices for 2018.

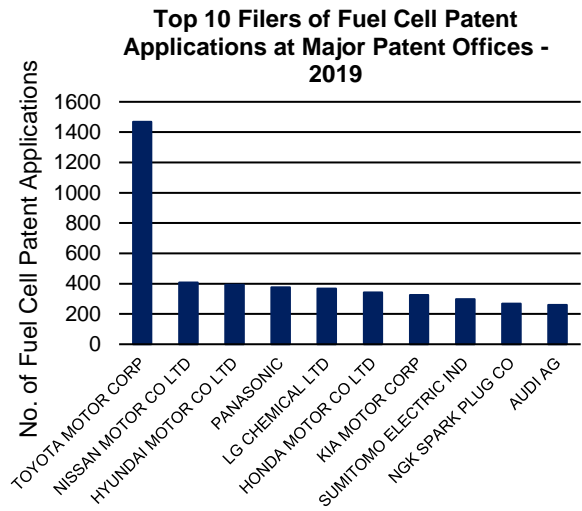


Figure A1.1.9. Top 10 filers of fuel cell patent applications at the Top 5 Offices for 2019.

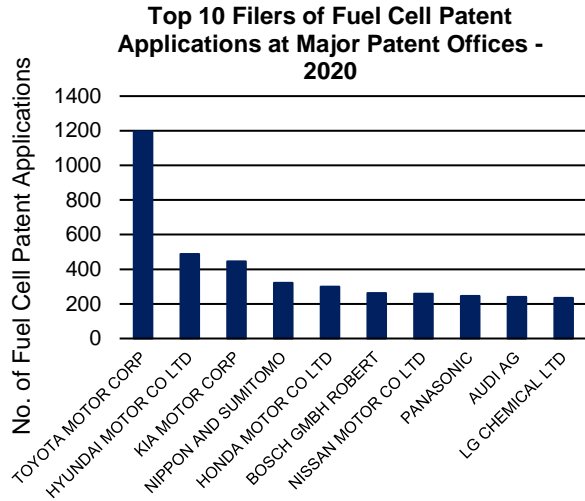


Figure A1.1.10. Top ten filers of fuel cell patent applications at the Top 5 Patent Offices for 2020.

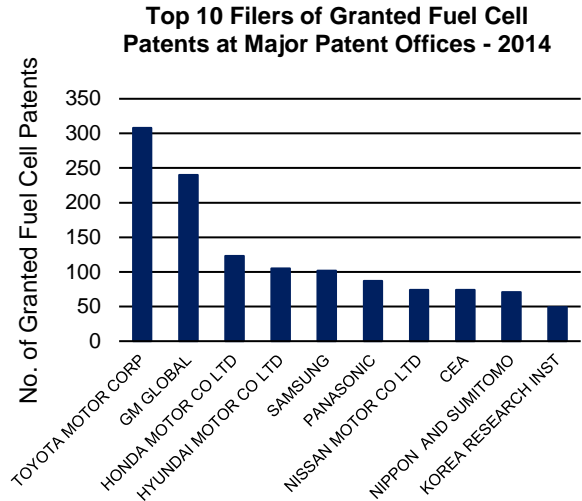


Figure 1.1.12. Top ten filers of granted fuel cell patents at the Top 5 Offices for 2014.

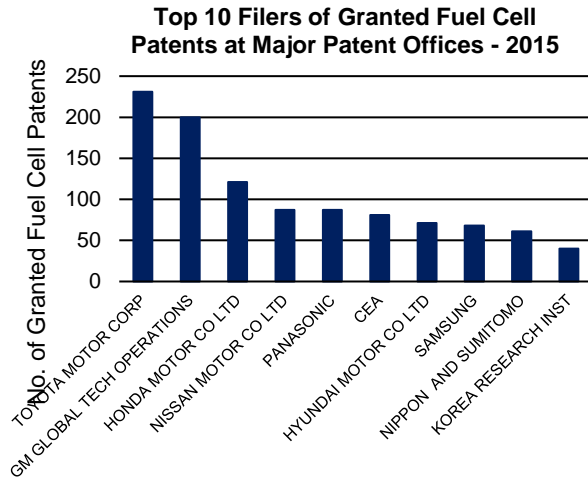


Figure A1.1.13. Top ten filers of granted fuel cell patents at the Top 5 Patent Offices for 2015.

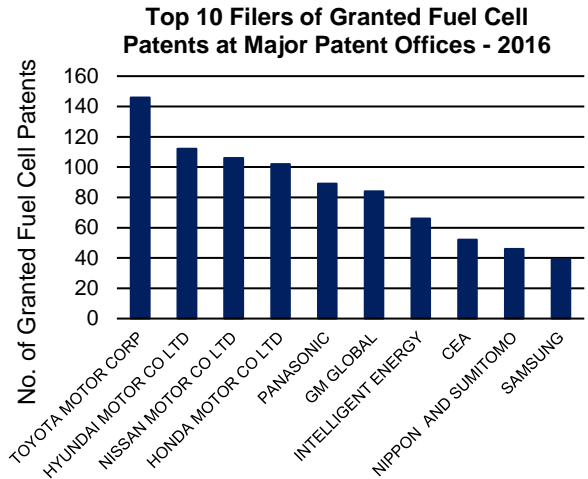


Figure A1.1.14. Top 10 filers of granted fuel cell patents at the Top 5 Offices for 2016.

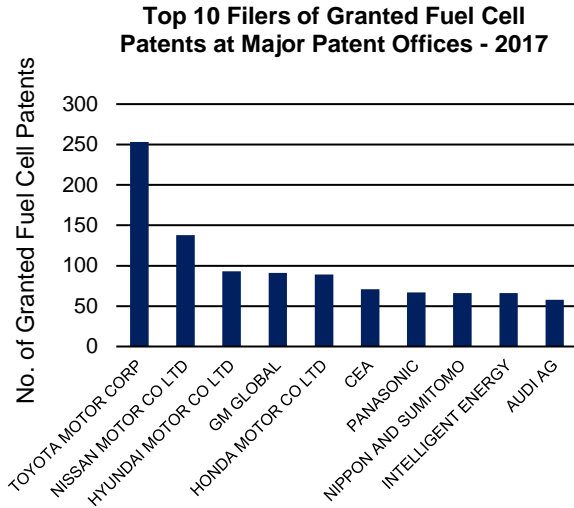


Figure A1.1.15. Top ten filers of granted fuel cell patents at the Top 5 Patent Offices for 2017.

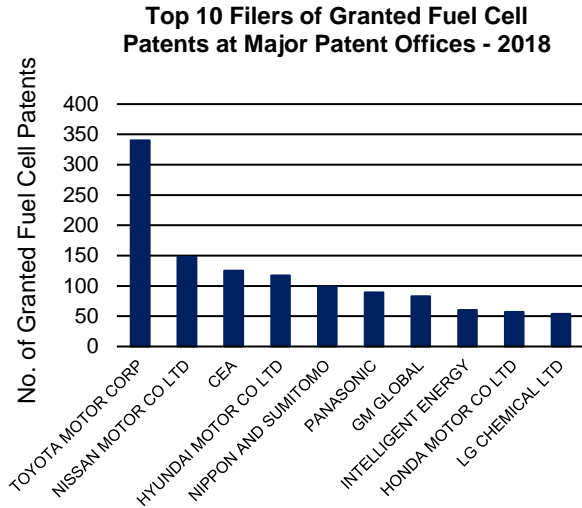


Figure A1.1.16. Top 10 filers of granted fuel cell patents at the Top 5 Offices for 2018.

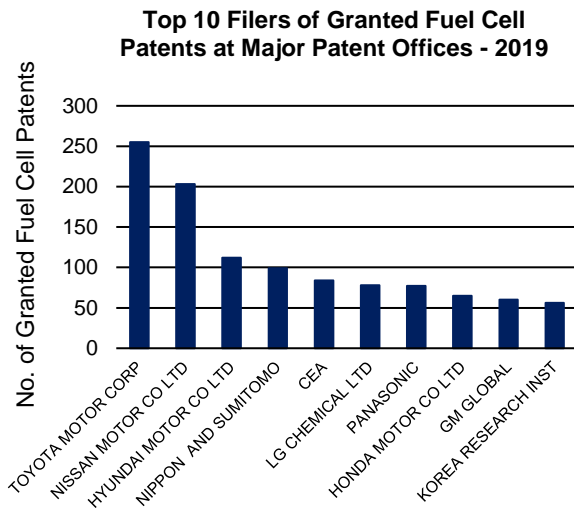


Figure A1.1.17. Top ten filers of granted fuel cell patents at the Top 5 Patent Offices for 2019.

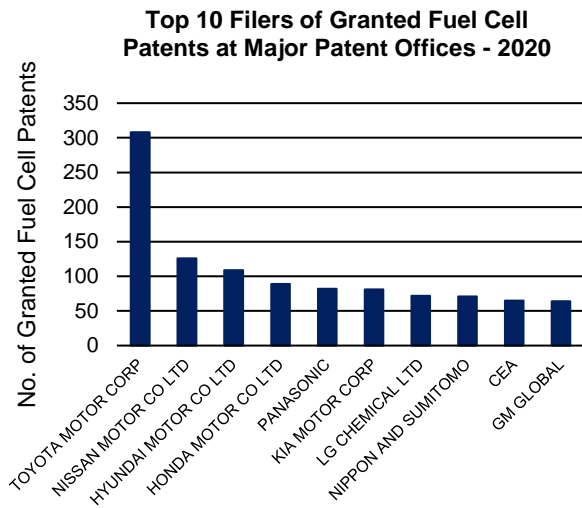


Figure A1.1.18. Top 10 filers of granted fuel cell patents at the Top 5 Offices for 2020.

Automotive companies dominate the filing statistics, followed by electronics companies. Intelligent Energy is the only dedicated fuel cell business featured amongst the top ten patentees

The trend in statistics relating to the number of granted fuel cell patents of the top 10 filers largely reflects that of the published patent applications. Unsurprisingly, given the filing statistics, Toyota, Nissan, Hyundai, GM, Panasonic, CEA and Honda feature in the top 10 patentees annually.

1.1.3. Academic Patent Filers

The data presented below shows the top 10 university filers of patent applications (Figures A1.1.19 to A1.1.25) and granted patents (Figures A1.1.26 to A1.1.32) in the area of fuel cells recorded annually from 2014 to 2020 at the top 5 patent offices. In each case the bars show the absolute number of patent applications associated with a particular entity.

The top 10 academic filers are dominated by Chinese and Japanese universities. The National University of Tsinghua features in the top two university filers annually from 2014 to 2020.

Whilst fluctuations in the numbers of granted fuel cell patents are observed, the National University of Tsinghua remains a prominent entity, featuring in the top four university filers of granted fuel cell patents annually, except for 2019 when it featured in the top 9 university filers.

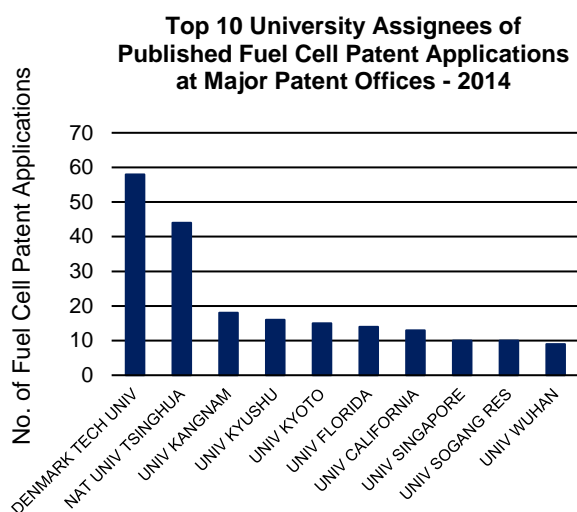


Figure A1.1.19. Top ten university filers of fuel cell patent applications at the Top 5 Patent Offices for 2014.

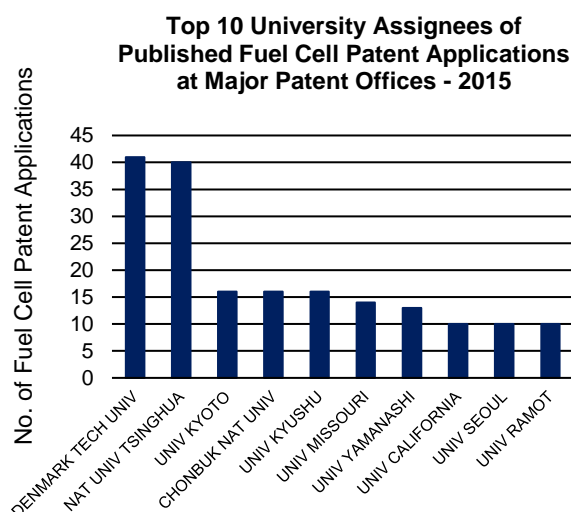


Figure A1.1.20. Top 10 university filers of fuel cell patent applications at the Top 5 Offices for 2015.

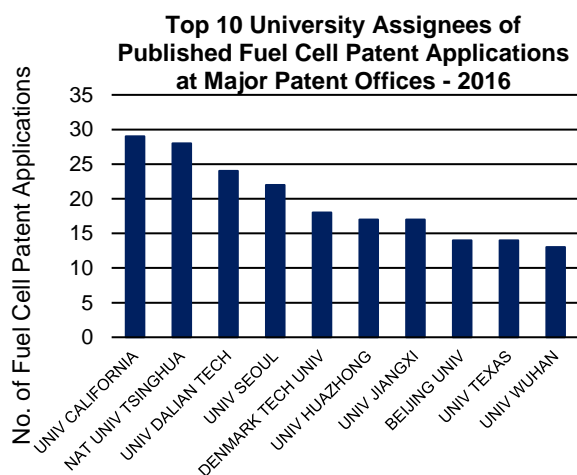


Figure A1.1.21. Top ten university filers of fuel cell patent applications at the Top 5 Patent Offices for 2016.

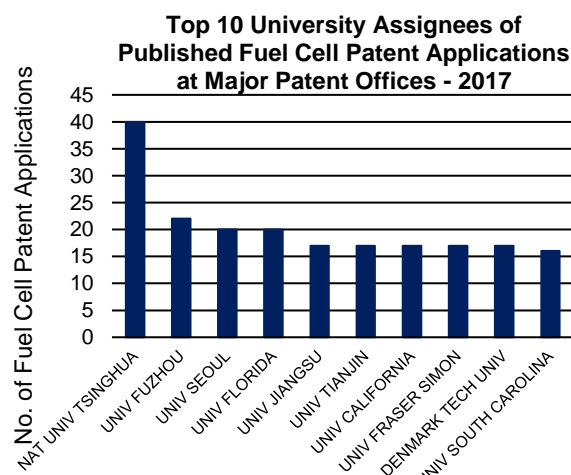


Figure A1.1.22. Top 10 university filers of fuel cell patent applications at the Top 5 Offices for 2017.

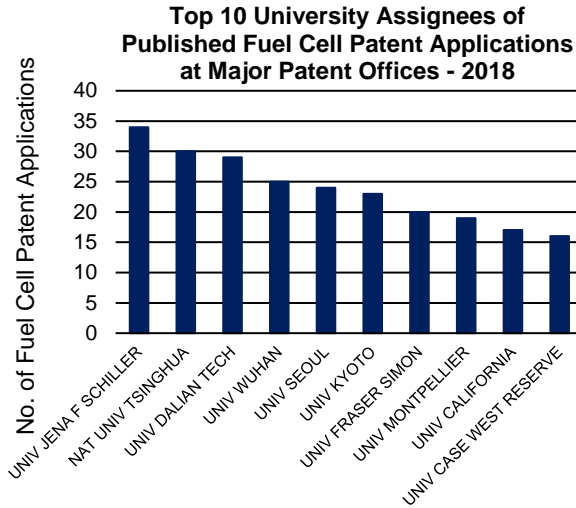


Figure A1.1.23. Top ten university filers of fuel cell patent applications at the Top 5 Patent Offices for 2018.

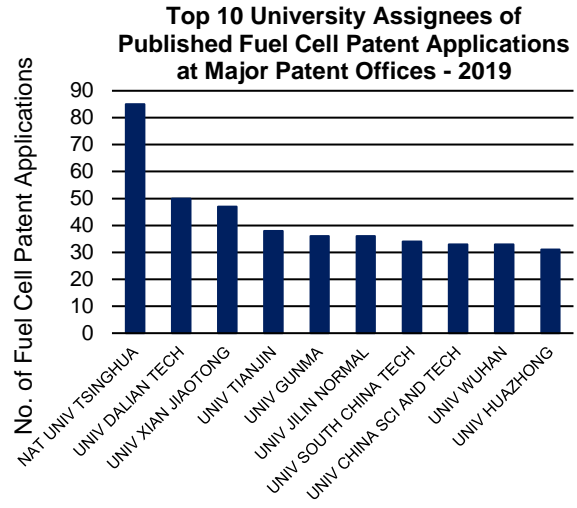


Figure A1.1.24. Top 10 university filers of fuel cell patent applications at the Top 5 Offices for 2019.

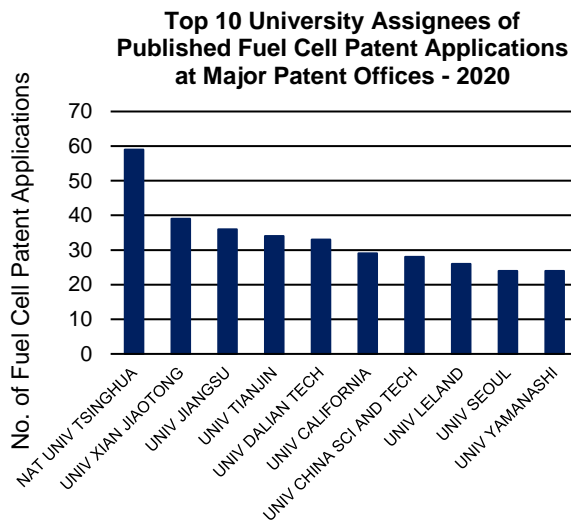


Figure A1.1.25. Top ten university filers of fuel cell patent applications at the Top 5 Patent Offices for 2020.

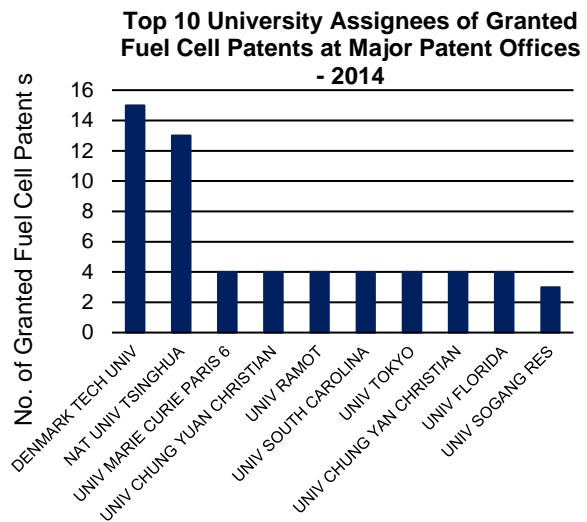


Figure A1.1.26. Top 10 university filers of granted fuel cell patents at the Top 5 Offices for 2014.

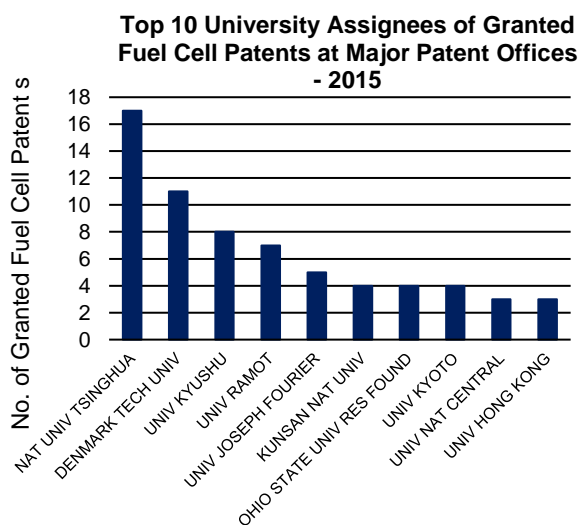


Figure A1.1.27. Top ten university filers of granted fuel cell patents at the Top 5 Patent Offices for 2015.

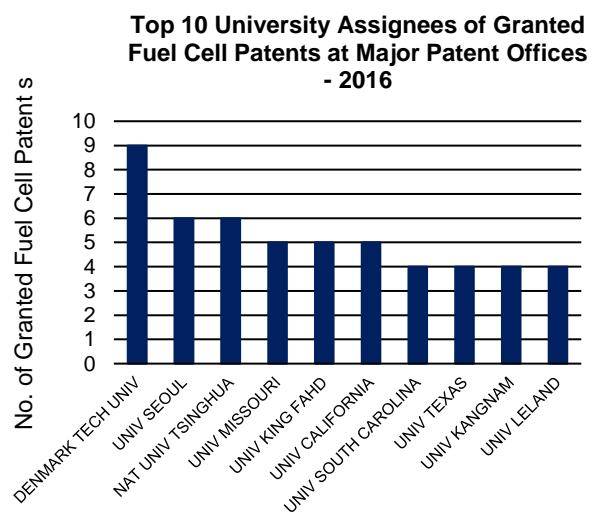


Figure A1.1.28. Top 10 university filers of granted fuel cell patents at the Top 5 Offices for 2016.

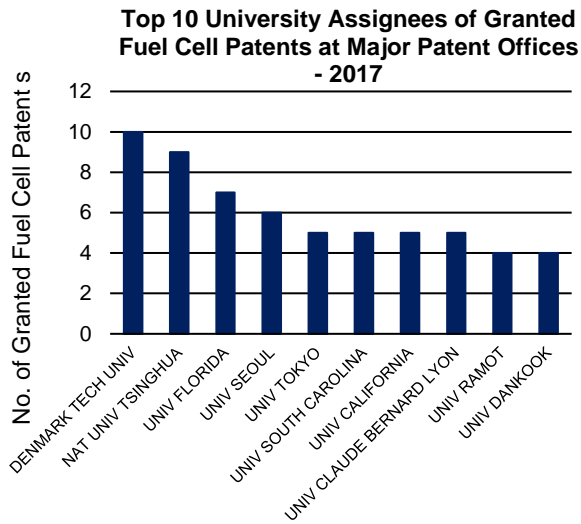


Figure A1.1.29. Top ten university filers of granted fuel cell patents at the Top 5 Patent Offices for 2017.

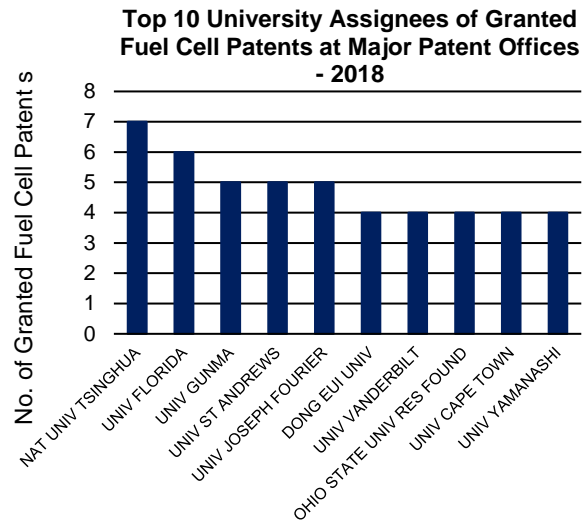


Figure A1.1.30. Top 10 university filers of granted fuel cell patents at the Top 5 Offices for 2018.

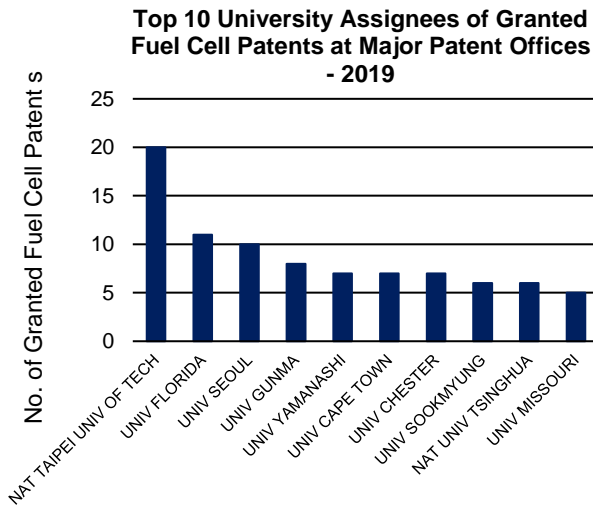


Figure A1.1.31. Top ten university filers of granted fuel cell patents at the Top 5 Patent Offices for 2019.

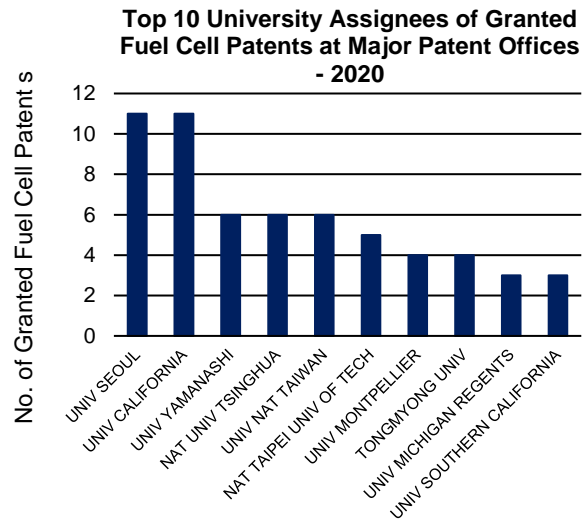


Figure A1.1.32. Top 10 university filers of granted fuel cell patents at the Top 5 Offices for 2020.

1.2. Fuel Cell Chemistry

The data presented below shows the top 10 filers of patent applications for each of the individual fuel cell chemistries, for the years 2014 to 2019, for each of the top 5 patent offices. In each case the bars show the absolute number of patent applications associated with a particular entity.

1.2.1. Direct Alcohol Fuel Cells

Figures 1.2.1 to 1.2.7 show the top 10 assignees of direct alcohol fuel cell (DAFC) patent applications, e.g. direct methanol fuel cells (DMFCs), for the top 5 offices.

The top filers appear to vary over the period.

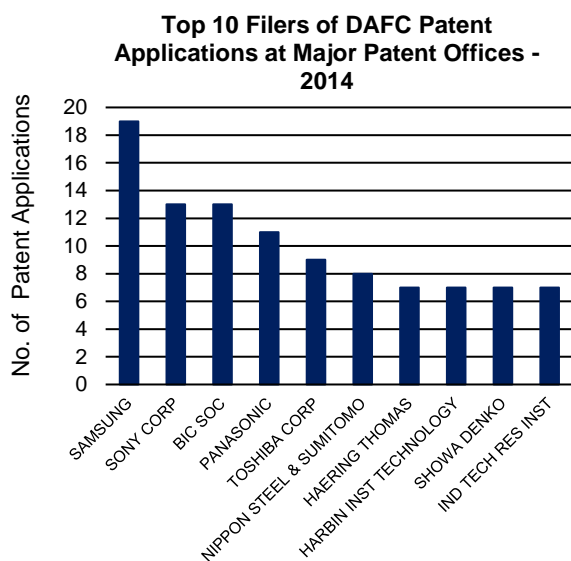


Figure A1.2.1. Top ten filers of DAFC patent applications at the Top 5 Patent Offices for 2014.

