The Influence of Fuel Cell, Hydrogen Production, and Hydrogen Storage Patents Funded by the U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office and Other DOE Offices

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Notice

Table of Contents

List of Figures

List of Tables

Executive Summary

This report describes the results of an analysis tracing the technological influence of hydrogen and fuel cell research funded by the Hydrogen and Fuel Cell Technologies Office (HFTO) in the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and its precursor programs – as well as hydrogen and fuel cell research funded by other offices in DOE. These offices include the Office of Fossil Energy, Office of Science, Office of Nuclear Energy, and the Advanced Research Projects Agency – Energy.

The report covers three distinct technologies – fuel cells, hydrogen production, and hydrogen storage. These are considered to be separate technologies. Each is analyzed individually, and the report contains separate results sections for the three technologies.

The influence tracing in this report is carried out both backwards and forwards in time, and focuses on patents filed in three systems: the U.S. Patent & Trademark Office (U.S. patents); the European Patent Office (EPO patents); and the World Intellectual Property Organization (WIPO patents). The primary period covered in this analysis is 1976 to 2018.

The main purpose of the backward tracing is to determine the extent to which HFTO-funded hydrogen and fuel cell research has formed a foundation for innovations patented by leading hydrogen and fuel cell companies. Meanwhile, the primary purpose of the forward tracing is to examine the broader influence of HFTO-funded hydrogen and fuel cell research upon subsequent technological developments, both within and outside hydrogen and fuel cell technology. In addition to these HFTO-based analyses, many elements of the analysis are extended to other DOE-funded hydrogen and fuel cell patents, in order to gain insights into their influence.

Fuel Cells

The main finding from the fuel cells element of this report is:

- DOE-funded patenting in fuel cell technology has increased over time, with HFTO-funded patents representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded fuel cell patents have had a strong influence on subsequent innovations associated with the leading companies in fuel cell technology. Meanwhile, the forward tracing reveals that their influence also extends beyond fuel cells into other technologies, including hydrogen production, advanced batteries and nanomaterials.

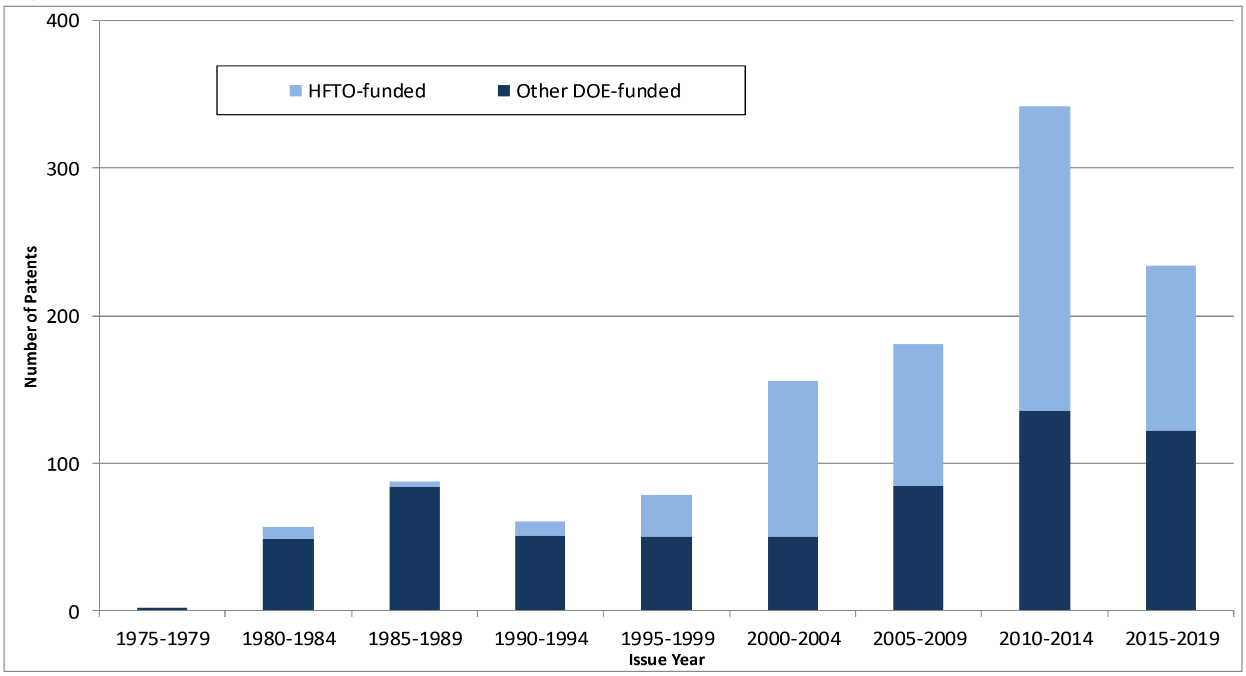
More detailed findings from the fuel cells element of this report include:

- In fuel cell technology, in the period 1976-2018, there are a total of 57,034 patents (22,039 U.S. patents, 15,232 EPO patents and 19,763 WIPO patents). These patents are grouped into 36,694 patent families, where each family contains all patents resulting from the same initial application (named the priority application). A patent family may include multiple patents from across patent systems, for example U.S., EPO, and WIPO patents.
- 906 fuel cell patents are confirmed to be associated with HFTO funding (571 U.S. patents, 154 EPO patents, and 181 WIPO patents). These HFTO-funded fuel cell patents are grouped into 456 patent families, again by matching priority applications.
- In addition, there are a further 1,000 fuel cell patents (629 U.S. patents, 205 EPO patents and 166 WIPO patents) that are associated with DOE funding from other offices or programs. These "Other DOE-funded" patents are grouped into 541 patent families.