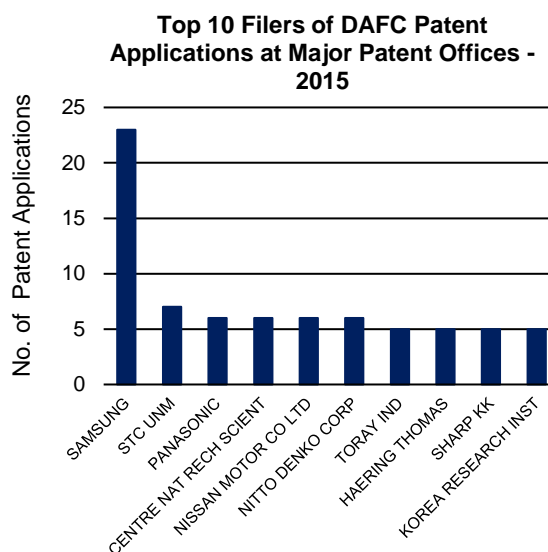


Figure A1.2.2. Top 10 filers of DAFC patent applications at the Top 5 Offices for 2015.

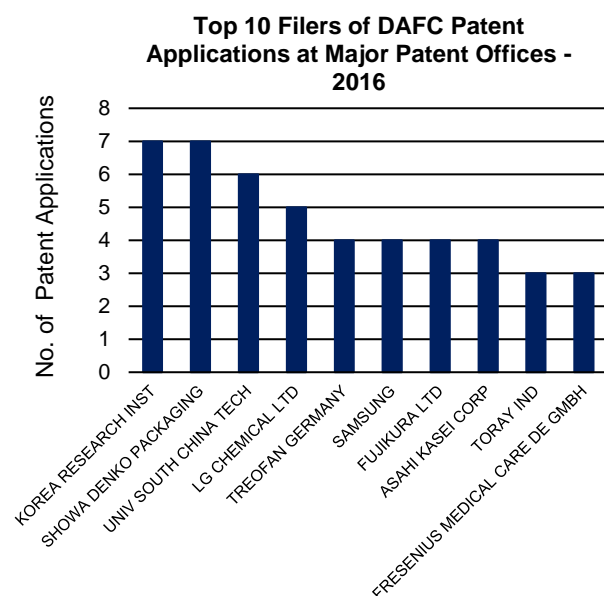


Figure A1.2.3. Top ten filers of DAFC patent applications at the Top 5 Patent Offices for 2016.

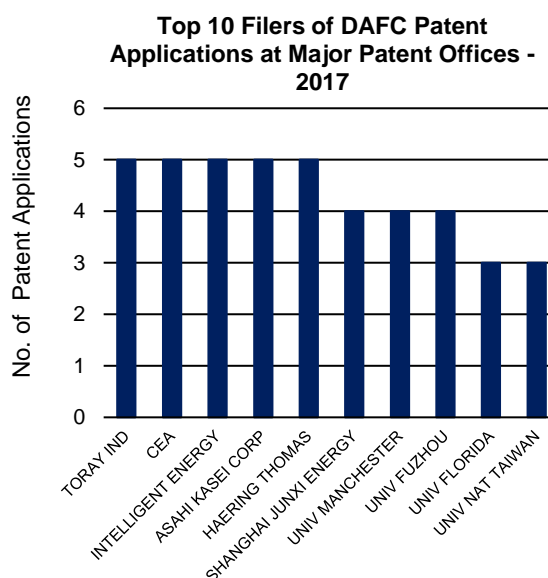


Figure A1.2.4. Top 10 filers of DAFC patent applications at the Top 5 Offices for 2017.

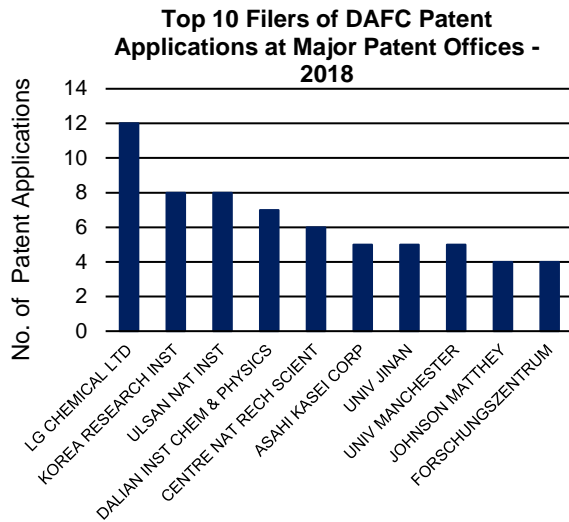


Figure A1.2.5. Top ten filers of DAFC patent applications at the Top 5 Patent Offices for 2018.

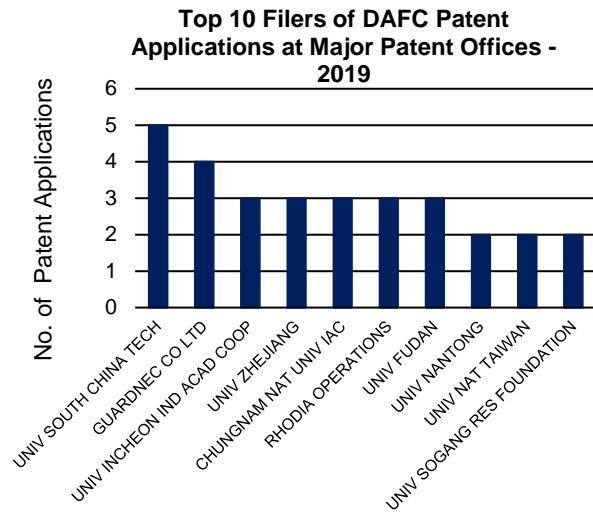


Figure A1.2.6. Top 10 filers of DAFC patent applications at the Top 5 Offices for 2019.

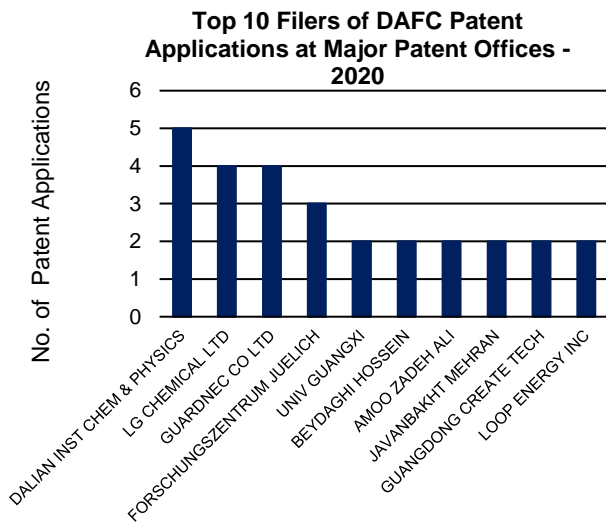


Figure A1.2.7. Top ten filers of DAFC patent applications at the Top 5 Patent Offices for 2020.

Figure 1.2.8 provides a technical comparison between patents filed for DAFCs for 2014 to 2019 as compared to a period ten years earlier.

Figure 1.2.8 shows that the technical fields in which DAFC patent applications are related has altered over time. For both periods (2005 to 2009 and 2014 to 2019) the electrical engineering aspects dominate but over time chemical aspects such as surface technology and macromolecular chemistry appear to become relatively more important.

The major blue bar in each case represents ‘Electrical apparatus, machinery and energy’ and the minor purple bars represent ‘Chemical Engineering’ and ‘Macromolecular Chemistry’. The major green bar is ‘Mechanical Engineering’ in both cases. Overall the technological map indicates that in the period 2014-19 research in this space continues along similar lines, compared with 2005-09, with perhaps a minor shift towards chemical research.

It should be noted that the size of the dataset for each respective period is not the same (2014/19 < 2005/09) and so this graph provides information about relative changes between the periods.

Technological Breakdown for DAFC Patent Applications 2005 – 2009



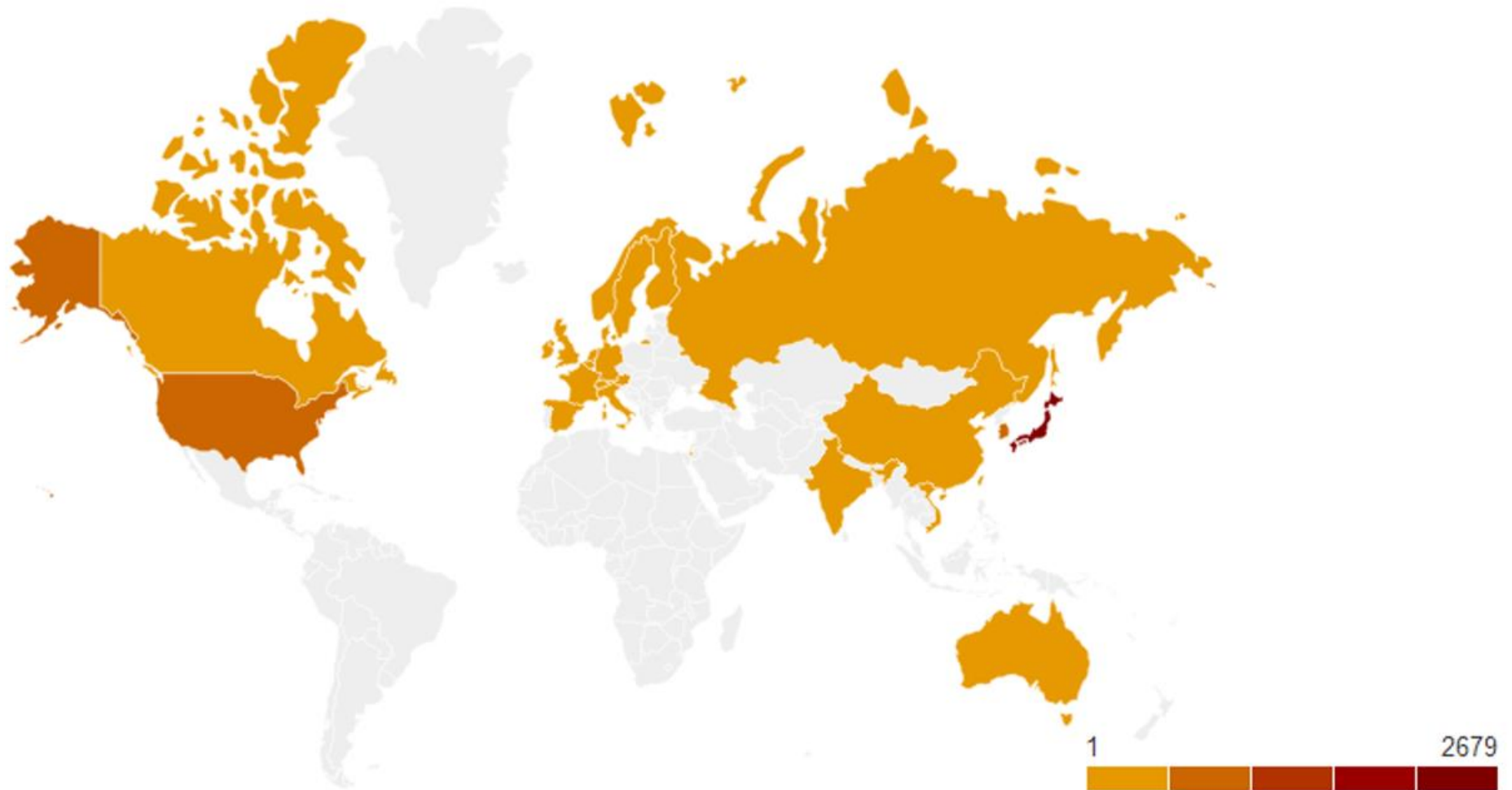
Technological Breakdown for DAFC Patent Applications 2014 - 2019



Figure A1.2.8. Technological breakdown for DAFC patent applications in comparison with 2005-2009 (PI).

Figure 1.2.9 provides data to show how applicant location has varied over a ten-year window. The data shows a concentration of research activity in USA, Europe (France, Germany, UK) and China with continued activity in Japan. It also shows the emergence of China, and to a lesser degree France, Germany and UK, as important locations for patent applicants.

Applicant location for worldwide DAFC patent applications 2005 – 2009



Applicant location for worldwide DAFC patent applications 2014 – 2019

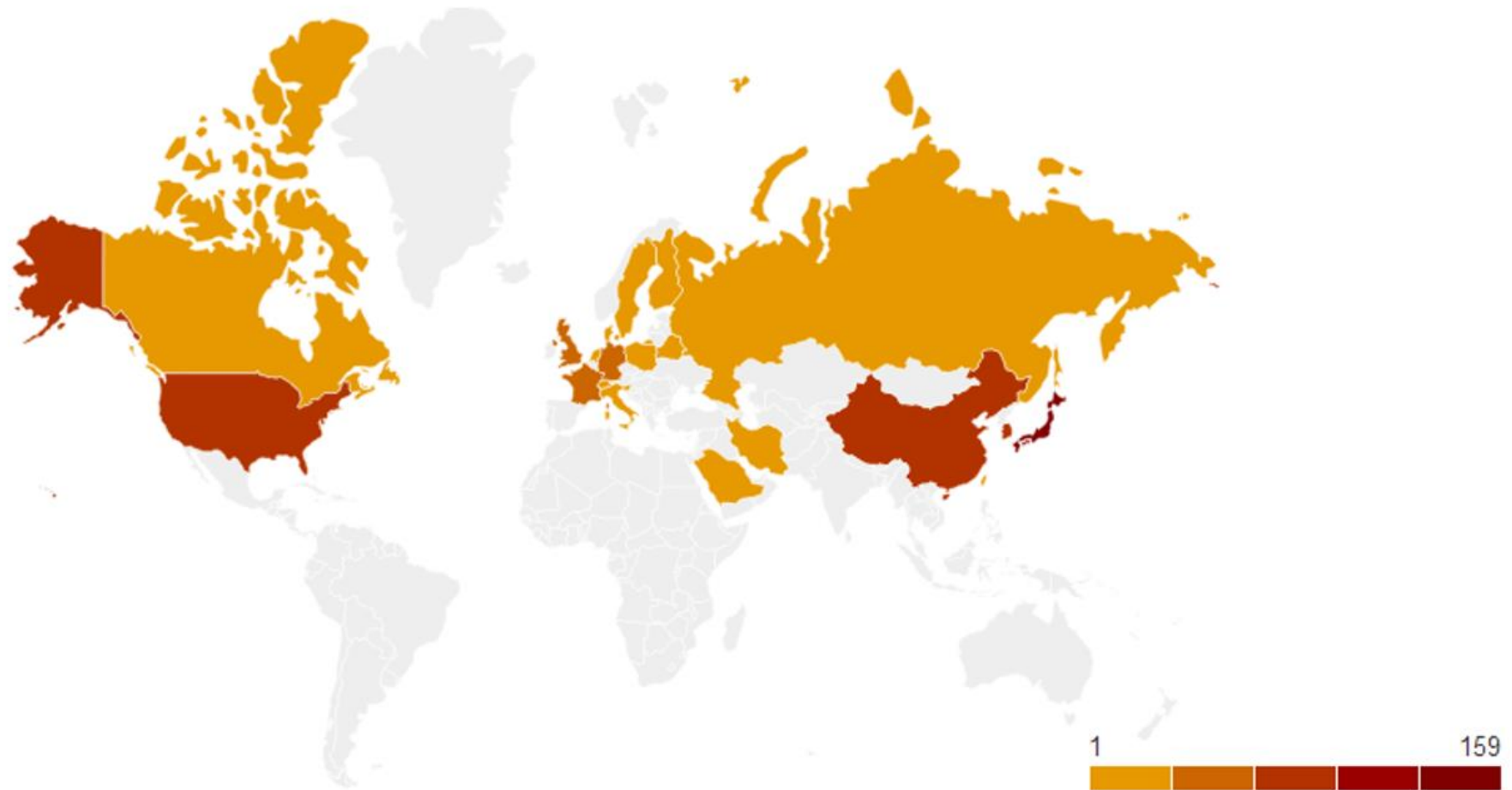


Figure A1.2.9. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.2.2. Molten Carbonate Fuel Cells

Figures 1.2.10 to 1.2.16 show the top 10 assignees of molten carbonate fuel cell (MCFC) patent applications, for the top 5 offices.

Exxon Mobil are the leading filer of MCFC patent applications, featuring in the top two annually from 2014 to 2020.

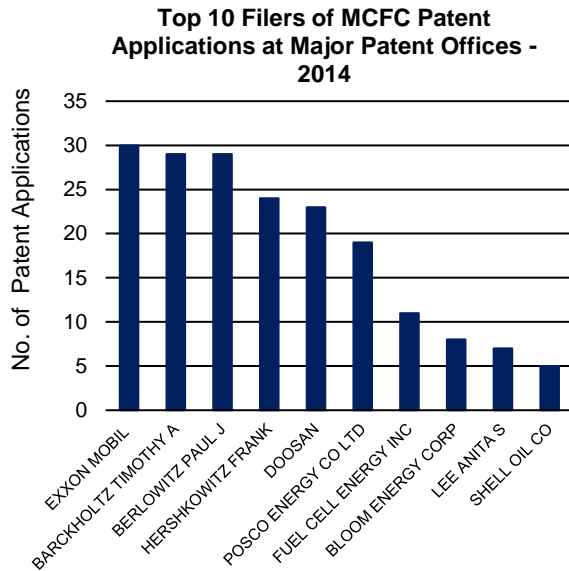


Figure A1.2.10. Top ten filers of MCFC patent applications at the Top 5 Patent Offices for 2014.

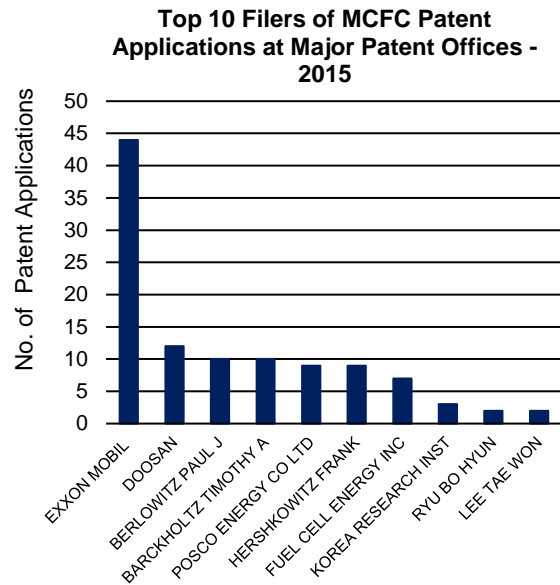


Figure A1.2.11. Top 10 filers of MCFC patent applications at the Top 5 Offices for 2015.

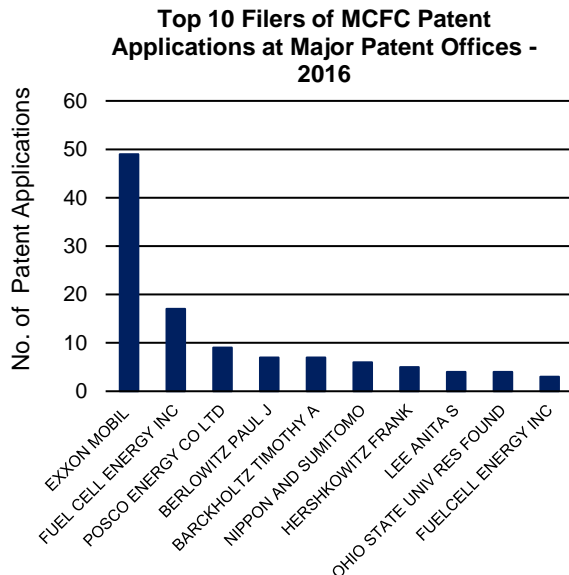


Figure A1.2.12. Top ten filers of MCFC patent applications at the Top 5 Patent Offices for 2016.

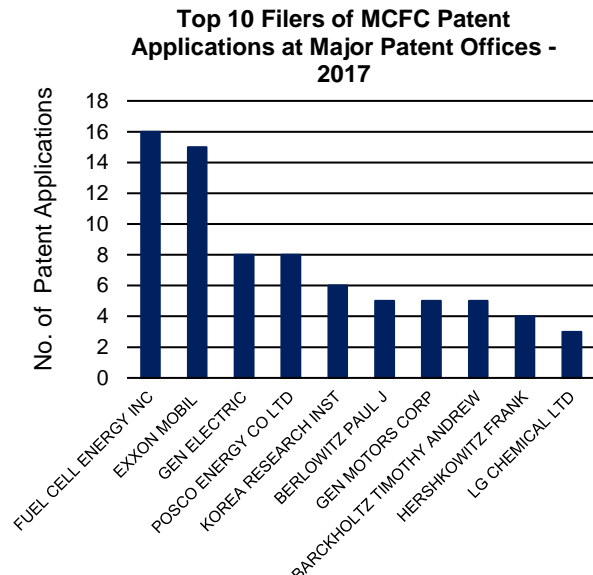


Figure A1.2.13. Top 10 filers of MCFC patent applications at the Top 5 Offices for 2017.

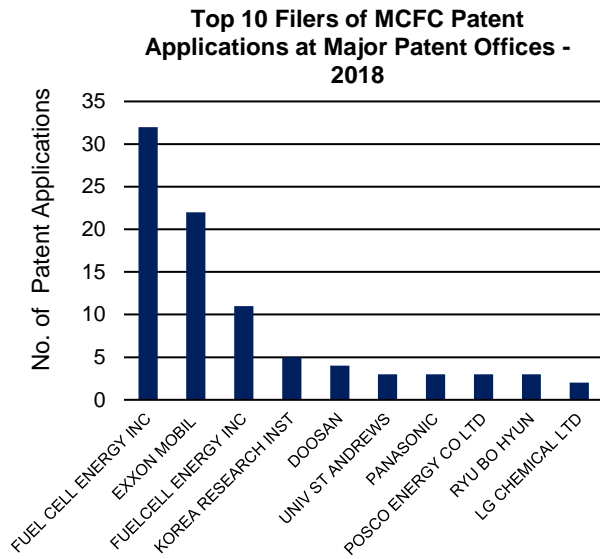


Figure A1.2.14. Top ten filers of MCFC patent applications at the Top 5 Patent Offices for 2018.

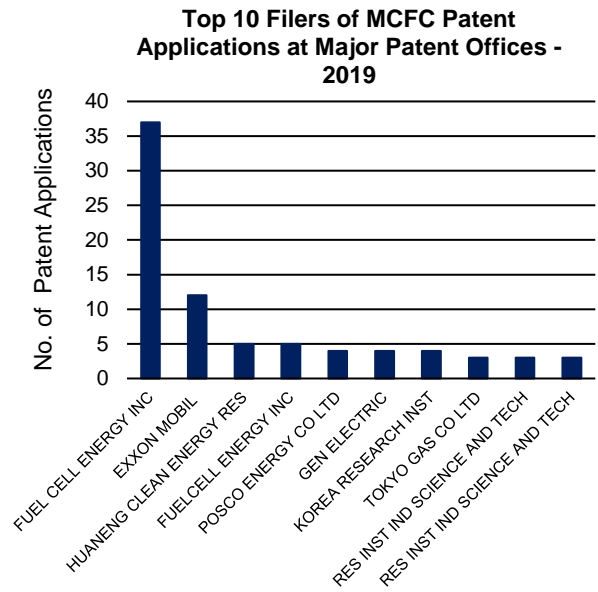


Figure A1.2.15. Top 10 filers of MCFC patent applications at the Top 5 Offices for 2019.

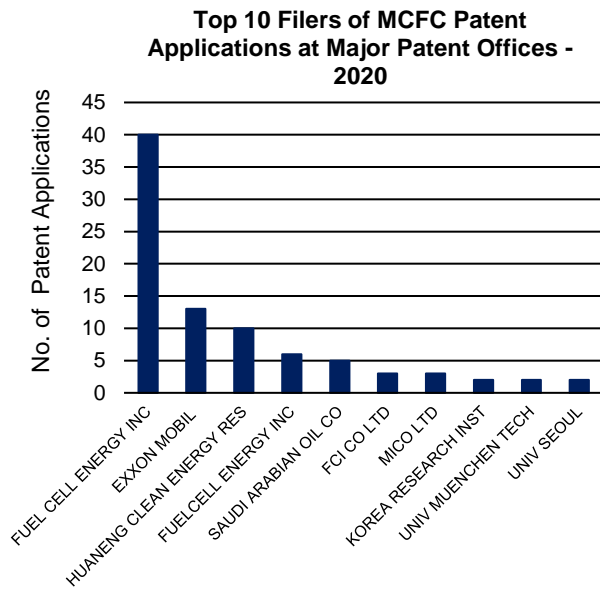


Figure A1.2.16. Top ten filers of MCFC patent applications at the Top 5 Patent Offices for 2020.

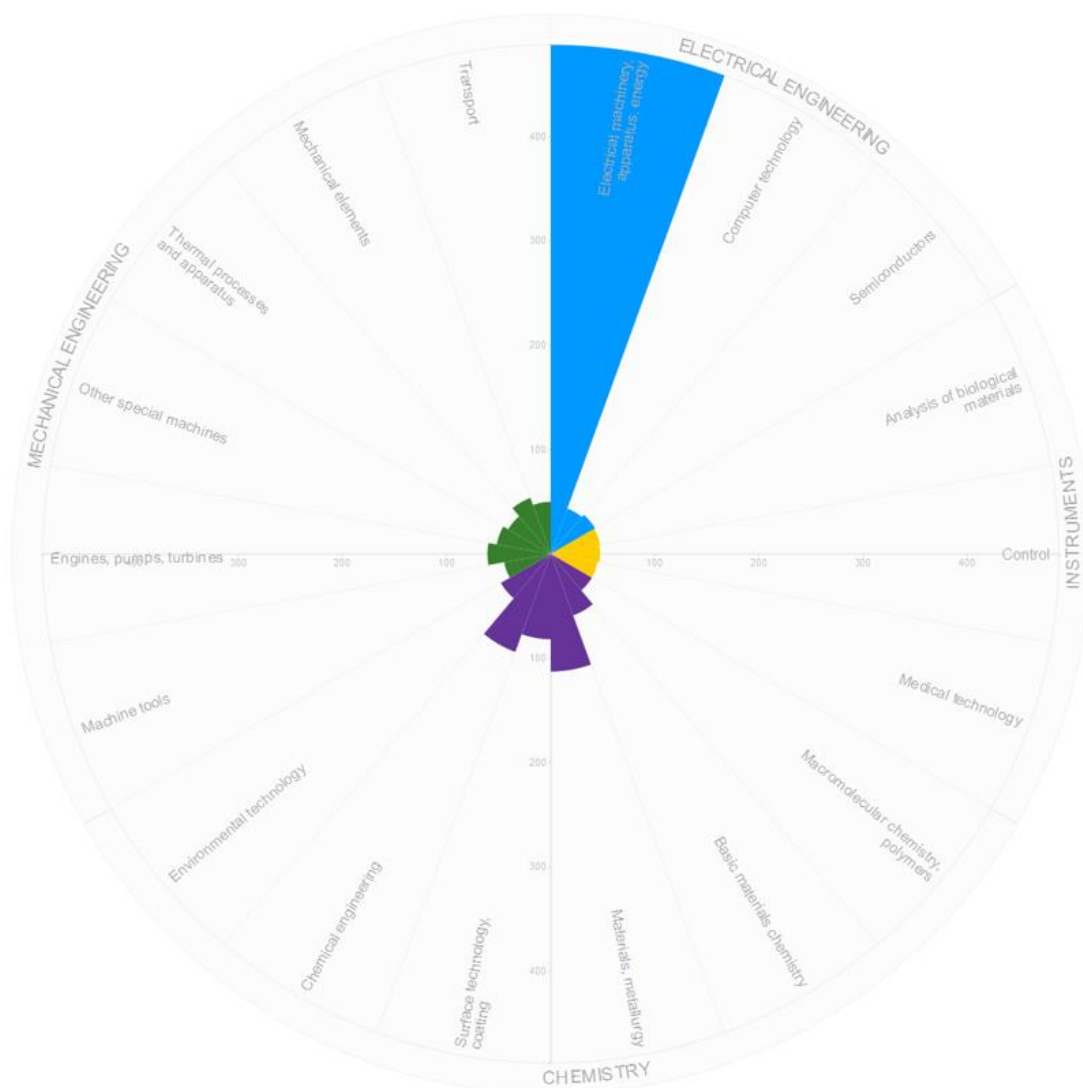
Figure A1.2.17 provides a technical comparison between patents filed for MCFCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.2.17 shows that materials are becoming less of a relative focus from the first period to the second.

The major blue bar in each case represents 'Electrical apparatus, machinery and energy'. The data appears to show a significant increase in 'Materials, Metallurgy' (major purple bar) for the later period as compared to the earlier. Indeed, it appears as if more chemical research (purple bars is being conducted) during the later period. The major green bars in each case relate to 'Thermal Processes' and 'Pumps' is 'Mechanical Engineering' in both cases.

It should be noted that the size of the dataset for each respective period is broadly similar (2005/09>2014/19).

Technological Breakdown for MCFC Patent Applications 2005 – 2009



Technological Breakdown for MCFC Patent Applications 2014 – 2019



A1.2.17. Technological breakdown for MCFC patent applications in comparison with 2005-2009 (PI).

Figure A1.2.18 provides data to show how applicant location has varied over a ten-year window.

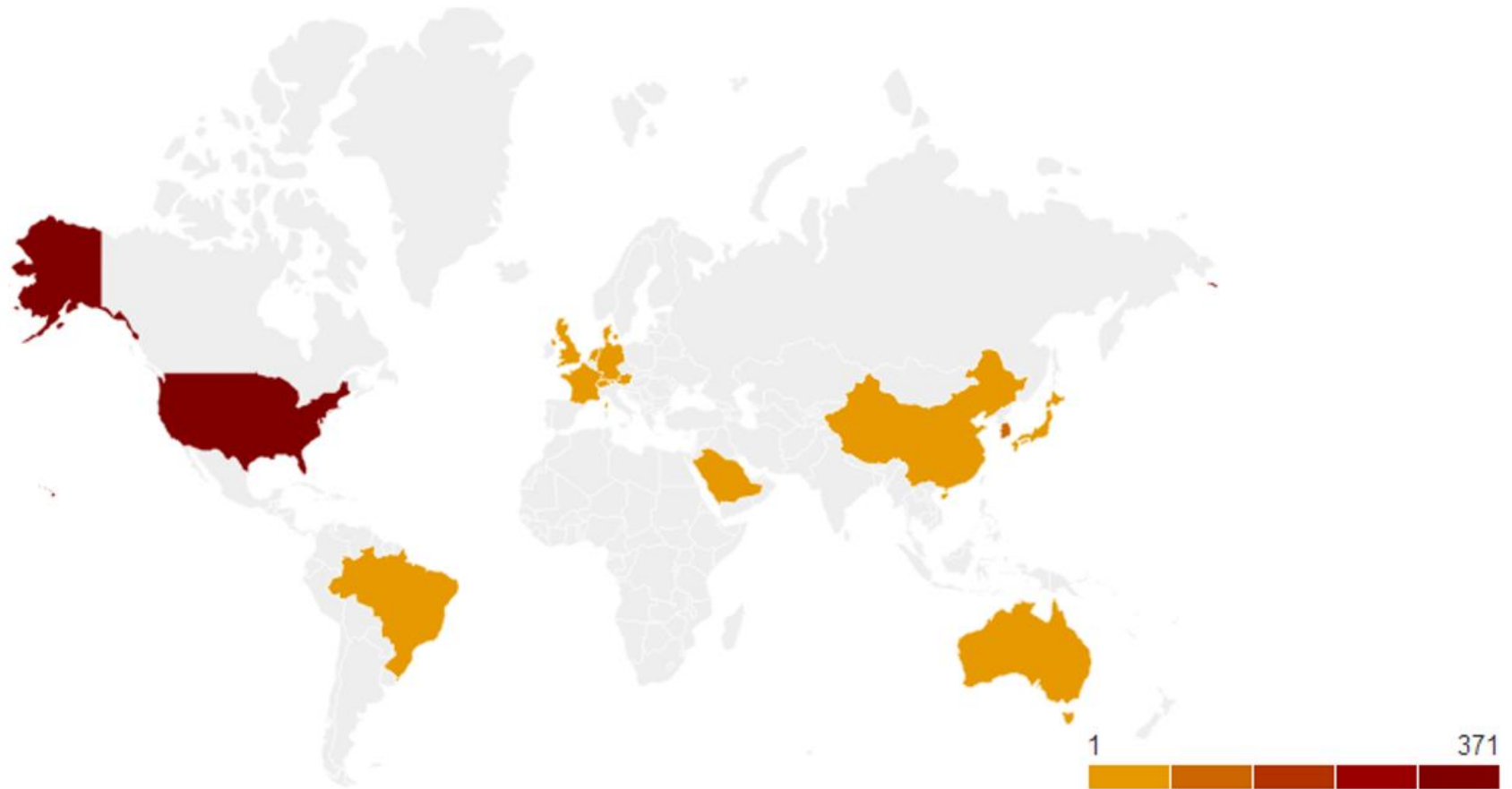
Figure A1.2.18 shows that the USA is becoming the dominant location for patent applicants in this space with countries in Europe, Australia and Brazil also maintaining their positions.

This shows a clear concentration in USA, Australia, Europe and China with Brazil also emerging.

Applicant location for worldwide MCFC patent applications 2005 – 2009



Applicant location for worldwide MCFC patent applications 2014 – 2019



A1.2.18. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.2.3. Alkaline Fuel Cells

Figures A1.2.19 to A1.2.15 show the top 10 assignees of alkaline fuel cell (AFC) patent applications, for the top 5 offices.

The top filers appear to vary over the period.

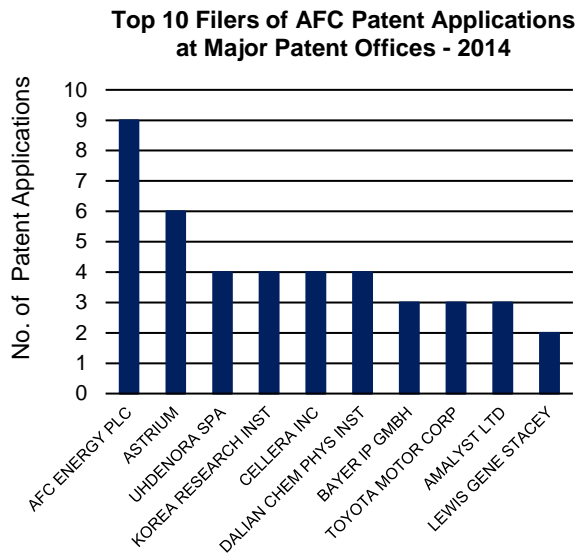


Figure A1.2.19. Top ten filers of AFC patent applications at the Top 5 Patent Offices for 2014.

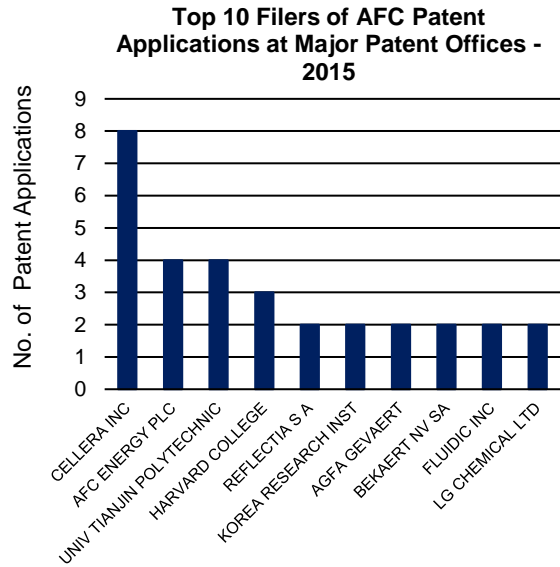


Figure A1.2.20. Top 10 filers of AFC patent applications at the Top 5 Offices for 2015.

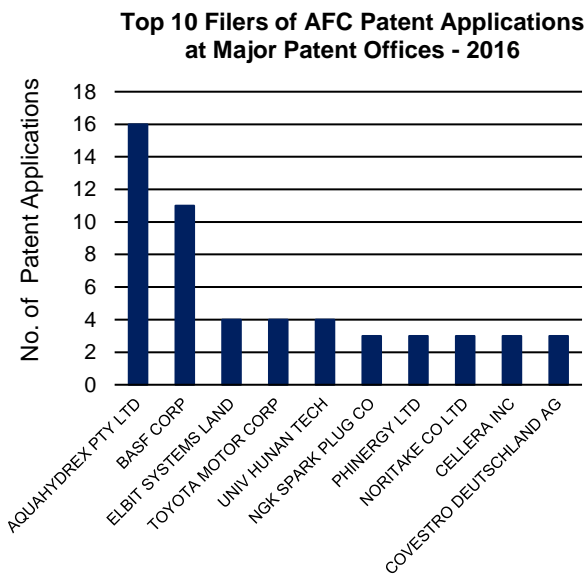


Figure A1.2.21. Top ten filers of AFC patent applications at the Top 5 Patent Offices for 2016.

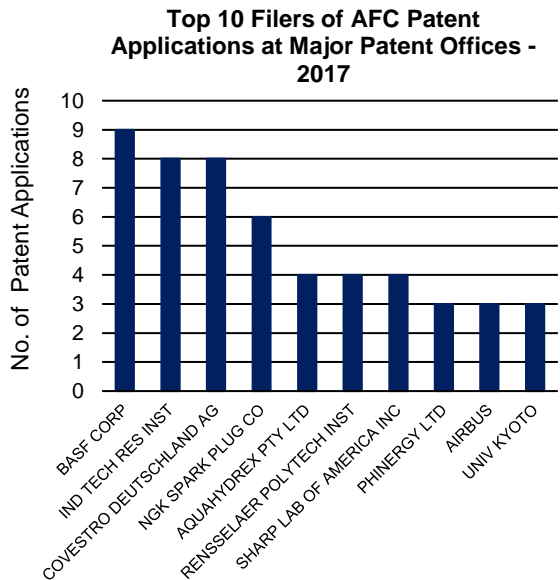


Figure A1.2.22. Top 10 filers of AFC patent applications at the Top 5 Offices for 2017.

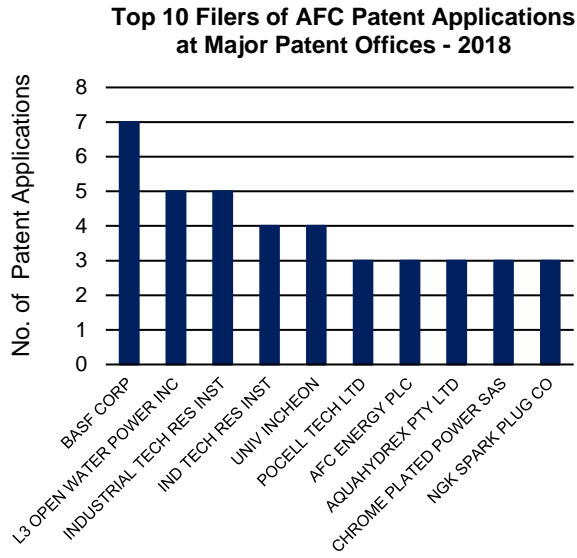


Figure A1.2.23. Top ten filers of AFC patent applications at the Top 5 Patent Offices for 2018.

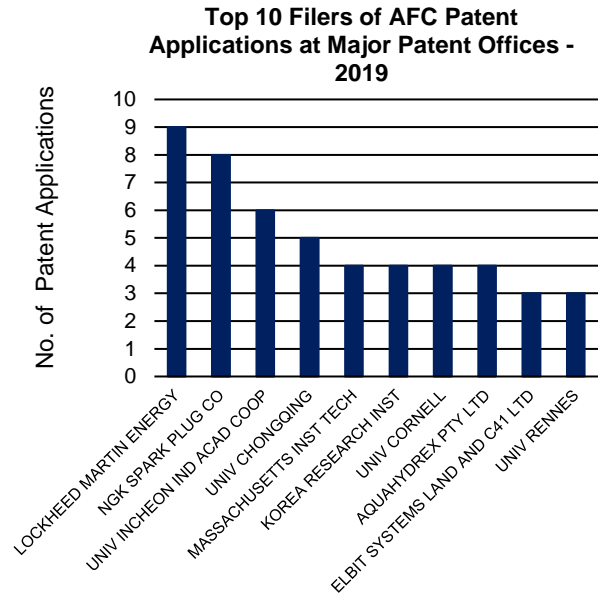


Figure A1.2.24. Top 10 filers of AFC patent applications at the Top 5 Offices for 2019.

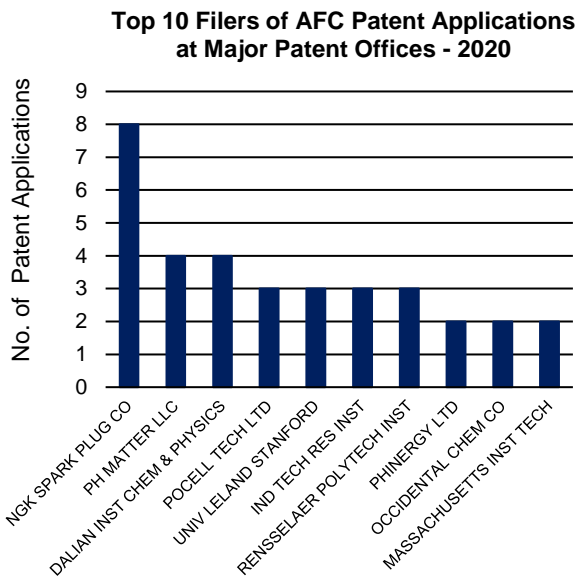


Figure A1.2.25. Top ten filers of AFC patent applications at the Top 5 Patent Offices for 2020.

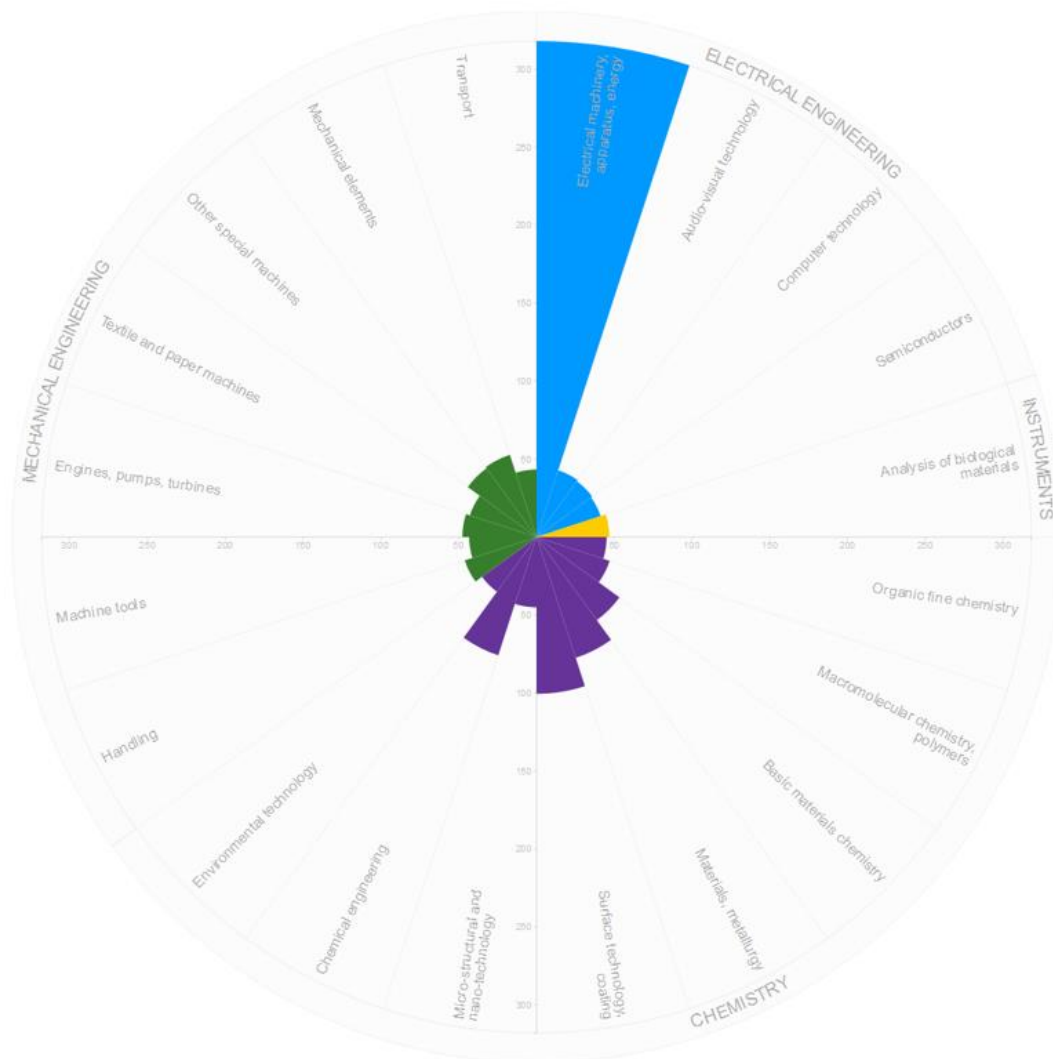
Figure A1.2.26 provides a technical comparison between patents filed for AFCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.2.26 clearly shows that surface chemistry and coating technologies are becoming increasingly important in the period 2014/19.

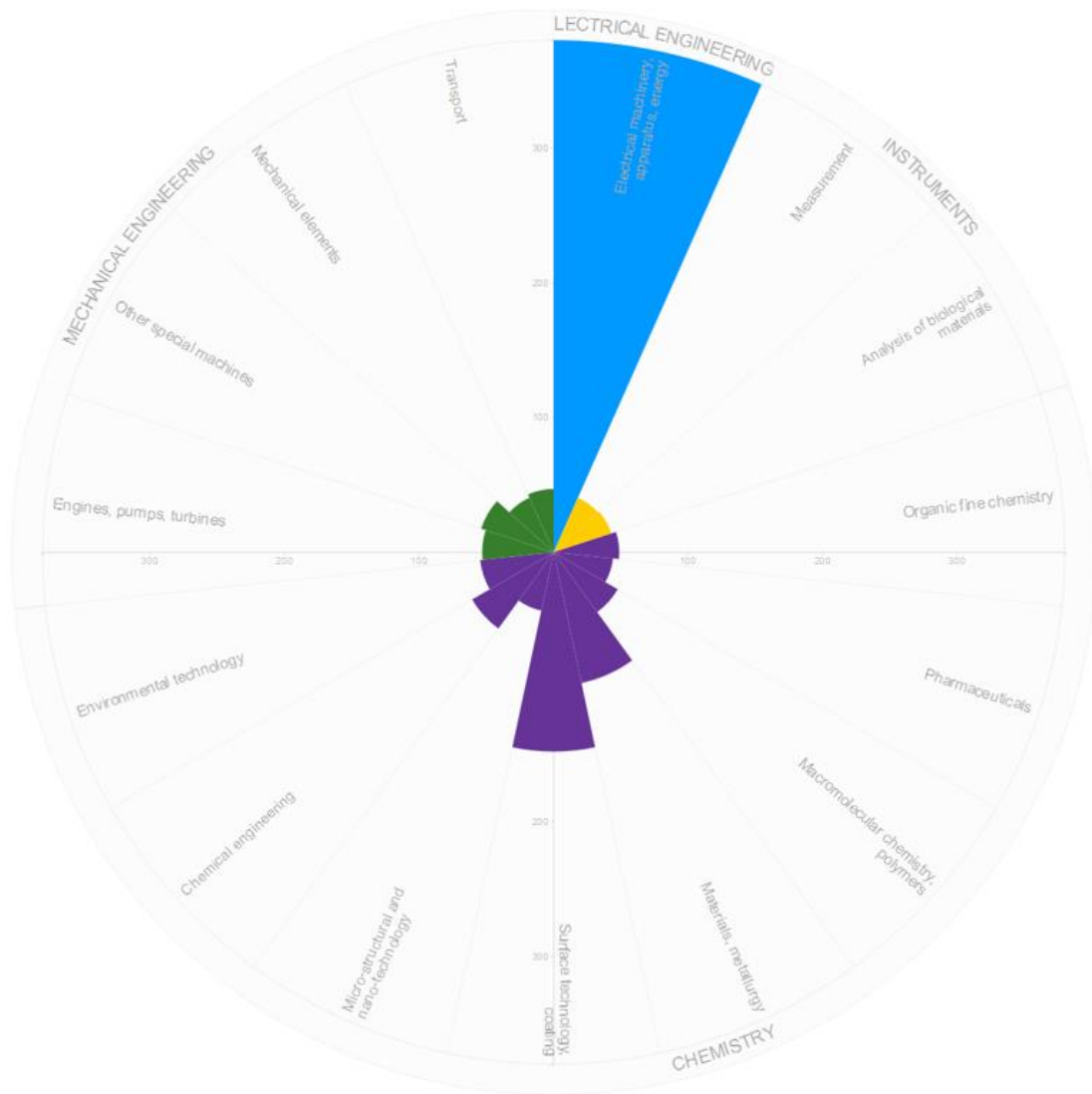
The overall technology picture in the later period is remarkably similar to that of the earlier period with the exception of surface chemistry technologies becoming more important relatively.

It should be noted that the size of the dataset for each respective period are similar (2014/19>2005/09).

Technological Breakdown for AFC Patent Applications 2005 – 2009



Technological Breakdown for AFC Patent Applications 2014 – 2019

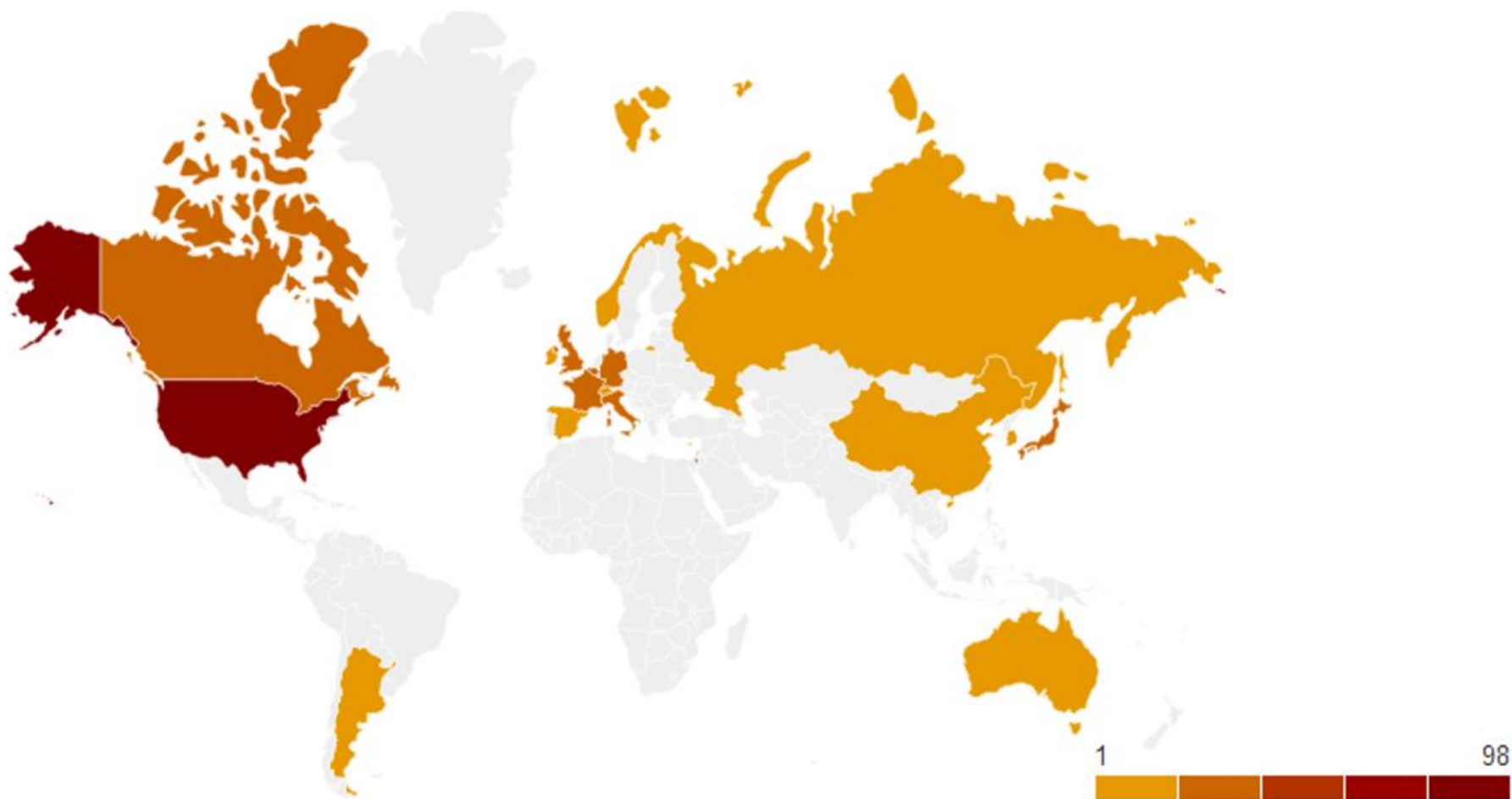


A1.2.26. Technological breakdown for AFC patent applications in comparison with 2005-2009 (PI).

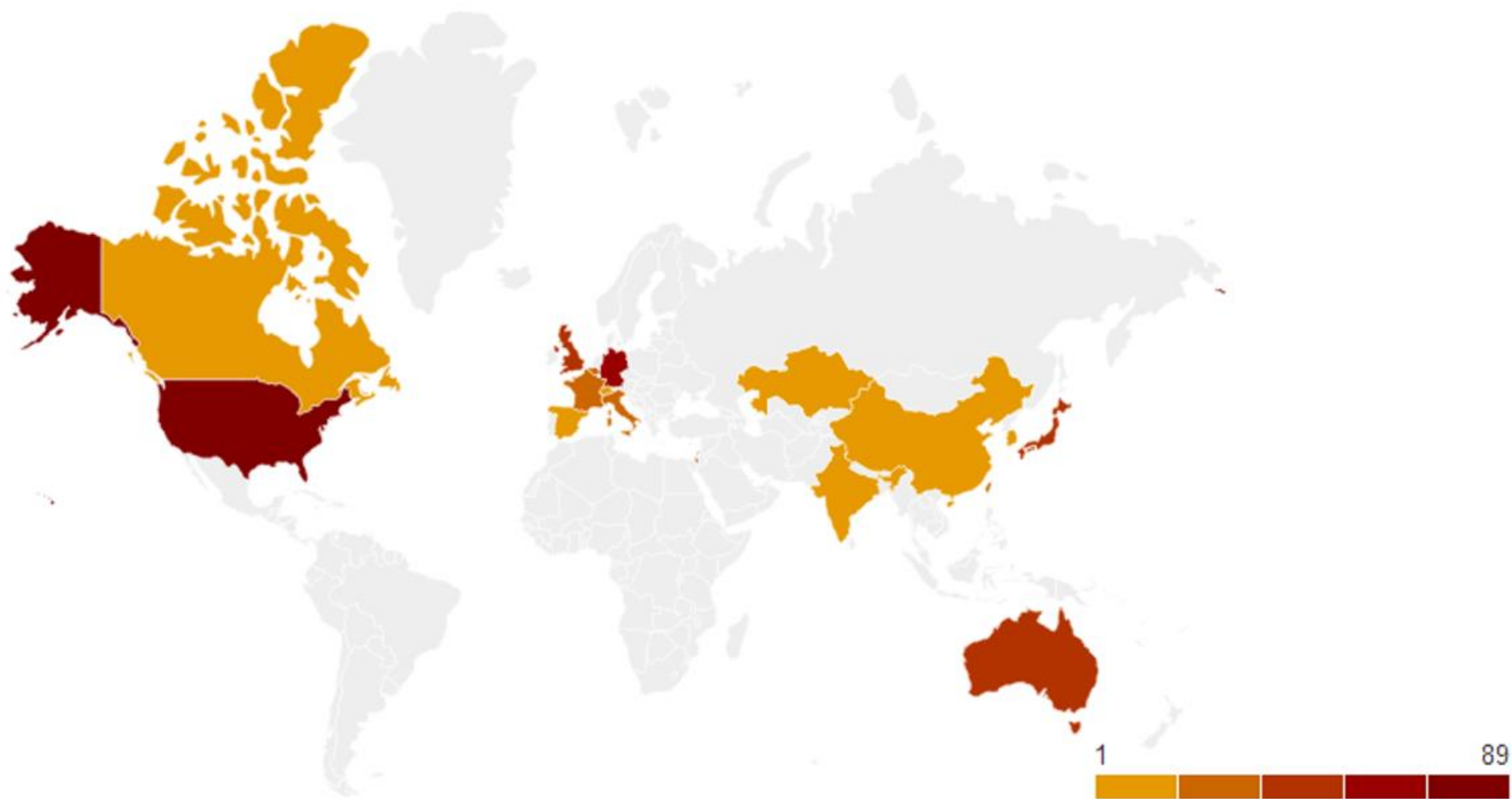
Figure A1.2.27 provides data to show how applicant location has varied over a ten-year window.

Figure A1.2.27 shows that applicants are increasingly found in fewer states with the USA maintaining its dominant position as the principal location for applicants.

Applicant location for worldwide AFC patent applications 2005 – 2009



Applicant location for worldwide AFC patent applications 2014 – 2019



A1.2.27. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.2.4. Phosphoric Acid Fuel Cells

Figures A1.2.28 to A1.2.34 show the top 10 assignees of phosphoric acid fuel cell (PAFC) patent applications, for the top 5 offices.

Doosan are consistently the top filers of PAFC patent applications annually between 2015 and 2020.

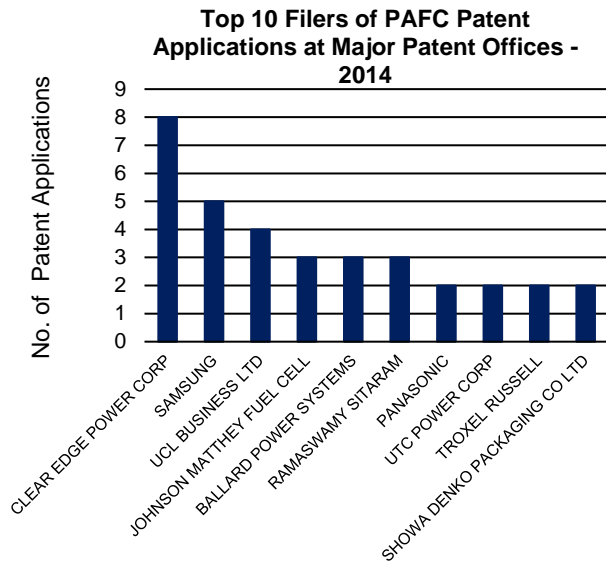


Figure A1.2.28. Top ten filers of PAFC patent applications at the Top 5 Patent Offices for 2014.

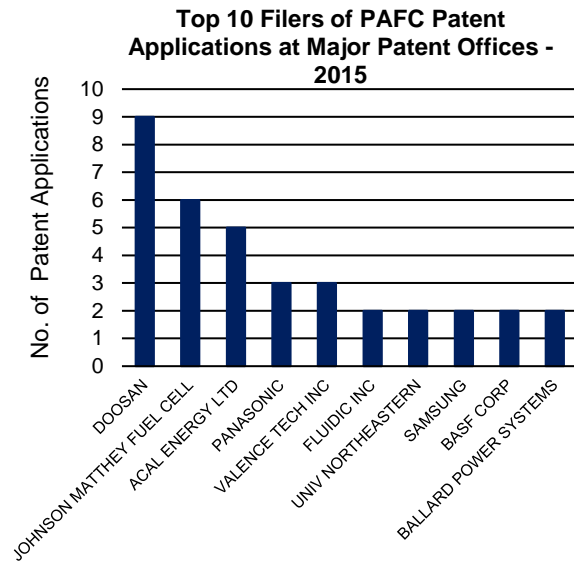


Figure A1.2.29. Top 10 filers of PAFC patent applications at the Top 5 Offices for 2015.

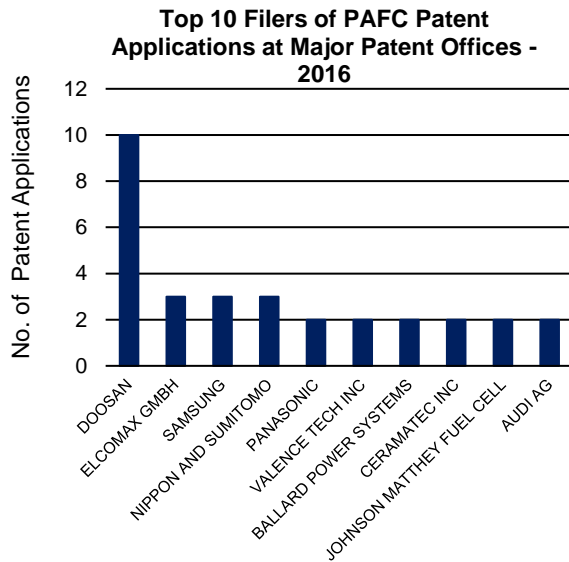


Figure A1.2.30. Top ten filers of PAFC patent applications at the Top 5 Patent Offices for 2016.

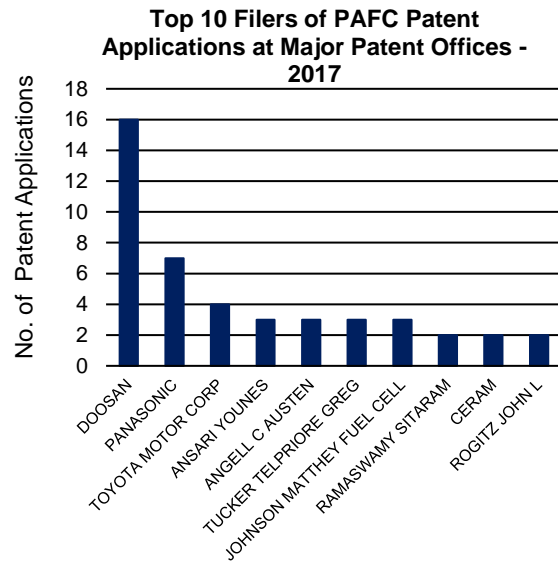


Figure A1.2.31. Top 10 filers of PAFC patent applications at the Top 5 Offices for 2017.

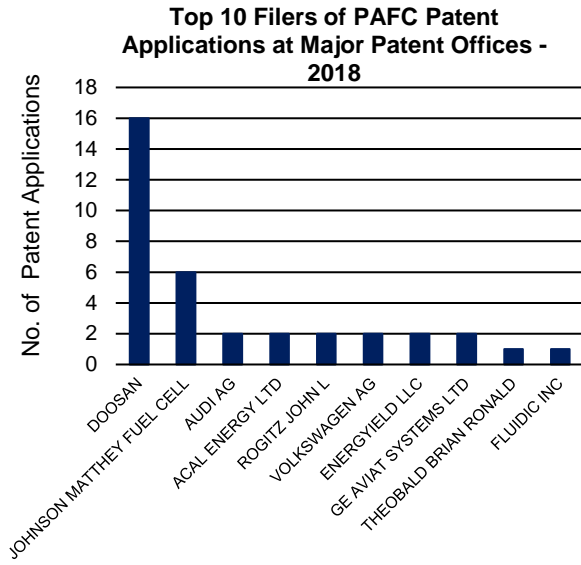


Figure A1.2.32. Top ten filers of PAFC patent applications at the Top 5 Patent Offices for 2018.

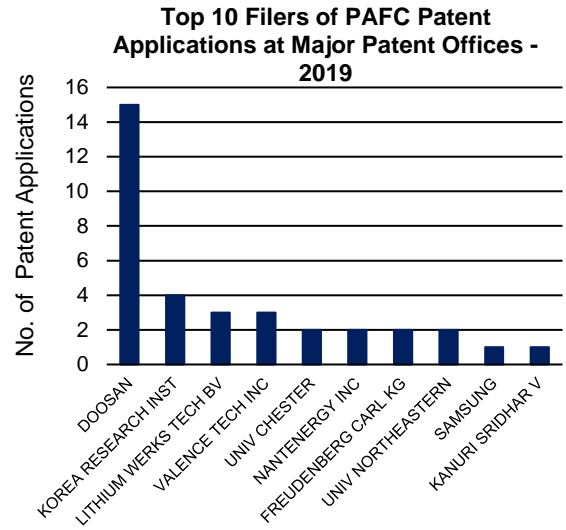


Figure A1.2.33. Top 10 filers of PAFC patent applications at the Top 5 Offices for 2019.

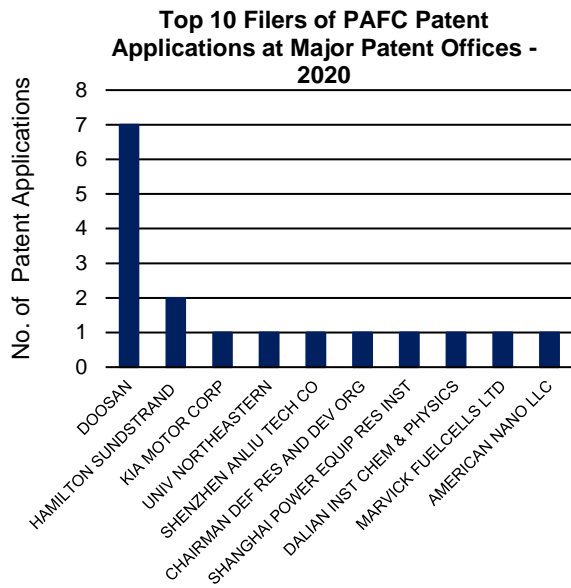


Figure A1.2.34. Top ten filers of PAFC patent applications at the Top 5 Patent Offices for 2020.

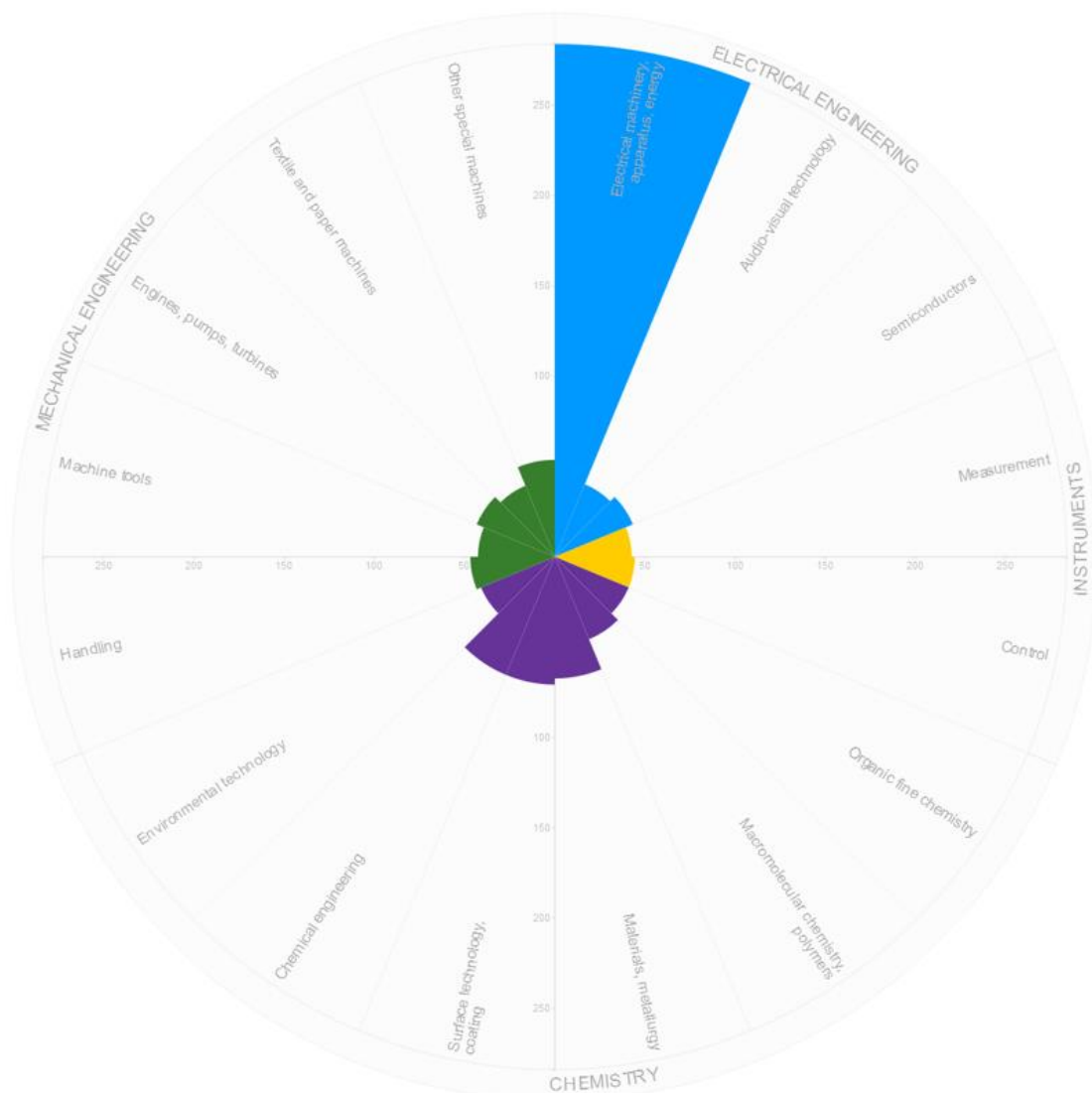
Figure A1.2.35 provides a technical comparison between patents filed for PAFCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.2.35 shows that surface technologies have become less relatively important, but the overall technology spread remained fairly constant.

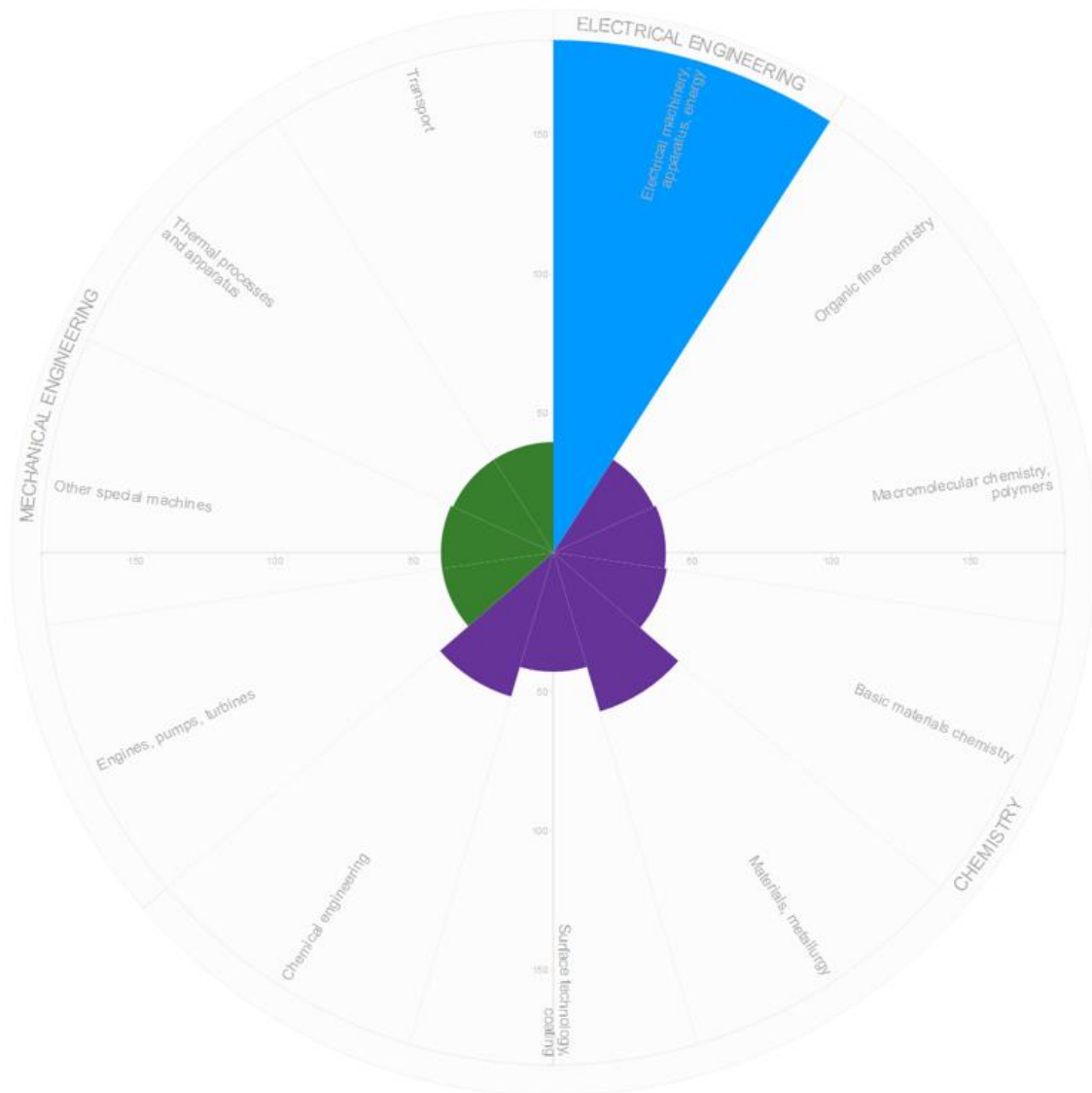
The overall picture is remarkably similar between the two periods. Notably, surface chemistry technology appears to have relatively decreased over time, as have “Measurement Techniques” (yellow bars in earlier period).

It should be noted that the size of the dataset for 2005/09 is larger than that for 2014/19.

Technological Breakdown for PAFC Patent Applications 2005 – 2009



Technological Breakdown for PAFC Patent Applications 2014 – 2019



A1.2.35. Technological breakdown for PAFC patent applications in comparison with 2005-2009 (PI).

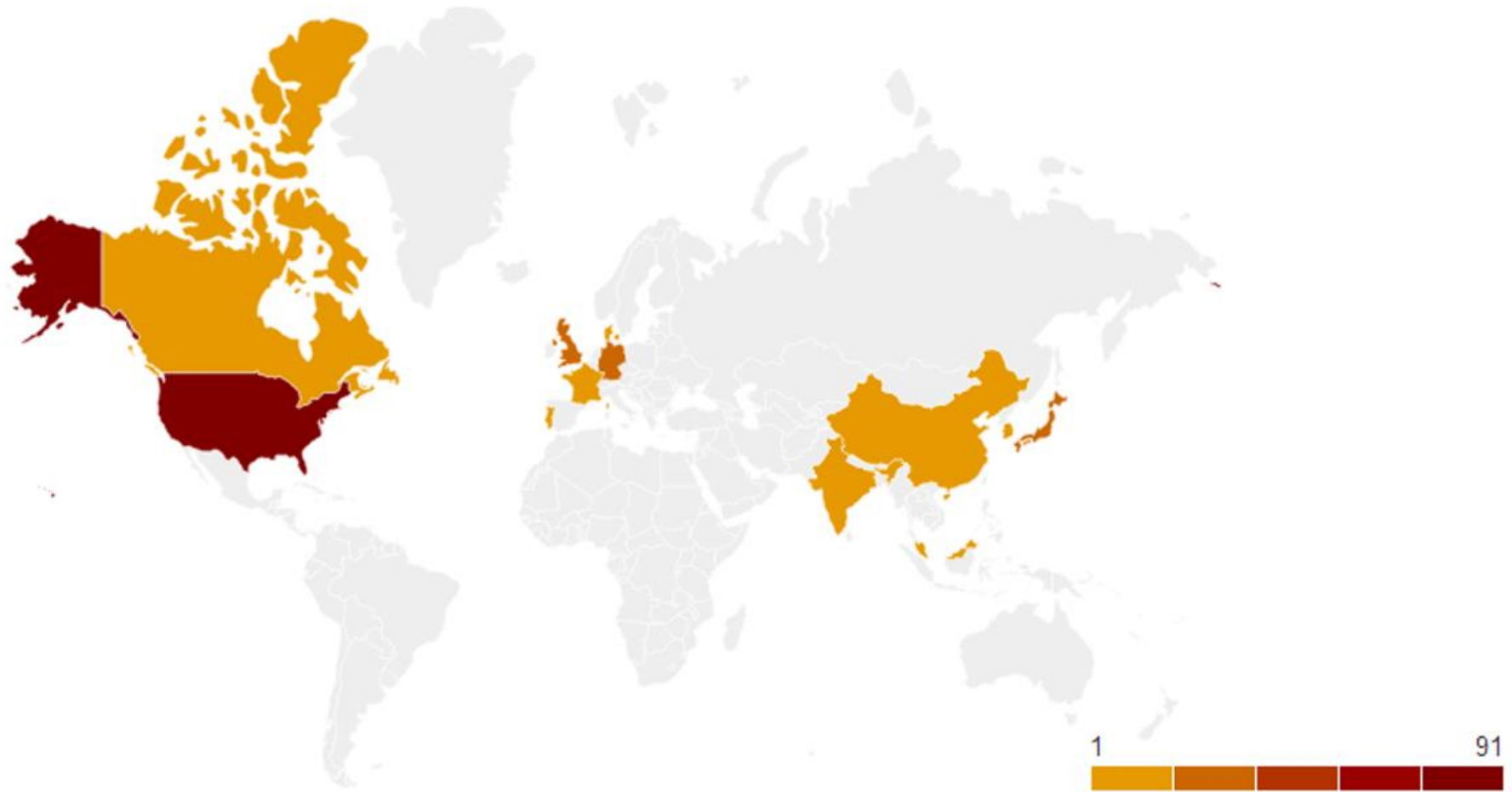
Figure A1.2.36 provides data to show how applicant location has varied over a ten-year window.

Figure A1.2.36 shows that the USA remains as the dominant location for patent filers. The data also shows that the UK, France and Germany have increased in importance.

Applicant location for worldwide PAFc patent applications 2005 – 2009



Applicant location for worldwide PAFI patent applications 2014 – 2019



A1.2.36. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.2.5. Proton Exchange Membrane Fuel Cell

Figures A1.2.37 to A1.2.43 show the top 10 assignees of proton exchange membrane fuel cell (PEMFC) patent applications, for the top 5 offices.

Many of the top 10 filers come from the automotive sector.

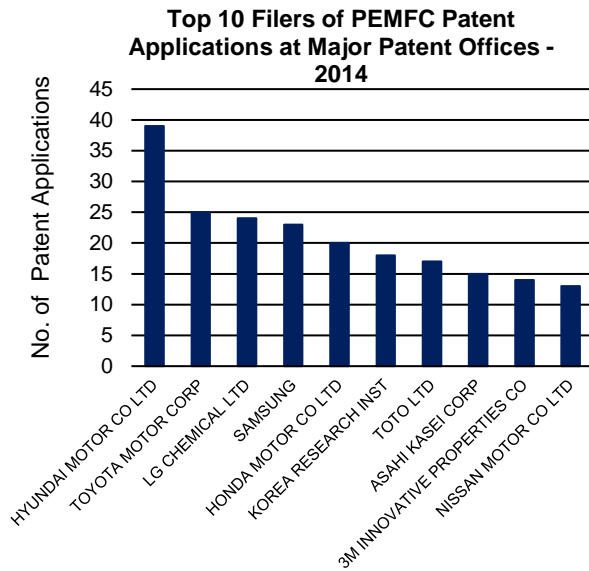


Figure A1.2.37. Top ten filers of PEMFC patent applications at the Top 5 Patent Offices for 2014.

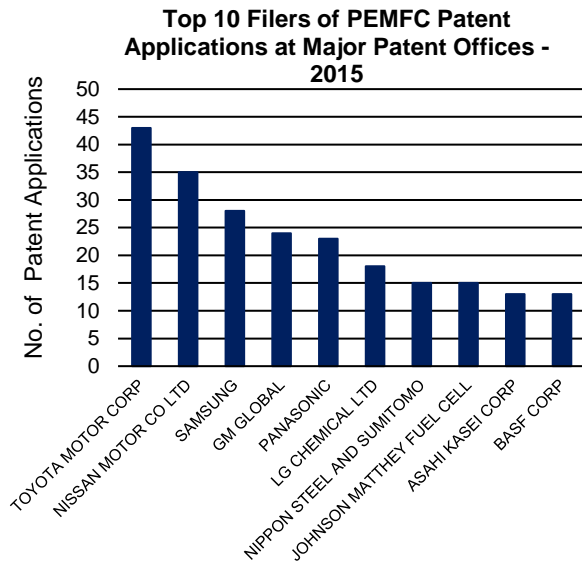


Figure A1.2.38. Top 10 filers of PEMFC patent applications at the Top 5 Offices for 2015.

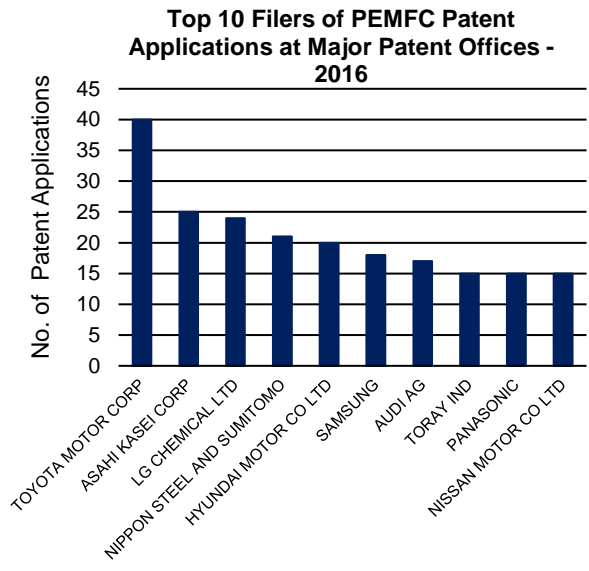


Figure A1.2.39. Top ten filers of PEMFC patent applications at the Top 5 Patent Offices for 2016.

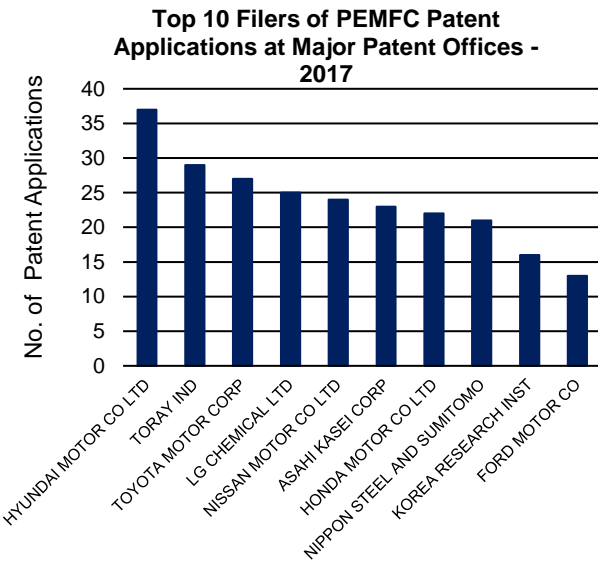


Figure A1.2.40. Top 10 filers of PEMFC patent applications at the Top 5 Offices for 2017.

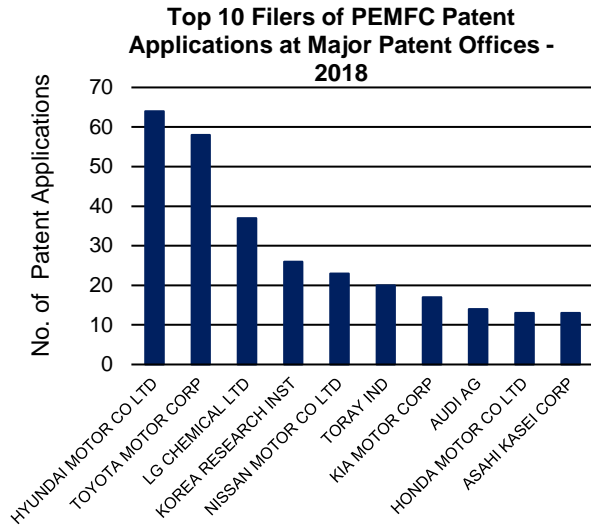


Figure A1.2.41. Top ten filers of PEMFC patent applications at the Top 5 Patent Offices for 2018.

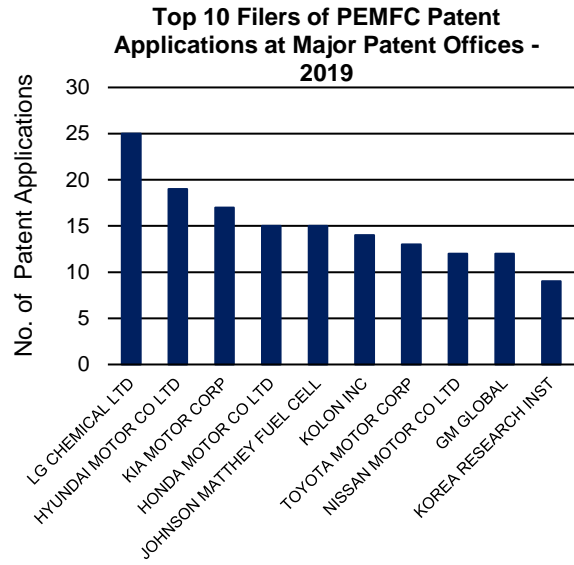


Figure A1.2.42. Top 10 filers of PEMFC patent applications at the Top 5 Offices for 2019.

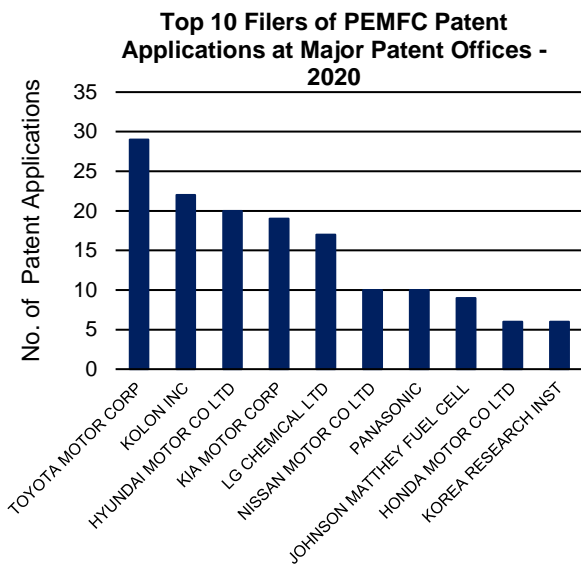


Figure A1.2.43. Top ten filers of PEMFC patent applications at the Top 5 Patent Offices for 2020.

Figure A1.2.44 provides a technical comparison between patents filed for PEMFCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.2.44 shows that the technical spread has broadened over the period, with surface technologies becoming more important.

The overall technological picture appears similar over time with the only notable change being the emergence of “Surface Technology and Coating” during the later period.

It should be noted that the size of the dataset for each respective period are not the same (2014/19< 2005/09) and so this graph provides information about relative changes between the periods.

Technological Breakdown for PEMFC Patent Applications 2005 – 2009



Technological Breakdown for PEMFC Patent Applications 2014 – 2019



A1.2.44 Technological breakdown for PEMFC patent applications in comparison with 2005-2009 (PI).

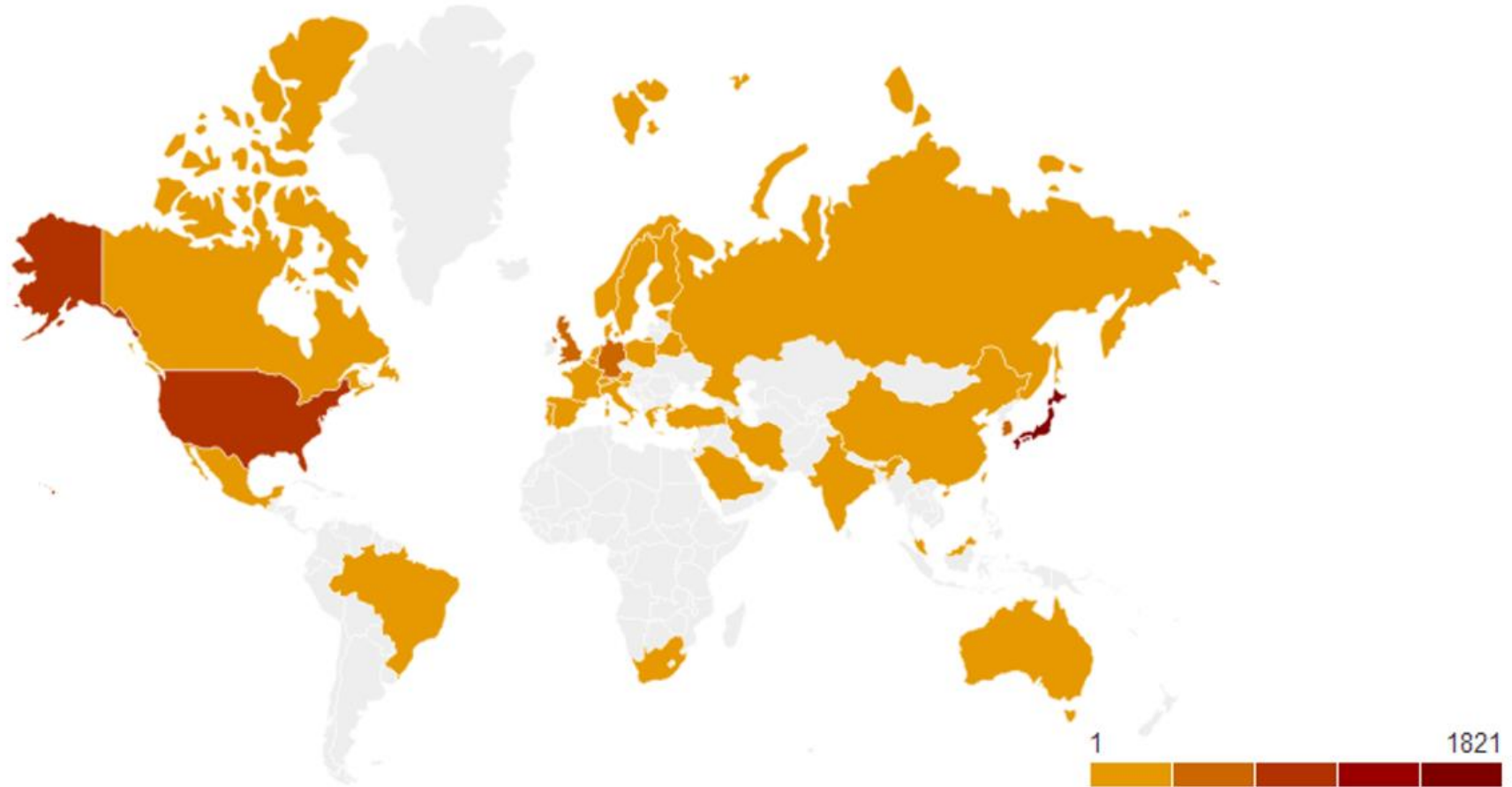
Figure A.1.2.45 provides data to show how applicant location has varied over a ten-year window.

Figure A1.2.45 shows that the USA has become increasingly dominant, with the UK Germany and Japan being important locations.

Applicant location for worldwide PEMFC patent applications 2005 – 2009



Applicant location for worldwide PEMFC patent applications 2014 – 2019



A1.2.45. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.2.6. Solid Oxide Fuel Cells

Figures 3.3.46 to 3.3.52 show the top 10 assignees of solid oxide fuel cell (SOFC) patent applications, for the top 5 offices.

The top filers are LG (China), NGK (Japan and Europe), Bloom Energy (USA) and the Korean Research Institute (Korea).

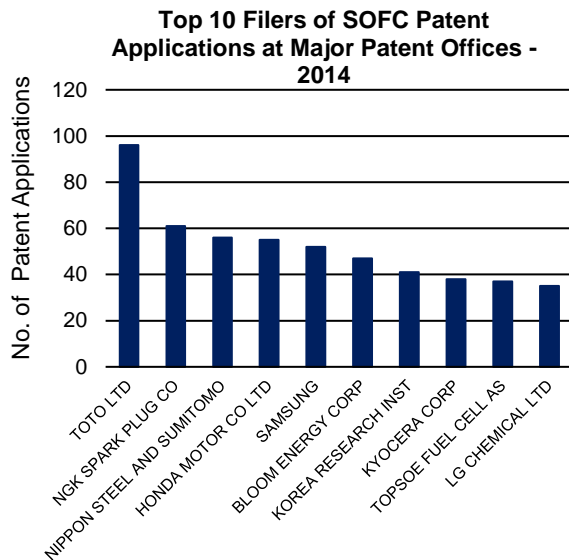


Figure A1.2.46. Top ten filers of SOFC patent applications at the Top 5 Patent Offices for 2014.

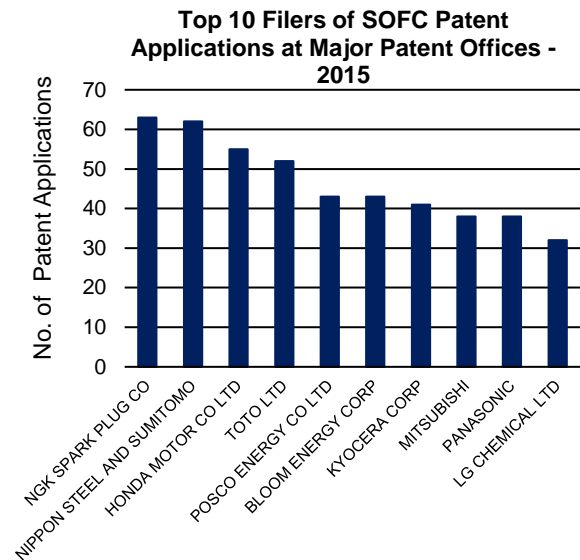


Figure A1.2.47. Top 10 filers of SOFC patent applications at the Top 5 Offices for 2015.

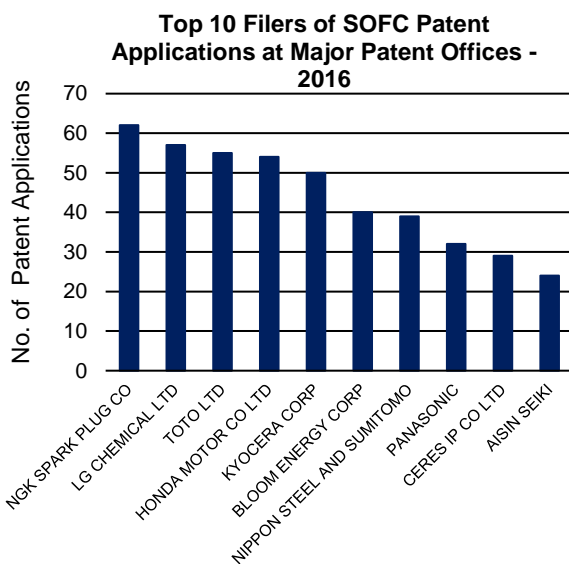


Figure A1.2.48. Top ten filers of SOFC patent applications at the Top 5 Patent Offices for 2016.

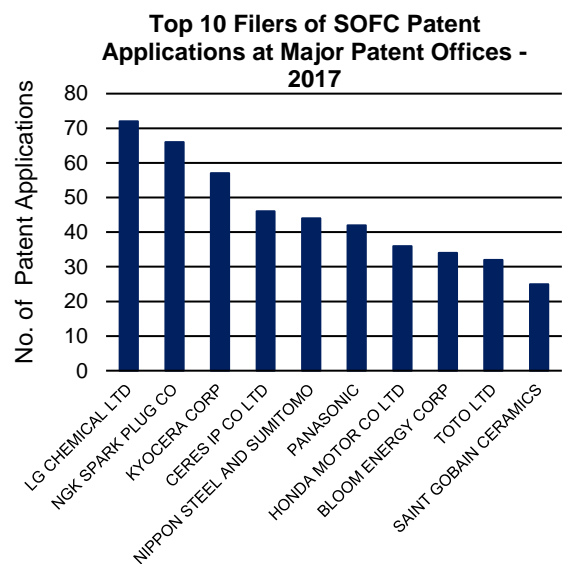


Figure A1.2.49. Top 10 filers of SOFC patent applications at the Top 5 Offices for 2017.

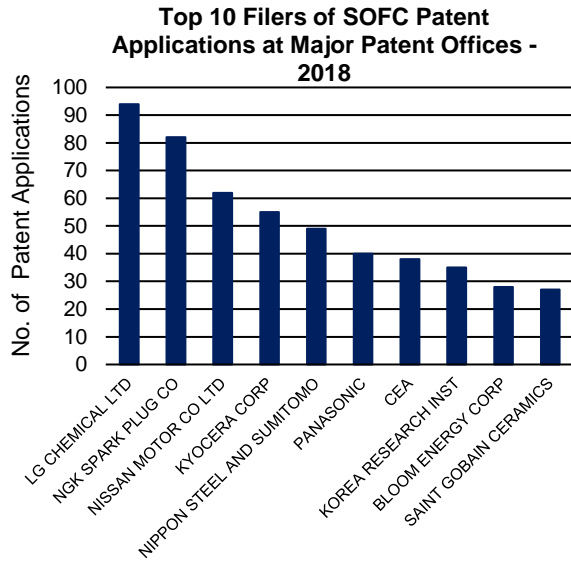


Figure A1.2.50. Top ten filers of SOFC patent applications at the Top 5 Patent Offices for 2018.

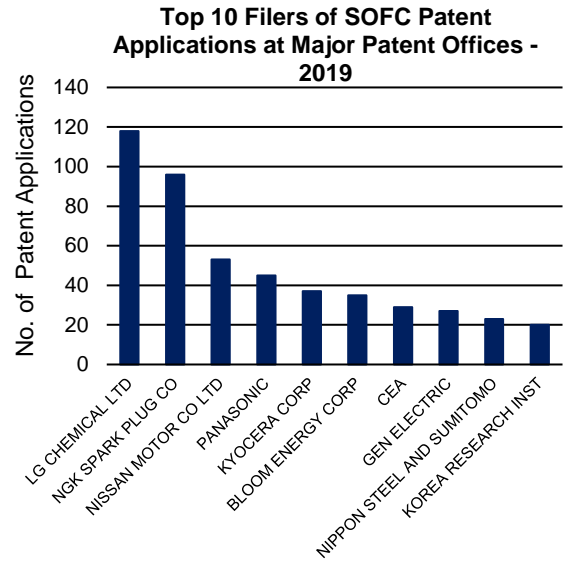


Figure A1.2.51. Top 10 filers of SOFC patent applications at the Top 5 Offices for 2019.

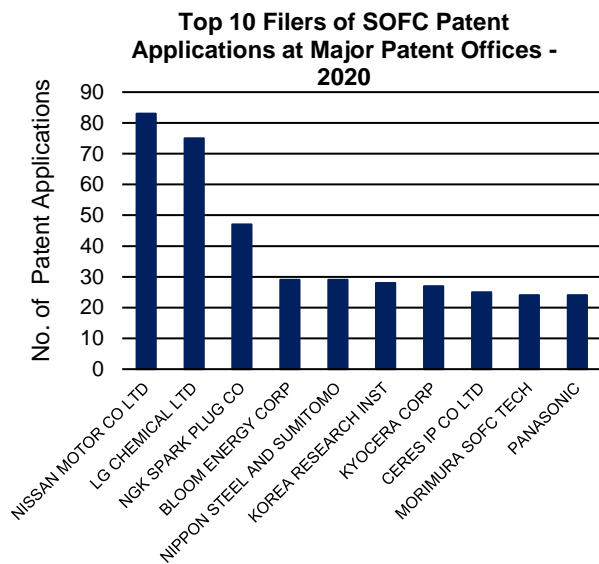


Figure A1.2.52. Top ten filers of SOFC patent applications at the Top 5 Patent Offices for 2020.

Figure A1.2.53 provides a technical comparison between patents filed for SOFCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.2.53 shows a similar technological spread over time.

The technological spread appears to be remarkably consistent over time.

It should be noted that the size of the dataset for each respective period are broadly similar (2014/19< 2005/09).

Technological Breakdown for SOFC Patent Applications 2005 – 2009



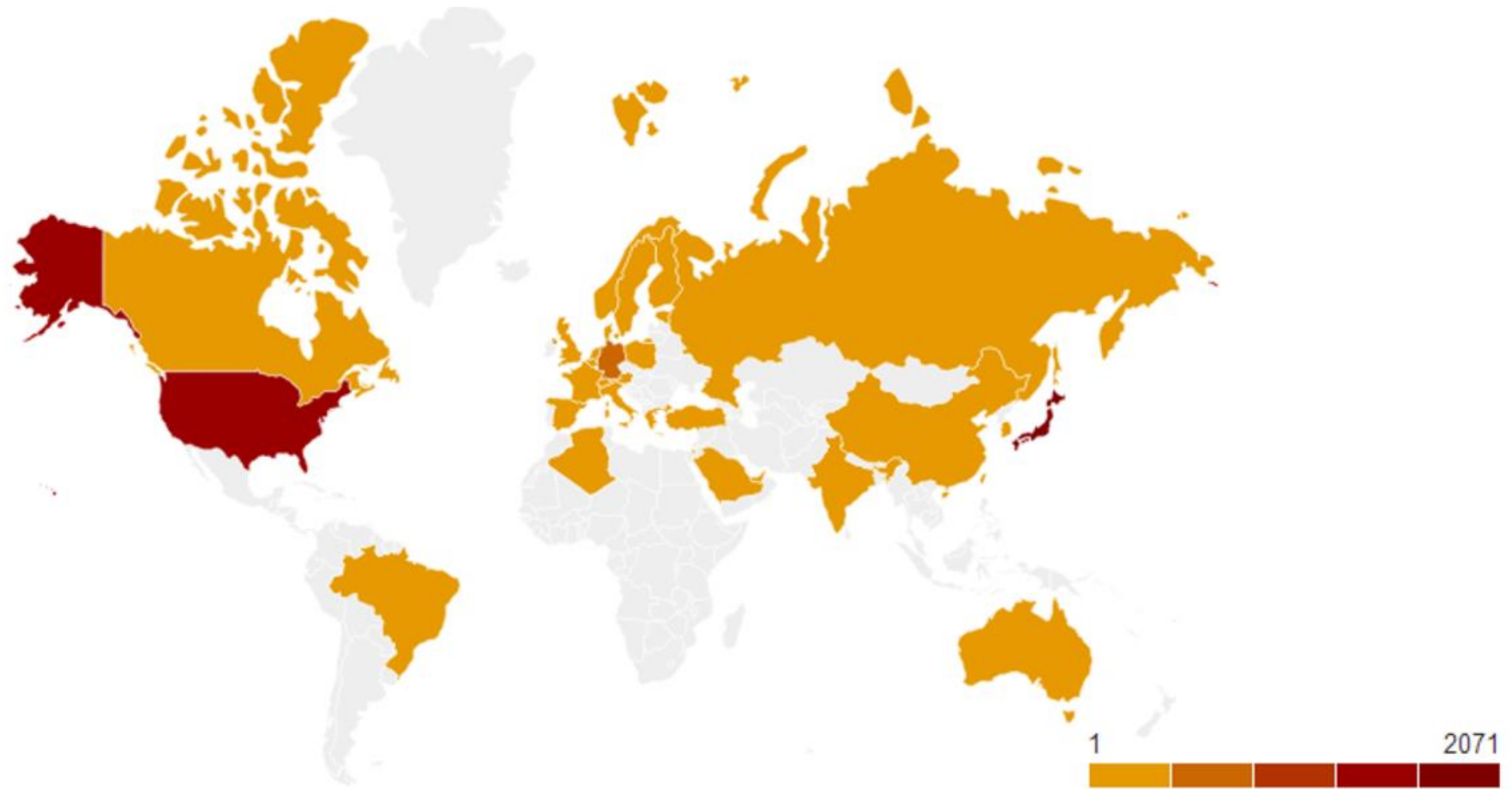
Technological Breakdown for SOFC Patent Applications 2014 – 2019



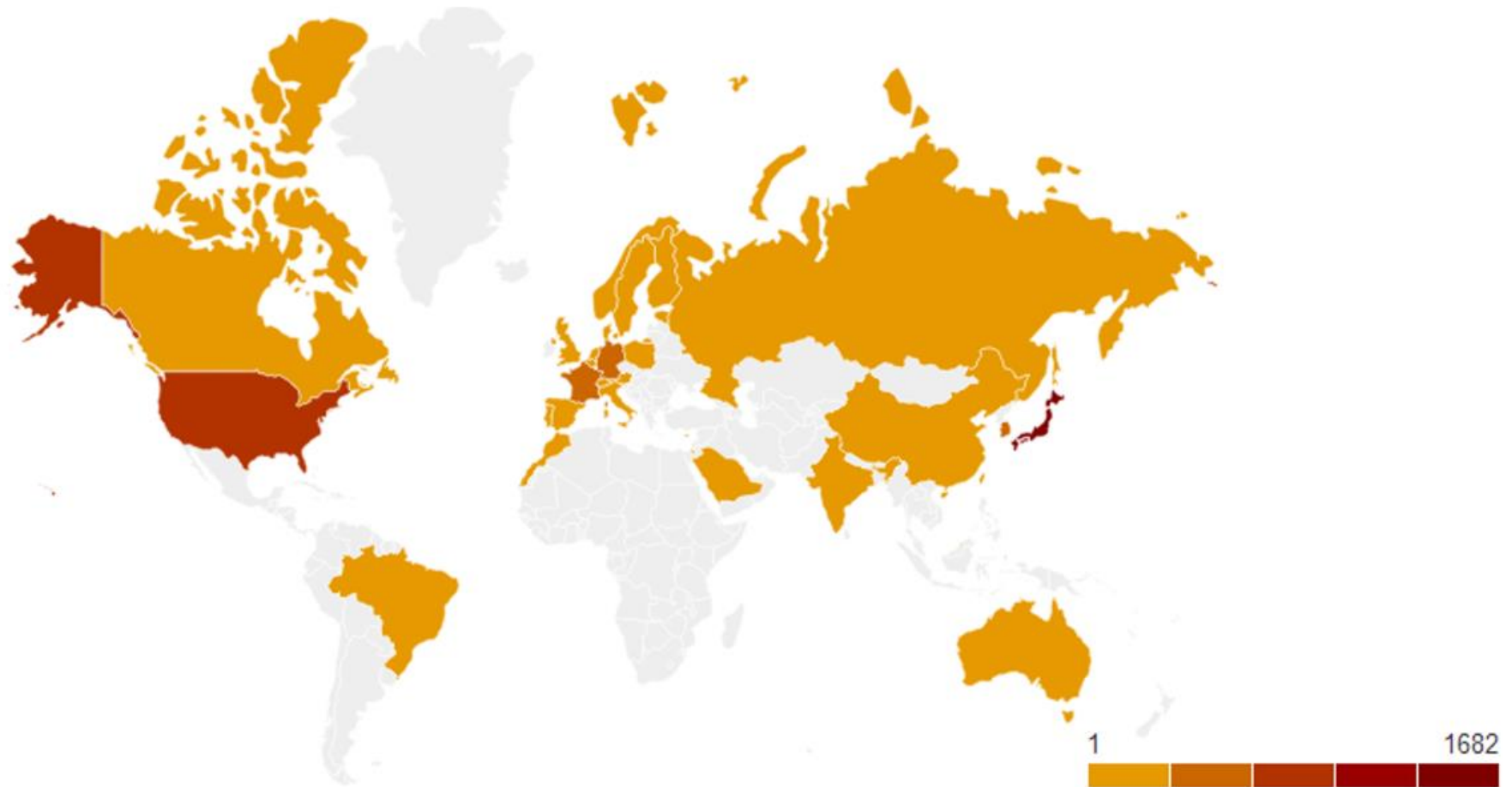
A1.2.53. Technological breakdown for SOFC patent applications in comparison with 2005-2009 (PI).

Figure A1.2.54 provides data to show how applicant location has varied over a ten-year window. Figure A1.2.54 shows that the location of patent applicants has remained very similar over time, except France emerging as a more important location and the USA slightly falling back.

Applicant location for worldwide SOFC patent applications 2005 – 2009



Applicant location for worldwide SOFC patent applications 2014 – 2019



A1.2.54. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.3. Fuel Cell Deployment

The data presented below shows the top 10 filers of patent applications for mobile, stationary and portable fuel cells, for the years 2014 to 2019, for each of the top 5 offices. In each case the bars show the absolute number of patent applications associated with a particular entity.

1.3.1. Mobile Fuel Cells

Figures A1.3.1 to A1.3.7 show the top 10 assignees of mobile fuel cell patent applications for the top 5 offices.

The top 10 assignees are unsurprisingly dominated by automotive companies.

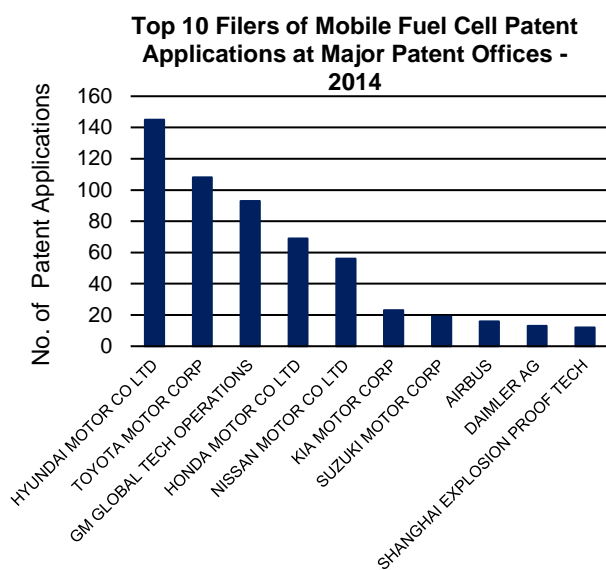


Figure A1.3.1. Top ten filers of mobile fuel cell patent applications at the Top 5 Patent Offices for 2014.

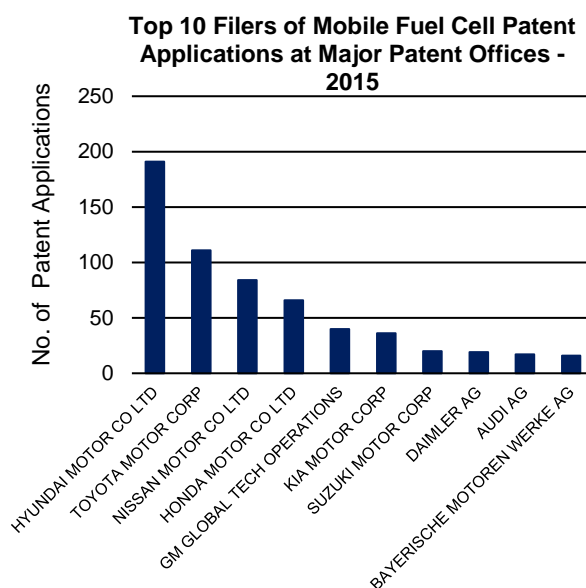


Figure A1.3.2. Top 10 filers of mobile fuel cell patent applications at the Top 5 Offices for 2015.

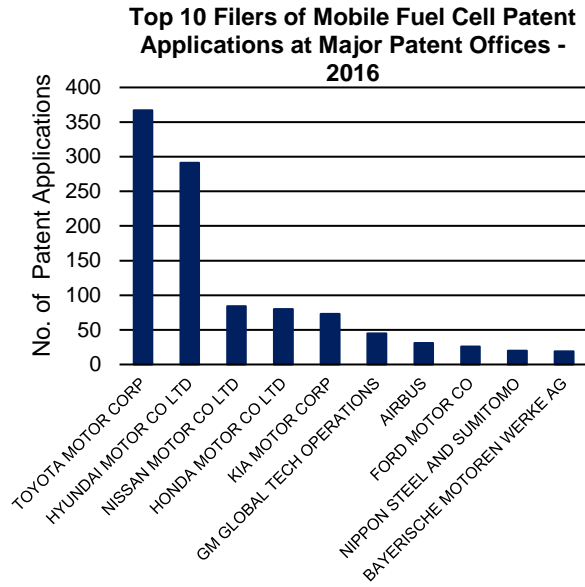


Figure A1.3.3. Top ten filers of mobile fuel cell patent applications at the Top 5 Patent Offices for 2016.

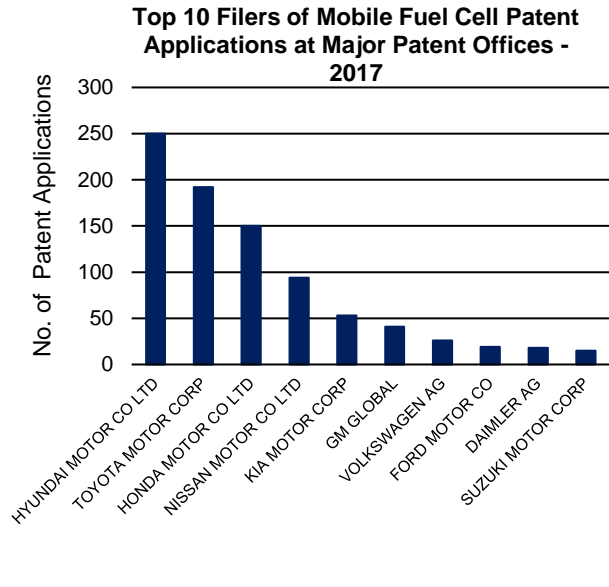


Figure A1.3.4. Top 10 filers of mobile fuel cell patent applications at the Top 5 Offices for 2017.

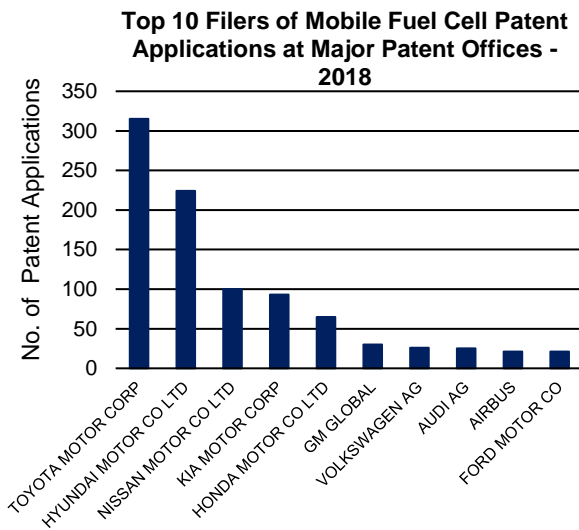


Figure A1.3.5. Top ten filers of mobile fuel cell patent applications at the Top 5 Patent Offices for 2018.

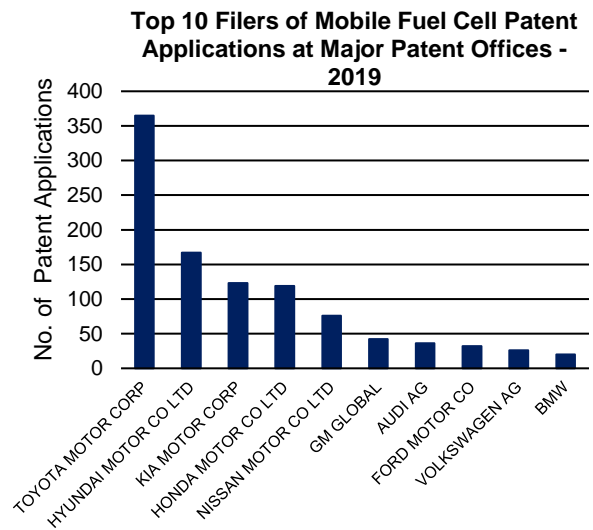


Figure A1.3.6. Top 10 filers of mobile fuel cell patent applications at the Top 5 Offices for 2019.

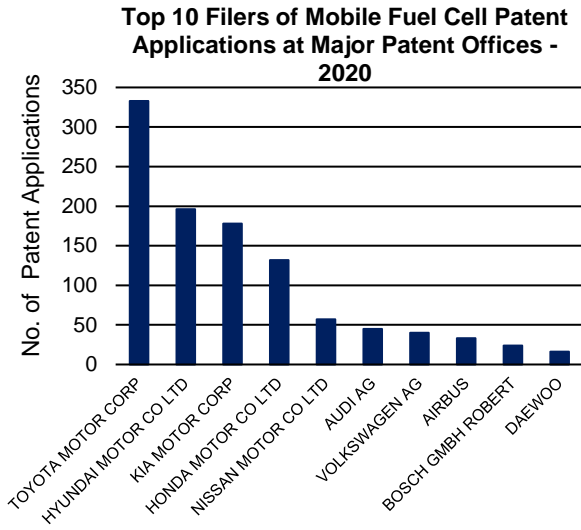


Figure A1.3.7. Top ten filers of mobile fuel cell patent applications at the Top 5 Patent Offices for 2020.

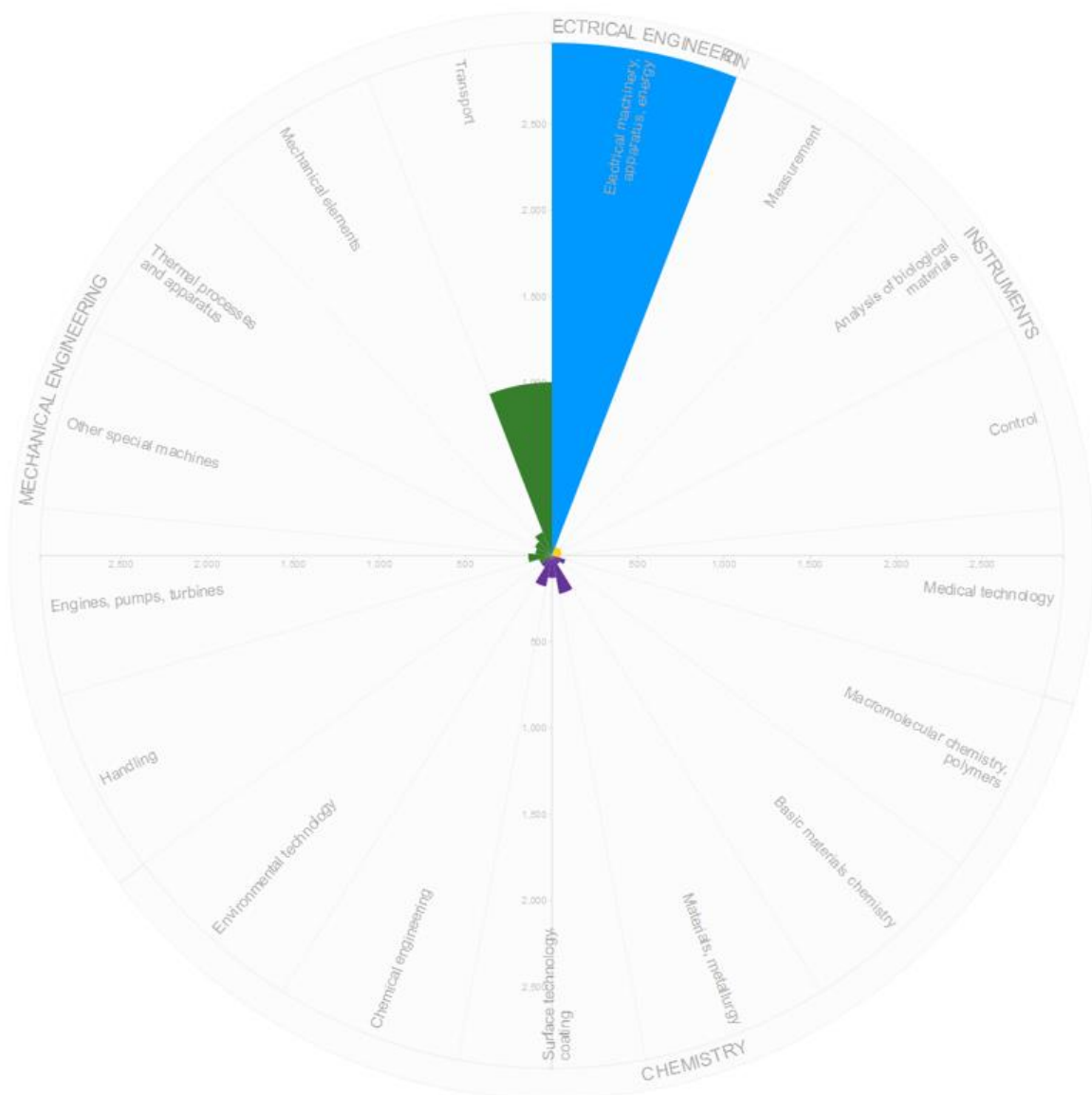
Figure A1.3.8 provides a technical comparison between patents filed for Mobile FCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.3.8 shows that chemical technologies appear to have become relatively less relevant.

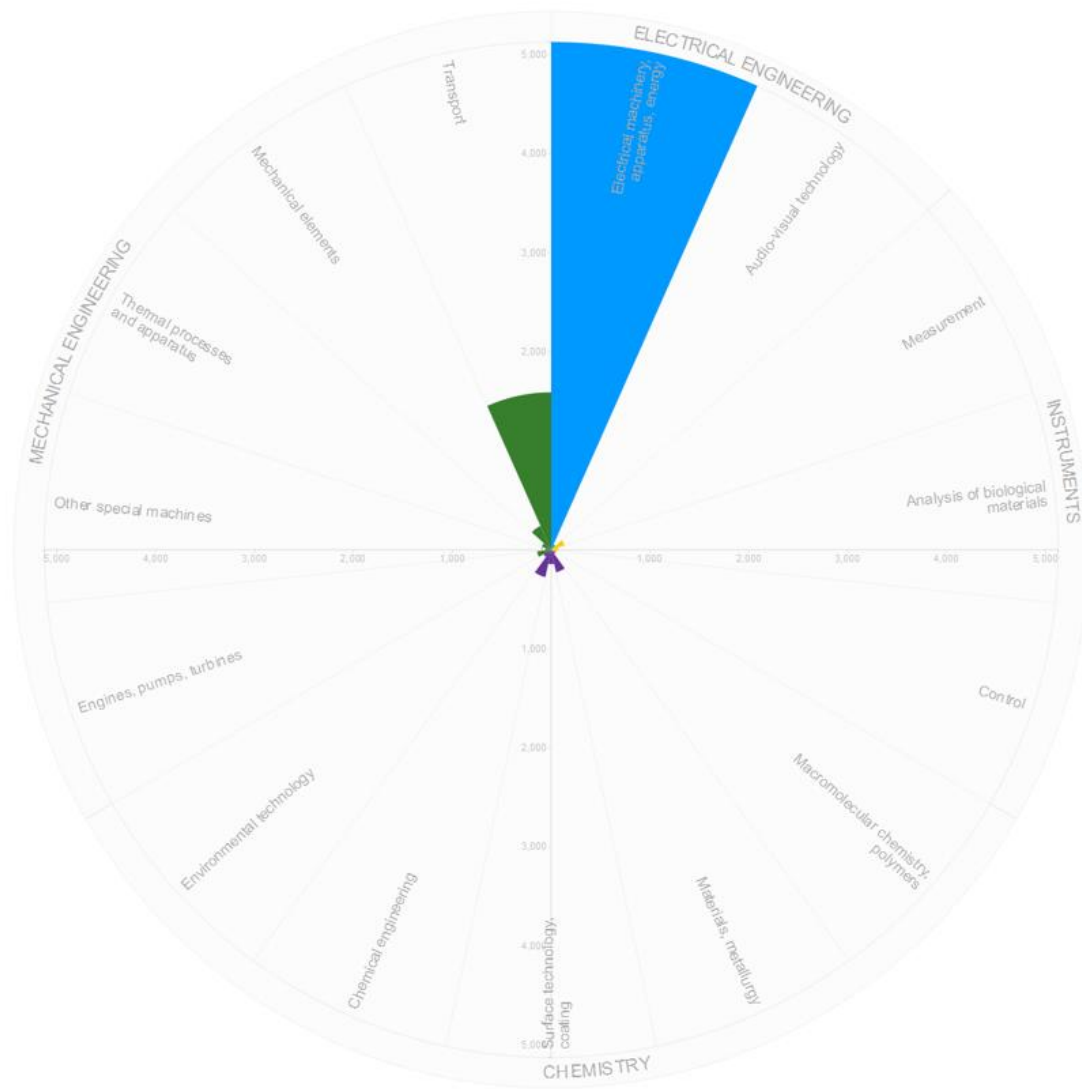
The relative decrease in the size of the purple bars indicates that chemical technologies have become relative less important over the period.

It should be noted that the size of the dataset for each respective period are very similar.

Technological Breakdown for Mobile FC Patent Applications 2005 – 2009



Technological Breakdown for Mobile FC Patent Applications 2014 – 2019

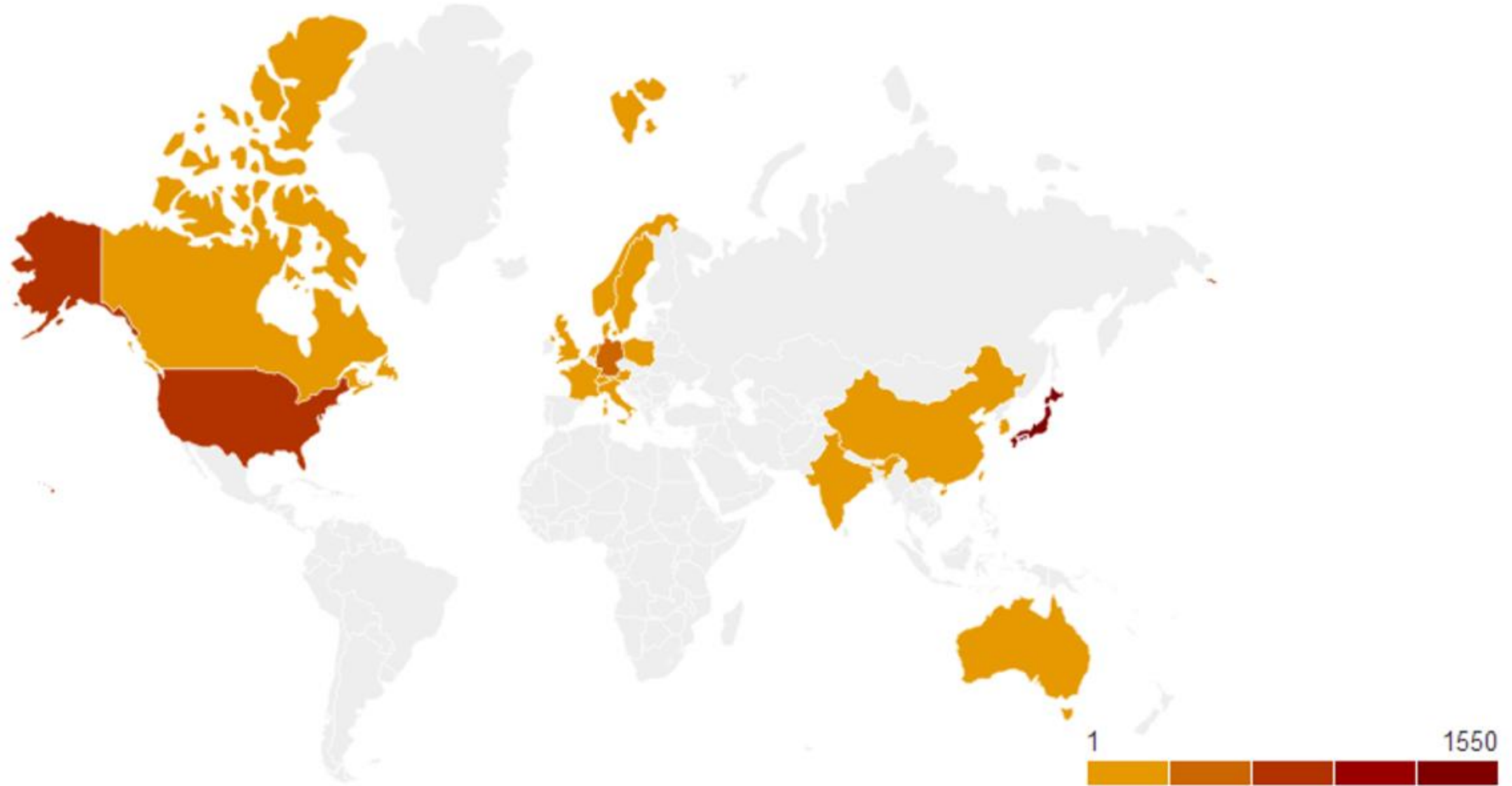


A1.3.8. Technological breakdown for Mobile FC patent applications in comparison with 2005-2009 (PI).

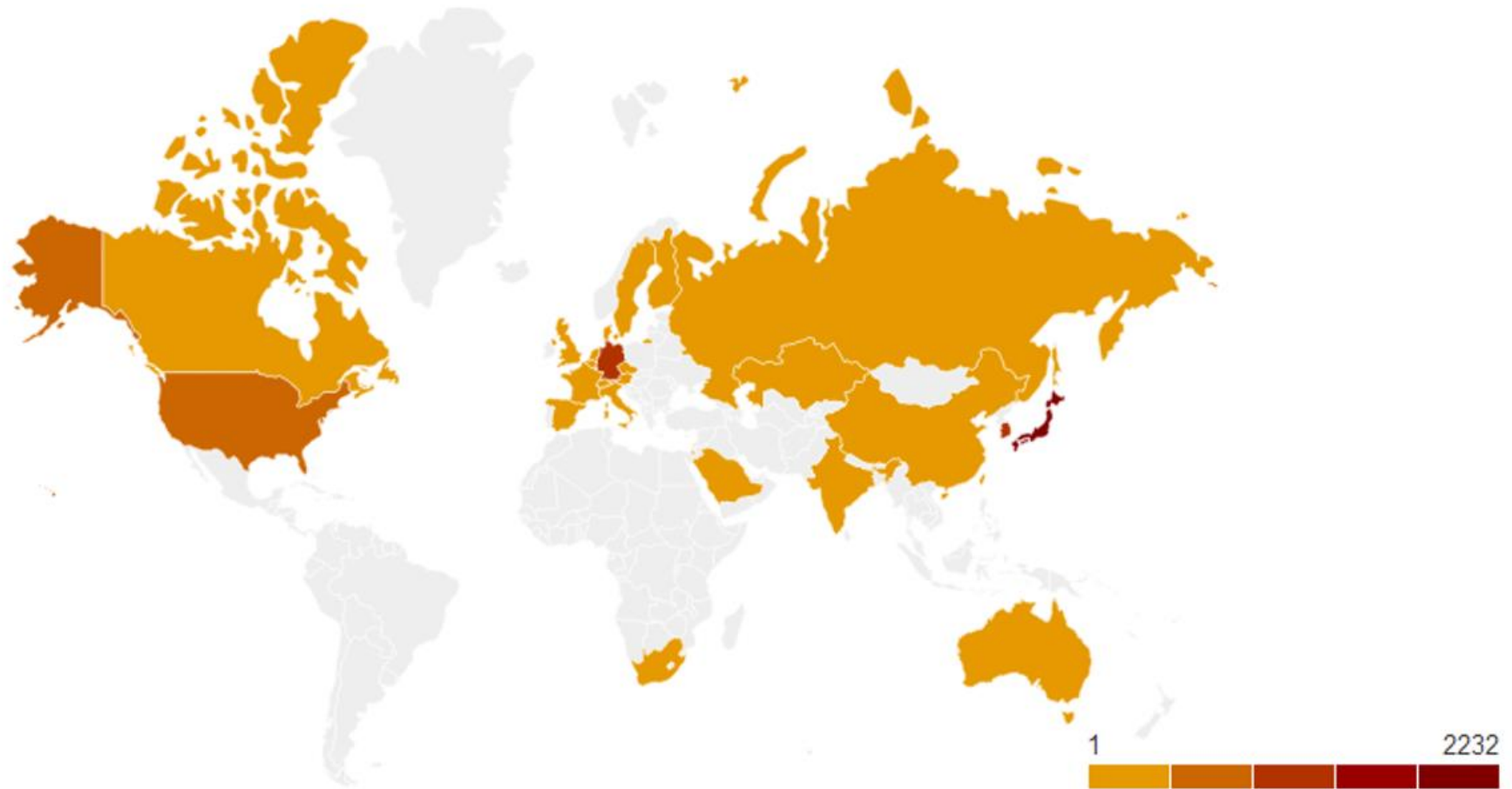
Figure A1.3.9 provides data to show how applicant location has varied over a ten-year window.

Figure A1.3.9 appears to show that there has been more diversification in the location of patent applicants in this space.

Applicant location for worldwide Mobile FC patent applications 2005 – 2009



Applicant location for worldwide Mobile FC patent applications 2014 – 2019



A1.3.9. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.3.2. Stationary Fuel Cells

Figures A1.3.10 to A1.3.16 show the top 10 assignees of stationary fuel cell patent applications for the top 5 offices.

The top filers appear to vary over the period.

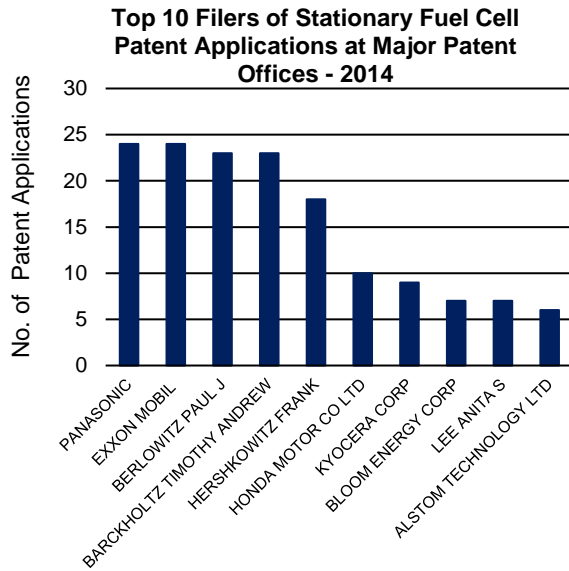


Figure A1.3.10. Top ten filers of stationary fuel cell patent applications at the Top 5 Patent Offices for 2014.

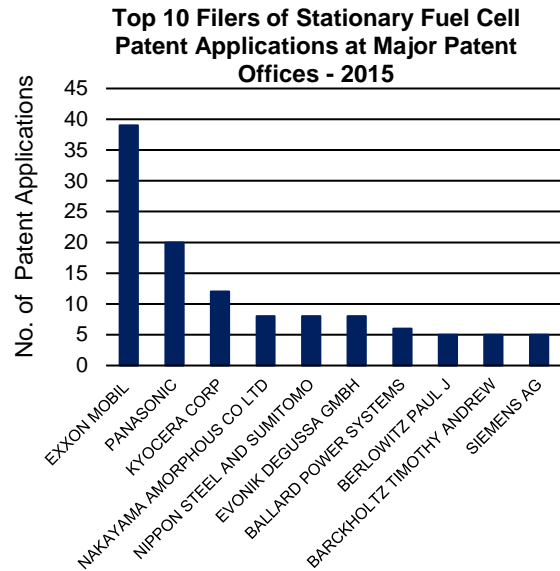


Figure A1.3.11. Top 10 filers of stationary fuel cell patent applications at the Top 5 Offices for 2015.

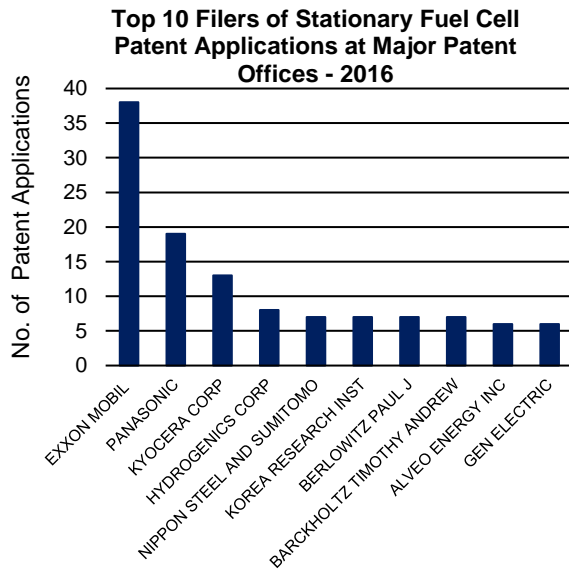


Figure A1.3.12. Top ten filers of stationary fuel cell patent applications at the Top 5 Patent Offices for 2016.

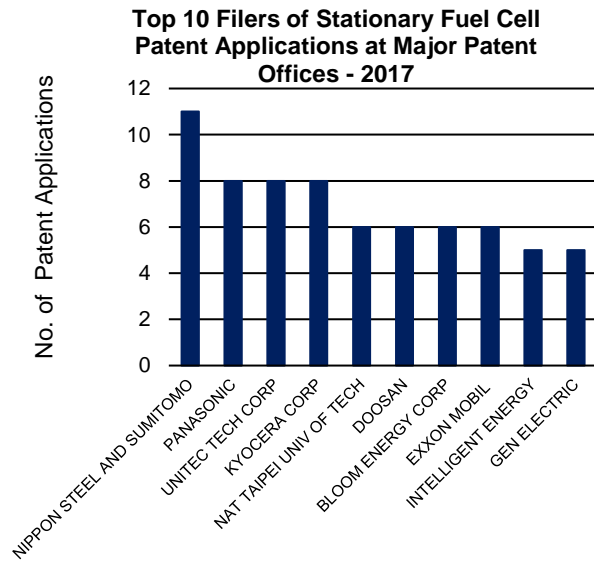


Figure A1.3.13. Top 10 filers of stationary fuel cell patent applications at the Top 5 Offices for 2017.

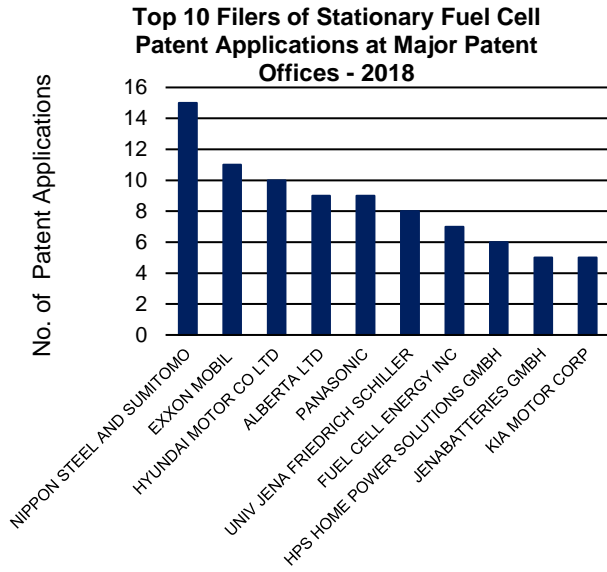


Figure A1.3.14. Top ten filers of stationary fuel cell patent applications at the Top 5 Patent Offices for 2018.

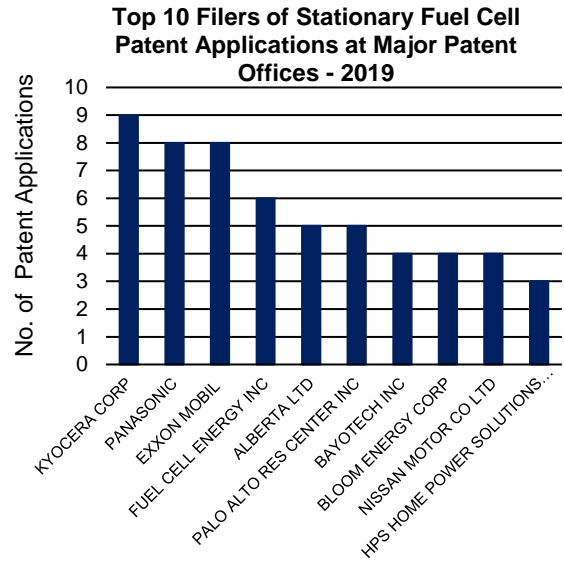


Figure A1.3.15. Top 10 filers of stationary fuel cell patent applications at the Top 5 Offices for 2019.

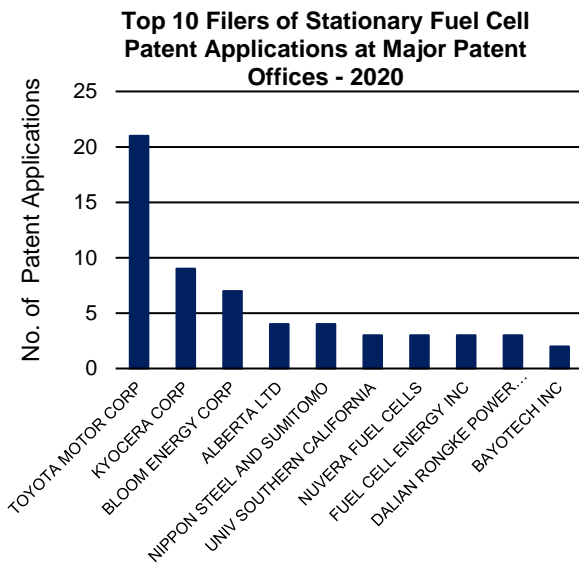


Figure A1.3.16. Top ten filers of stationary fuel cell patent applications at the Top 5 Patent Offices for 2020

Figure A1.3.17 provides a technical comparison between patents filed for Stationary FCs for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.3.17 shows that chemical technologies are becoming increasingly important.

In contrast to mobile FC position, the increase in purple bars shows that chemical technologies (purple bars) are becoming increasingly important, especially “Metallurgy” (major purple bar).

It should be noted that the size of the dataset for each respective period are not the same (2014/19> 2005/09) and so this graph provides information about relative changes between the periods.

Technological Breakdown for Stationary FC Patent Applications 2005 – 2009



Technological Breakdown for Stationary FC Patent Applications 2014 – 2019

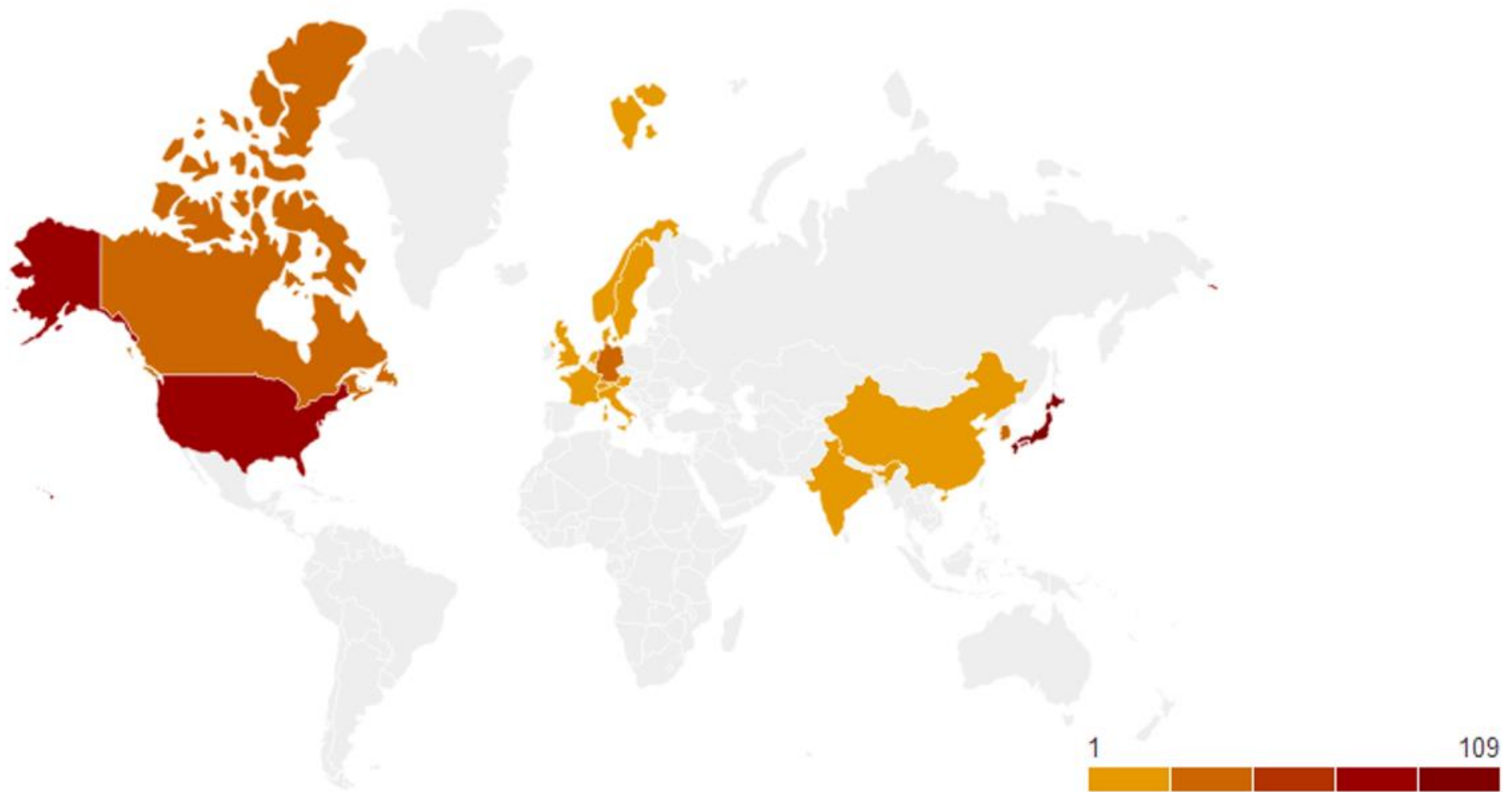


A1.3.17. Technological breakdown for Stationary FC patent applications in comparison with 2005-2009 (PI).

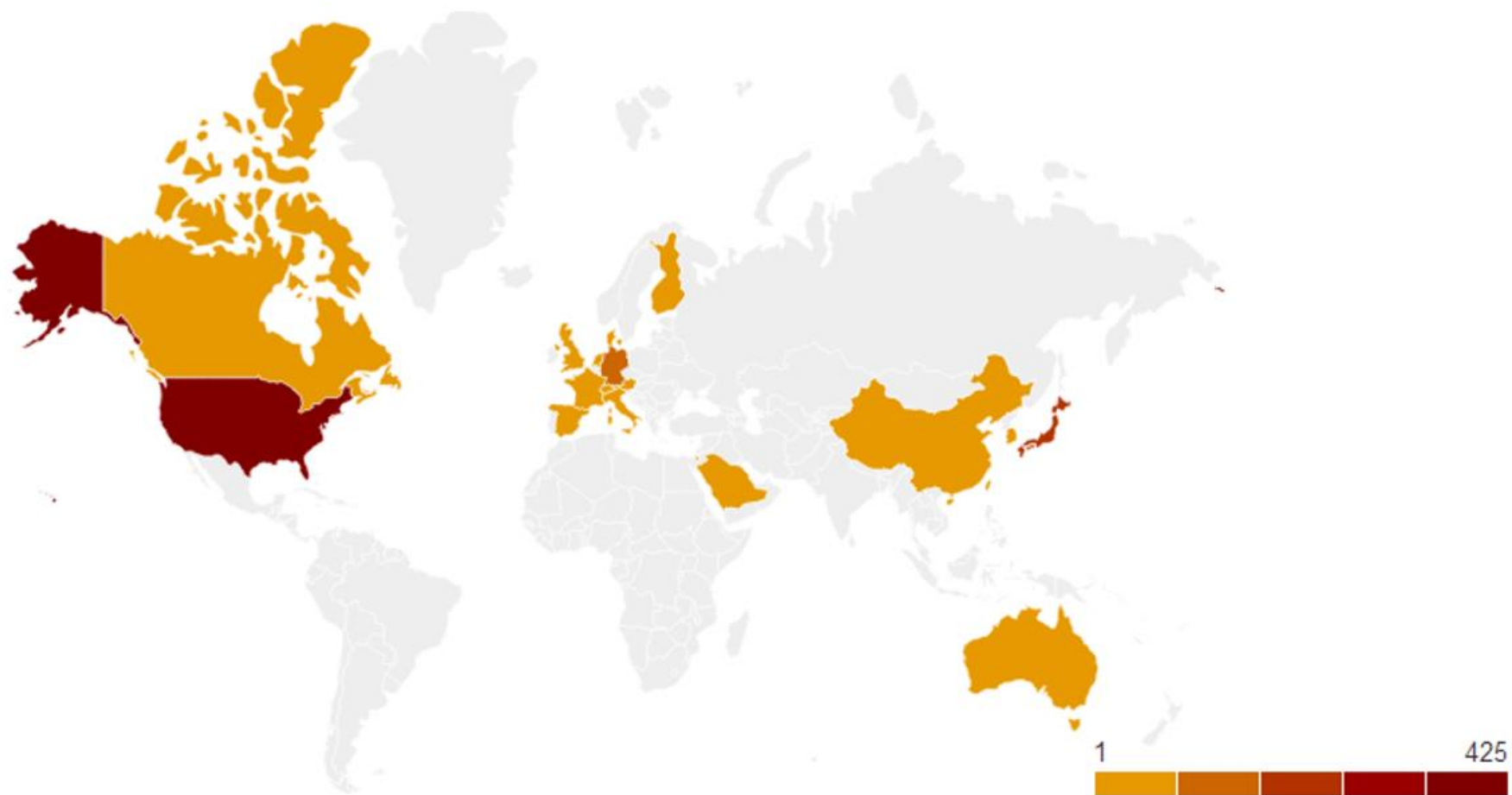
Figure A1.3.18 provides data to show how applicant location has varied over a ten-year window.

Figure A1.3.18 shows that Canada has become a less important jurisdiction as a location for patent filers and that there has been some consolidation.

Applicant location for worldwide Stationary FC patent applications 2005 – 2009



Applicant location for worldwide Stationary FC patent applications 2014 – 2019



A1.3.18. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.3.3. Portable Fuel Cells

Figures A1.3.19 to A1.3.25 show the top 10 assignees of portable fuel cell patent applications for each of the top 5 offices.

Intelligent Energy are the top filer of portable fuel cell patent applications featuring in the top two annually between 2014 and 2019.

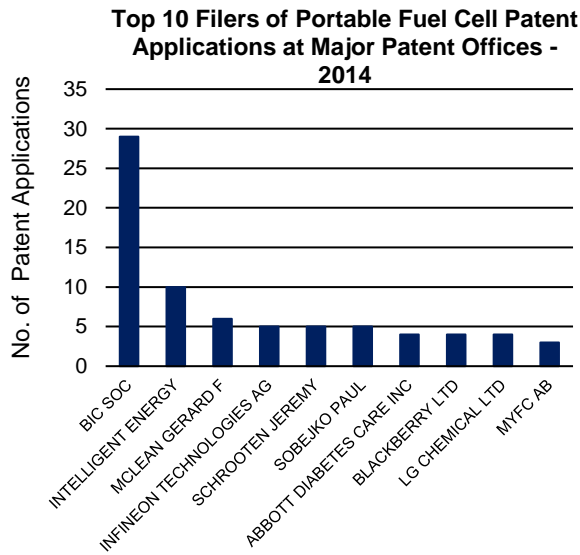


Figure A1.3.19. Top ten filers of portable fuel cell patent applications at the Top 5 Patent Offices for 2014.

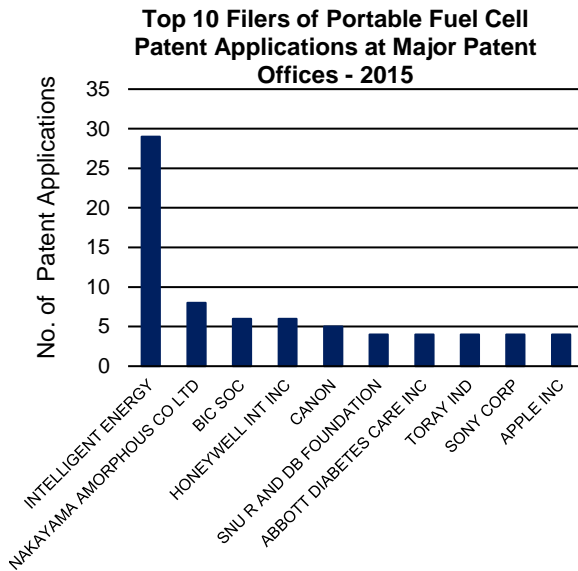


Figure A1.3.20. Top 10 filers of portable fuel cell patent applications at the Top 5 Offices for 2015.

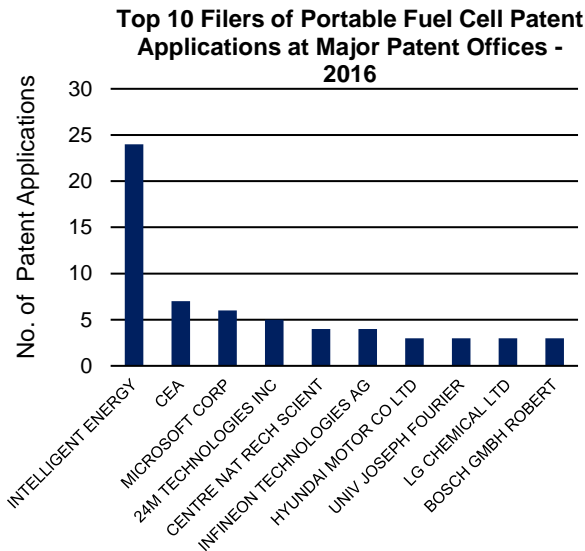


Figure A1.3.21. Top ten filers of portable fuel cell patent applications at the Top 5 Patent Offices for 2016.

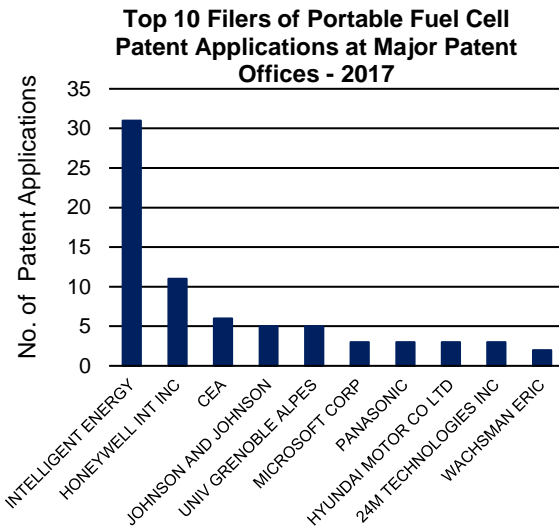


Figure A1.3.22. Top 10 filers of portable fuel cell patent applications at the Top 5 Offices for 2017.

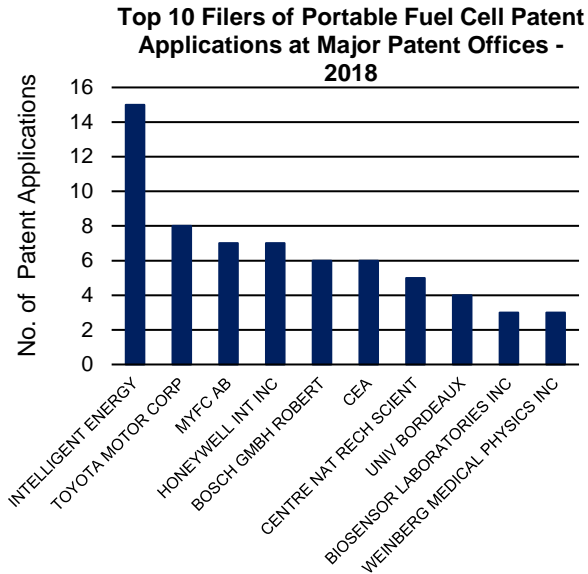


Figure A1.3.123. Top ten filers of portable fuel cell patent applications at the Top 5 Patent Offices for 2018.

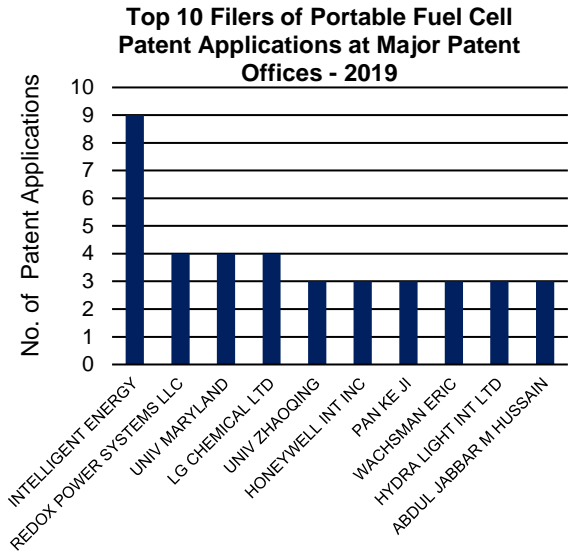


Figure A1.3.24. Top 10 filers of portable fuel cell patent applications at the Top 5 Offices for 2019.

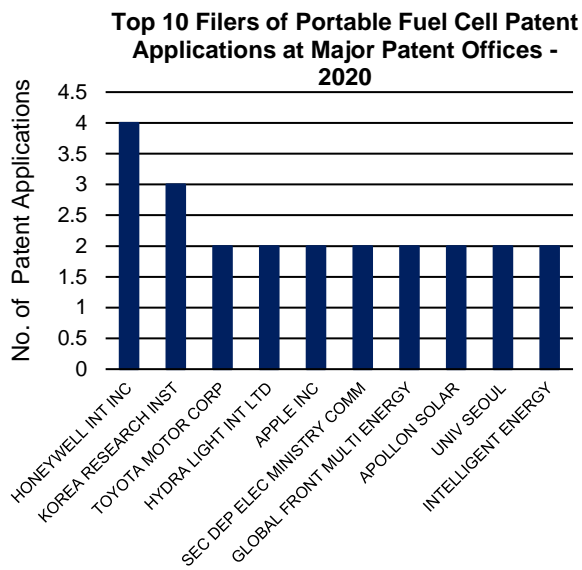


Figure A1.3.25. Top ten filers of portable fuel cell patent applications at the Top 5 Patent Offices for 2020

Figure A1.3.26 provides a technical comparison between patents filed for portable fuel cells for 2014 to 2019 as compared to a period ten years earlier.

Figure A1.3.26 shows that chemical technologies have become increasingly important with a relative decrease in handling technologies.

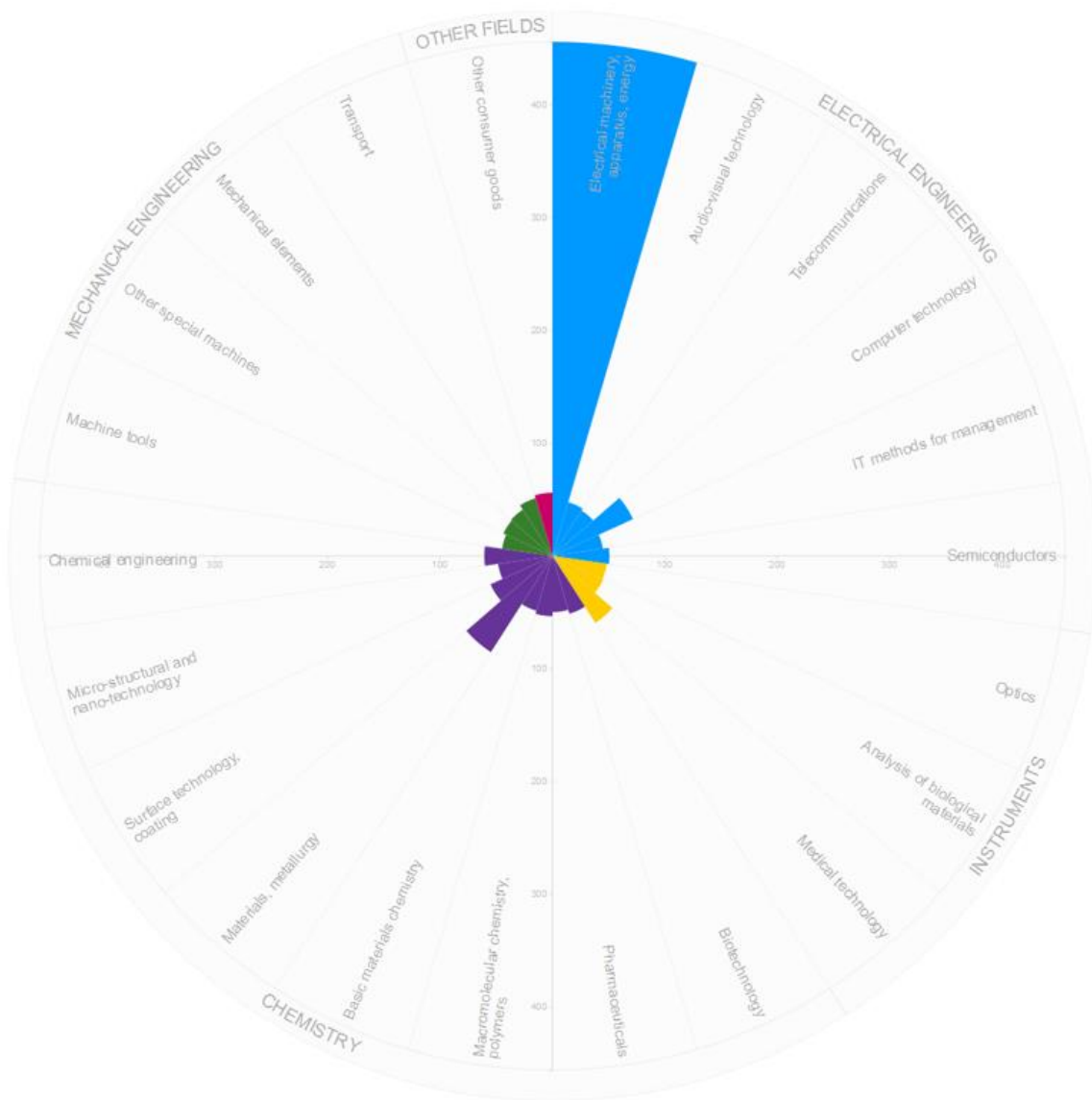
Again, the increase in purple bars shows that chemical technologies (purple bars) are becoming increasingly important, especially “Metallurgy” (major purple bar), with mechanical engineering technologies (green bars) (also slightly increasing relatively).

It should be noted that the size of the dataset for each respective period are not the same (2014/19< 2005/09) and so this graph provides information about relative changes between the periods.

Technological Breakdown for Portable FC Patent Applications 2005 – 2009



Technological Breakdown for Portable FC Patent Applications 2014 – 2019



A1.3.26. Technological breakdown for Portable FC patent applications in comparison with 2005-2009 (PI).

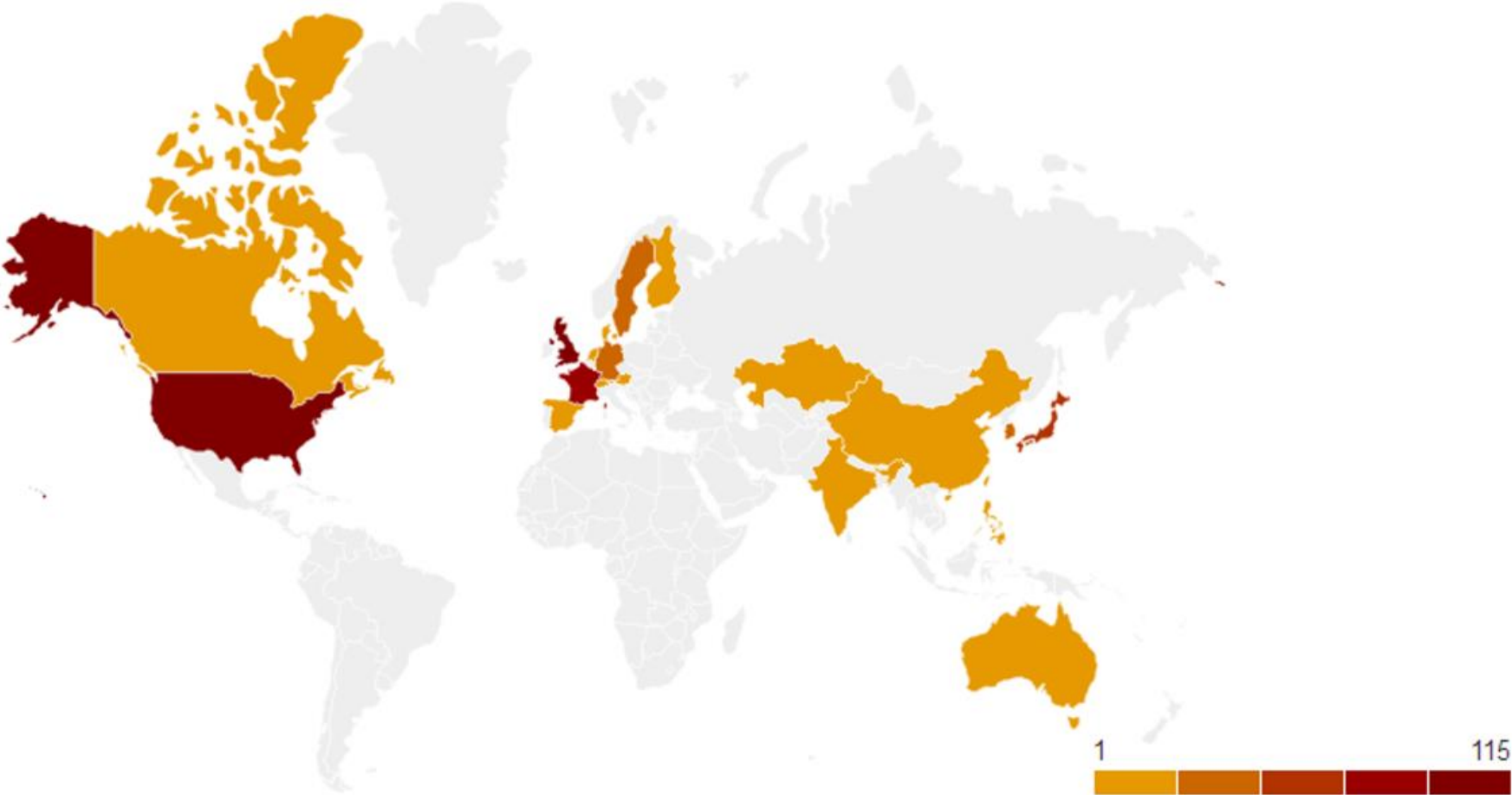
Figure A1.3.27 shows that there has been significant consolidation in the location of patent applicants.

Figure A1.3.27 provides data to show how applicant location has varied over a ten-year window.

Applicant location for worldwide Portable FC patent applications 2005 – 2009



Applicant location for worldwide Portable FC patent applications 2014 – 2019



A1.3.27. Geographical breakdown of application location in comparison with 2005-2009 (PI).

1.4. Hydrogen Transportation

The data presented below shows the top 10 filers of patent applications for hydrogen storage, distribution and production, for the years 2014 to 2019, for each of the top 5 offices. In each case the bars show the absolute number of patent applications associated with a particular entity.

1.4.1. Hydrogen Storage

The data presented below in Figures A1.4.1 to A1.4.7 shows the top 10 filers of hydrogen storage patent applications, for the years 2014 to 2019, for each of the top 5 offices.

The data shows that the number of patents filed by the top 10 assignees has increased significantly in 2019 and 2020 (compared to the period 2014 to 2018), with Toyota a prominent entity.

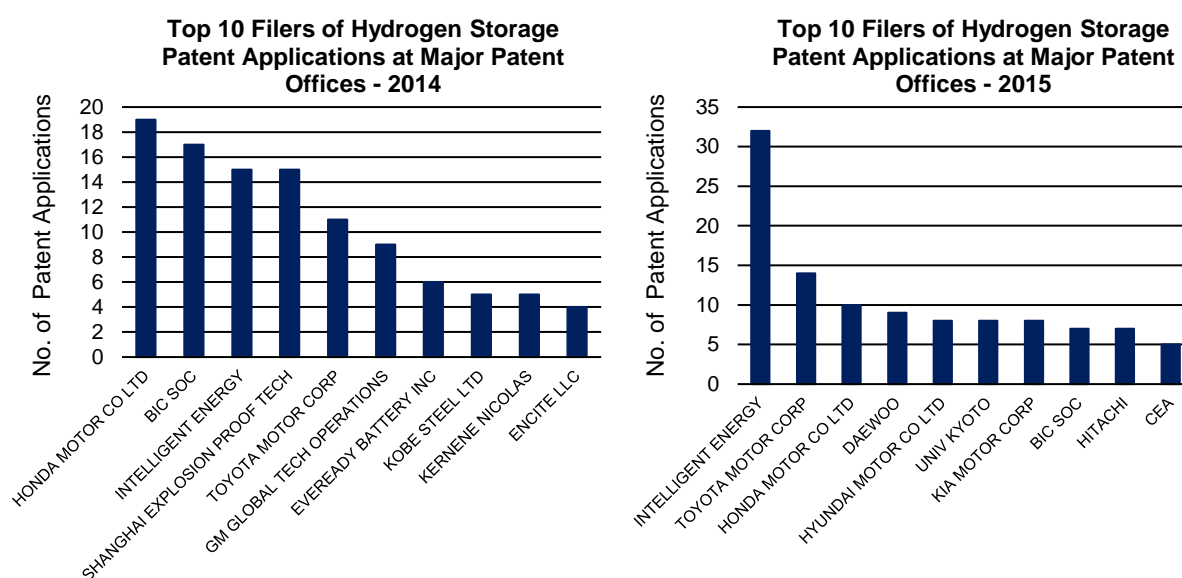


Figure A1.4.1. Top ten filers of hydrogen storage patent applications at the Top 5 Patent Offices for 2014.

Figure A1.4.2. Top 10 filers of hydrogen storage patent applications at the Top 5 Offices for 2015.

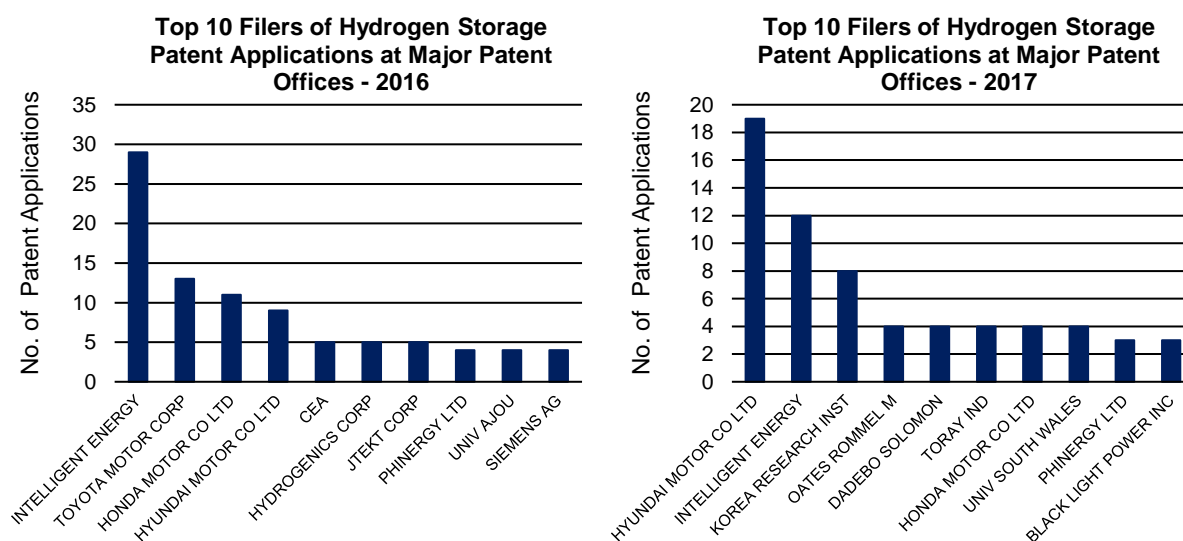


Figure A1.4.3. Top ten filers of hydrogen storage patent

Figure A1.4.4. Top 10 filers of hydrogen storage patent

applications at the Top 5 Patent Offices for 2016.

applications at the Top 5 Offices for 2017.

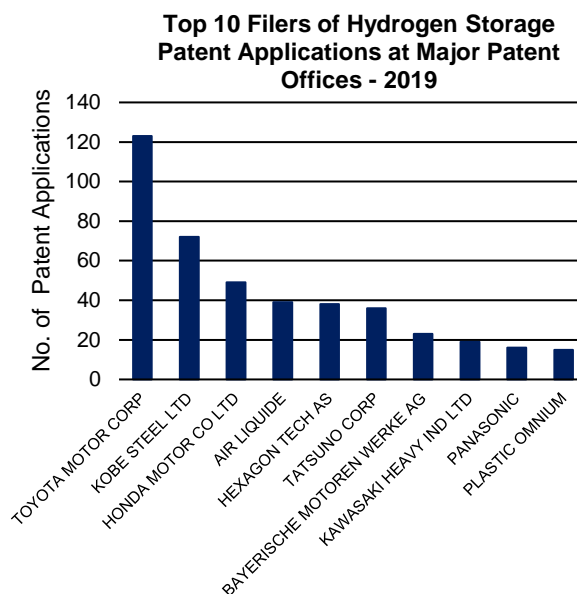
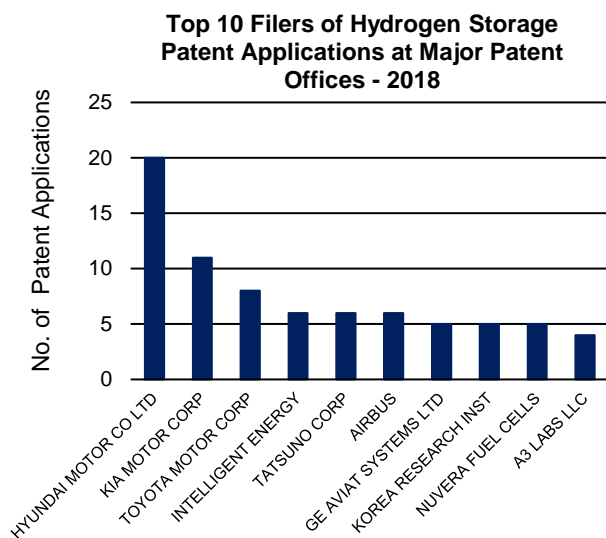


Figure A1.4.5. Top ten filers of hydrogen storage patent applications at the Top 5 Patent Offices for 2018.

Figure A1.4.6. Top 10 filers of hydrogen storage patent applications at the Top 5 Offices for 2019.

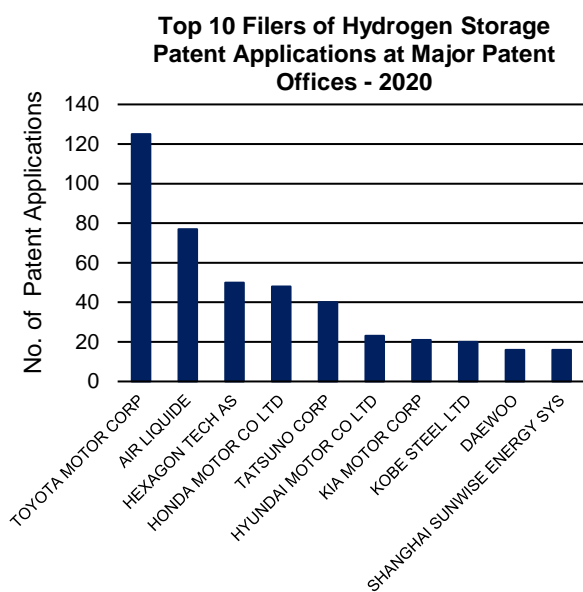


Figure A1.4.7. Top ten filers of hydrogen storage patent applications at the Top 5 Patent Offices for 2020.

1.4.2. Hydrogen Distribution

The data presented below in Figures A1.4.8 to A1.4.14 shows the top 10 filers of hydrogen distribution patent applications, for the years 2014 to 2019, for each of the top 5 offices.

Whilst the top filers appear to vary over the period, the number of patent applications filed within this sector remain relatively low.

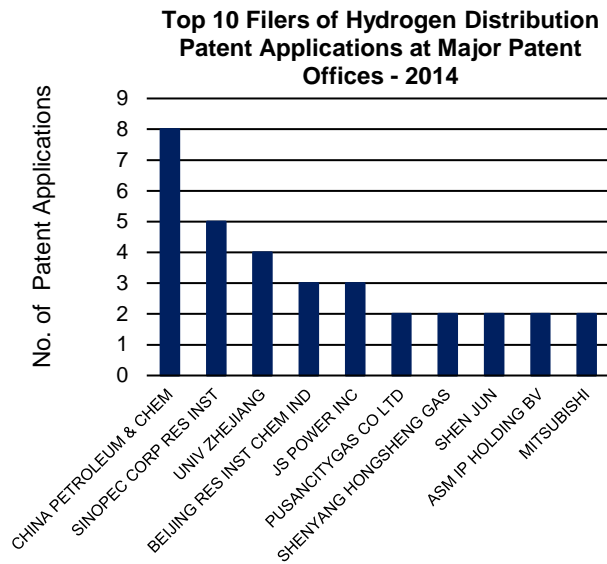


Figure A1.4.8. Top ten filers of hydrogen distribution patent applications at the Top 5 Patent Offices for 2014.

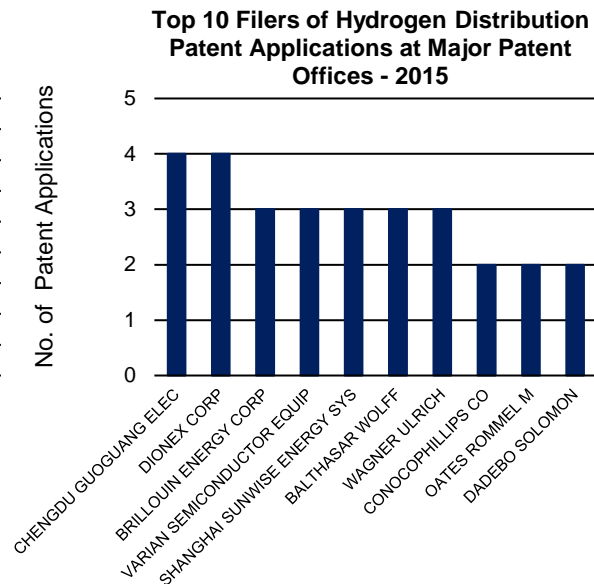


Figure A1.4.9. Top 10 filers of hydrogen distribution patent applications at the Top 5 Offices for 2015.

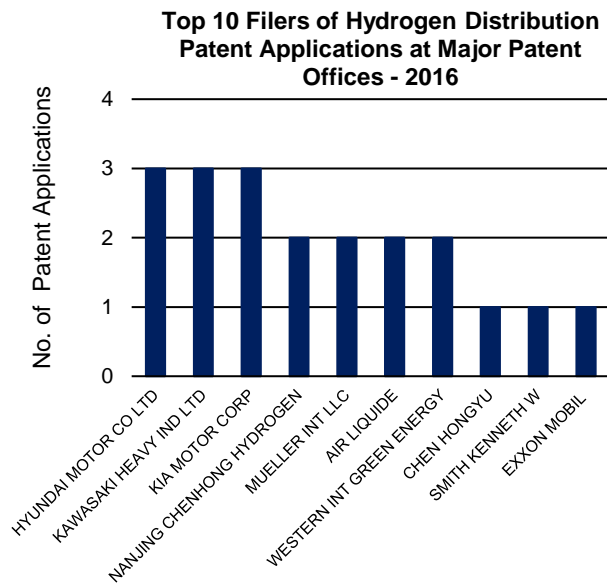


Figure A1.4.10. Top ten filers of hydrogen distribution patent applications at the Top 5 Patent Offices for 2016.

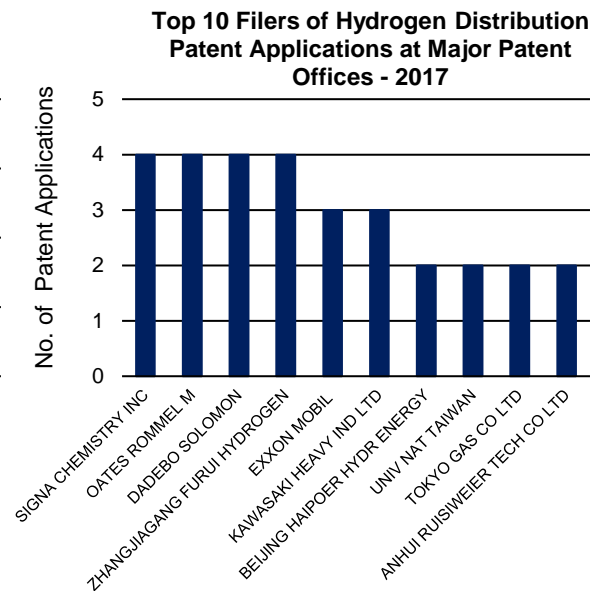


Figure A1.4.11. Top 10 filers of hydrogen distribution patent applications at the Top 5 Offices for 2017.

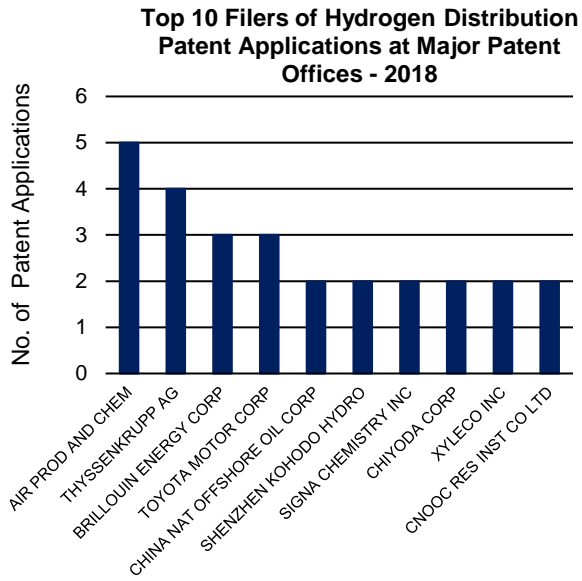


Figure A1.4.12. Top ten filers of hydrogen distribution patent applications at the Top 5 Patent Offices for 2018.

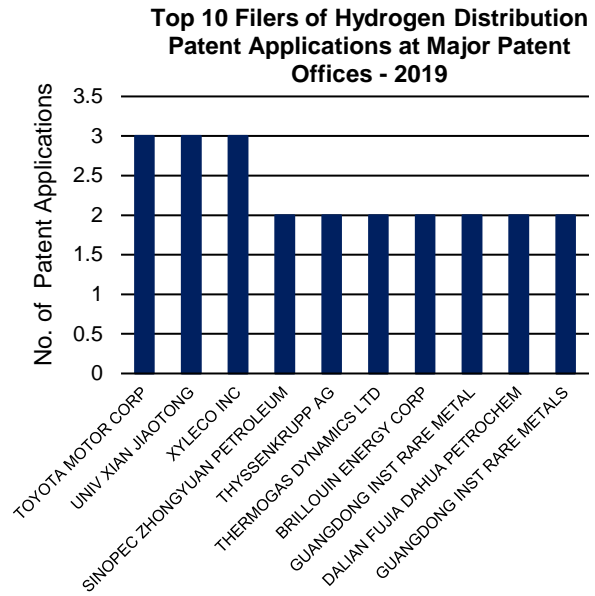


Figure A1.4.13. Top 10 filers of hydrogen distribution patent applications at the Top 5 Offices for 2019.

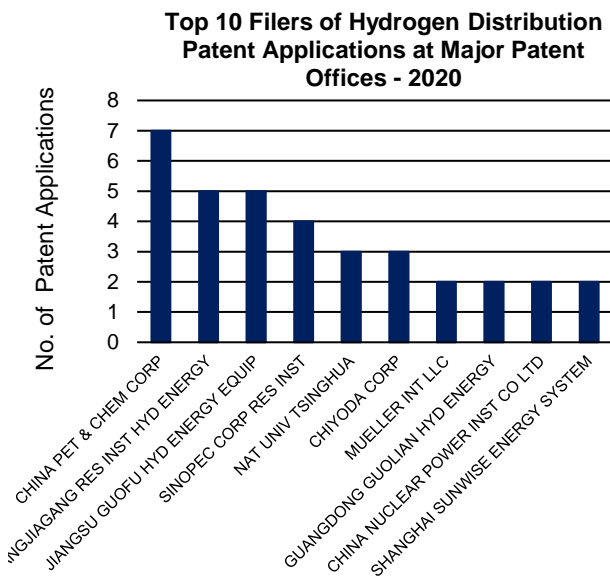


Figure A1.4.14. Top ten filers of hydrogen distribution patent applications at the Top 5 Patent Offices for 2020.

1.4.3. Hydrogen Production from Electrolysis

The data presented below in Figures A1.4.15 to A1.4.21 shows the top 10 filers of hydrogen production from electrolysis across the top 5 patent offices.

The top filers appear to vary over the period.

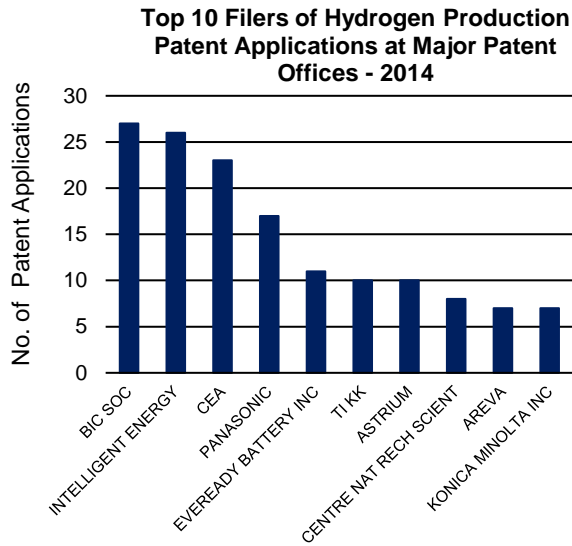


Figure A1.4.15. Top ten filers of hydrogen production patent applications at the Top 5 Patent Offices for 2014.

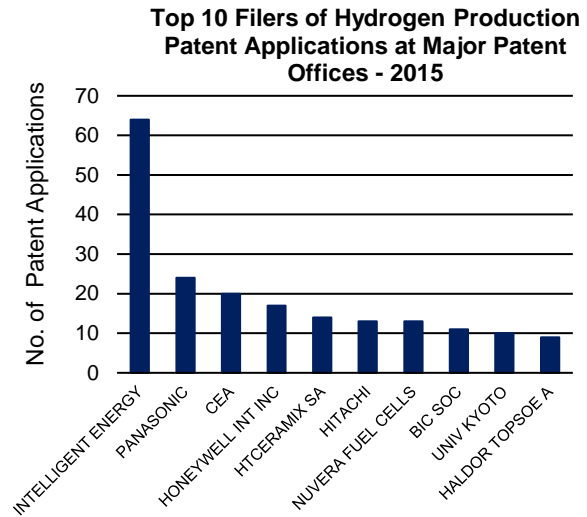


Figure A1.4.16. Top 10 filers of hydrogen production patent applications at the Top 5 Offices for 2015.

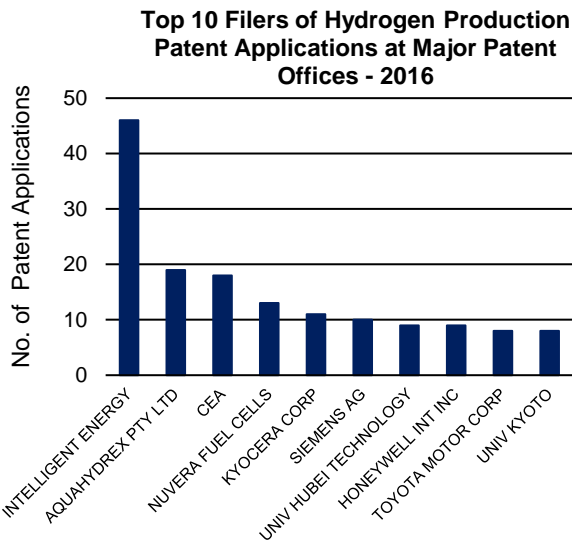


Figure A1.4.17. Top ten filers of hydrogen production patent applications at the Top 5 Patent Offices for 2016.

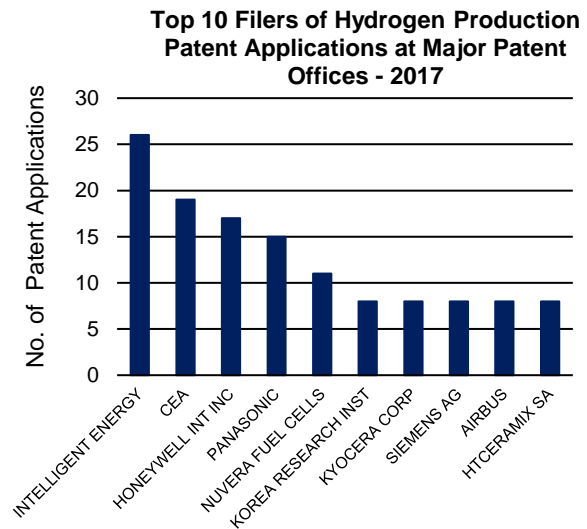


Figure A1.4.18. Top 10 filers of hydrogen production patent applications at the Top 5 Offices for 2017.

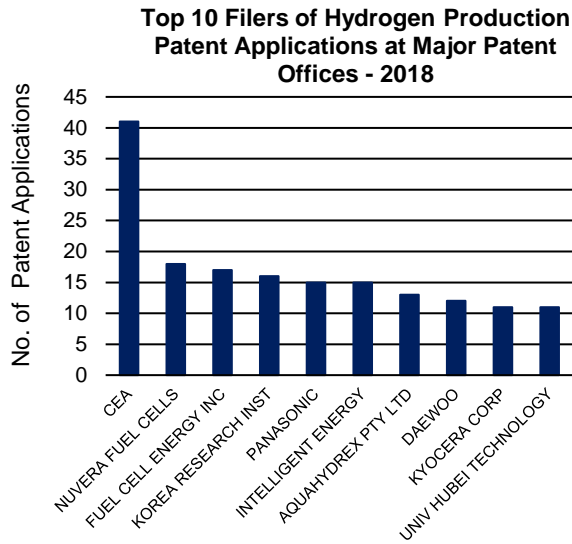


Figure A1.4.19. Top ten filers of hydrogen production patent applications at the Top 5 Patent Offices for 2018.

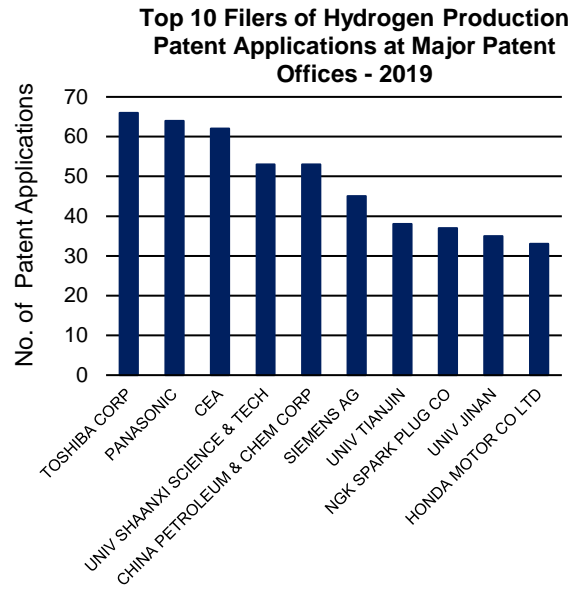


Figure A1.4.20. Top 10 filers of hydrogen production patent applications at the Top 5 Offices for 2019.

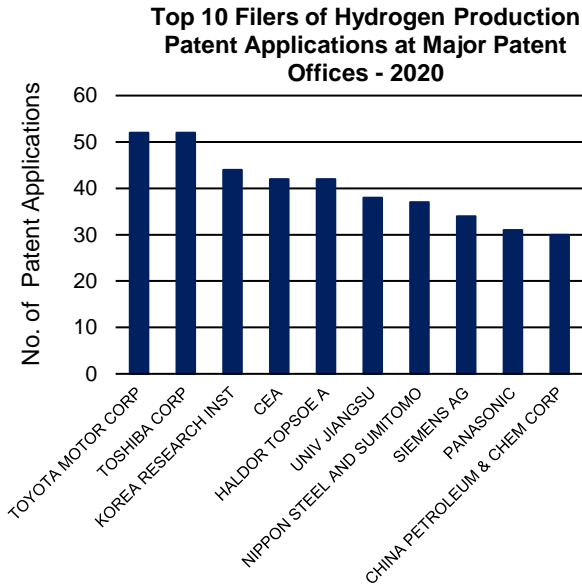


Figure A1.4.21. Top ten filers of hydrogen production patent applications at the Top 5 Patent Offices for 2020.