- The total number of DOE-funded fuel cell patents (HFTO-funded plus Other DOE-funded) is 1,906, corresponding to 997 patent families. This represents 2.7% of all fuel cell patent families in the period 1976-2018.

- Figure FC-E1 shows the number of fuel cell granted U.S. patents funded by DOE. This figure reveals that the number of DOE-funded fuel cell U.S. patents was below 100 in each five year period through 1999, peaking at 88 patents in 1985-1989. Other DOE-funded patents represented a high percentage of the total throughout these early time periods. From 2000 onwards, the number of DOE-funded fuel cell U.S. patents increased sharply, reaching 342 patents granted in 2010-2014. HFTO-funded patents account for a higher percentage of DOE-funded patents in the post-2000 time period. Out of the 913 DOE-funded fuel cell U.S. patents granted since 2000, 520 (57%) are confirmed as HFTO-funded. The data for 2015-2019 indicate a decline in DOE-funded fuel cell patents during that period. However, data for this time period are incomplete, since the primary data collection only included patents issued through the end of the 2018 study period.

Figure FC-E1 – No. of DOE-Funded Fuel Cell U.S. Patents by Issue Year (5-Year Totals)



Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

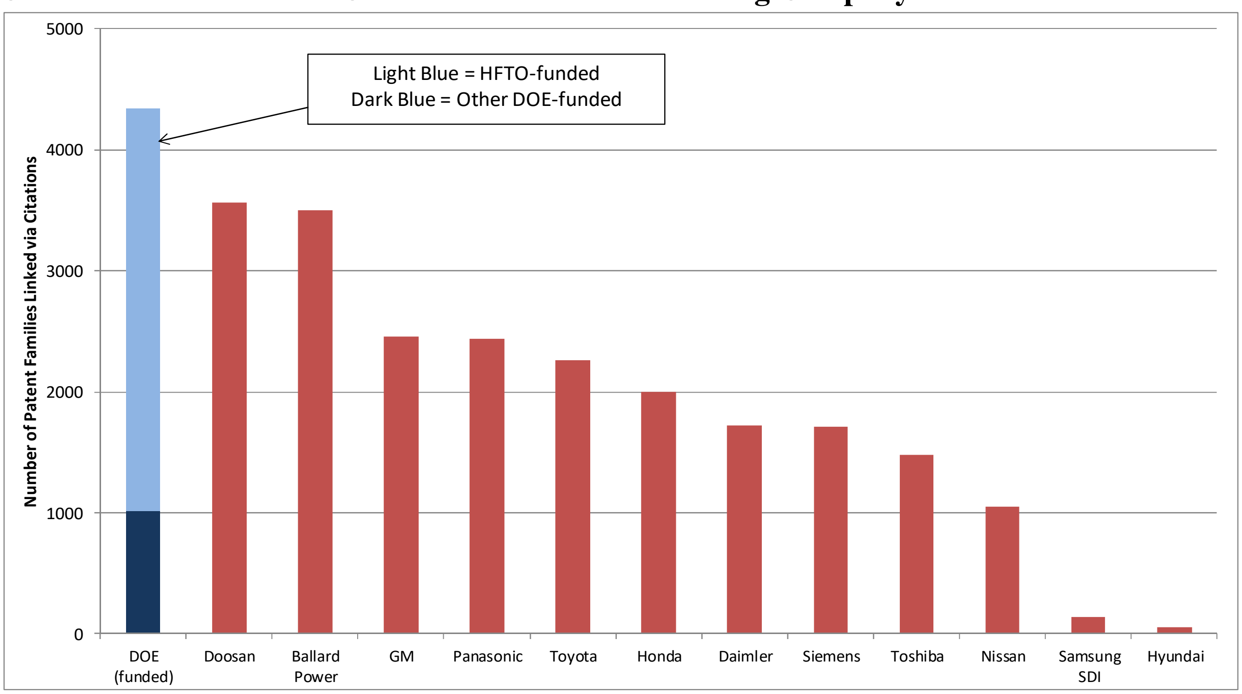
- The twelve organizations responsible for the highest percentage of HFTO-funded fuel cell U.S. patents are: Los Alamos National Laboratory (10.2%), General Motors (7.4%), 3M Company (6.9%), Argonne National Laboratory (6.7%), Brookhaven National Laboratory (4.8%), Oak Ridge National Laboratory (2.8%), Pacific Northwest National Laboratory (2.5%), Lawrence Berkeley National Laboratory (2.3%), Lawrence Livermore National Laboratory (2.3%), Nanotek Instruments, Inc. (2.3%) and University of New Mexico (2.3%). See Appendix FC-A for a list of HFTO-funded fuel cell patents.

- HFTO-funded fuel cell patents have a particular focus on polymeric electrolytes, membrane electrode assemblies and platinum-based alloys (used as fuel cell catalysts).

Meanwhile, the patents assigned to the leading companies have a greater emphasis on the practical application of fuel cells in vehicles.

- The twelve companies with the largest number of fuel cell patent families (overall, not just DOE-funded) are: Toyota (2,158 families); General Motors (1,397); Honda (1,274); Panasonic (1,106); Nissan (917); Doosan Holdings (914); Daimler (602); Samsung SDI (588); Ballard Power (579); Siemens (495); Hyundai (456); and Toshiba (401). Eight of these companies are based in Asia, two in Europe and two in North America. The portfolio of 997 DOE-funded fuel cell patent families (456 HFTO-funded; 561 Other DOE-funded) is fifth largest when compared to the portfolios of the leading companies.
- Figure FC-E2 provides an indication of the influence of DOE-funded research. It shows the number of fuel cell patent families assigned to the leading companies that are linked via citations to earlier fuel cell patent families assigned to each of the leading companies, plus families funded by DOE. As shown in the figure, 4,439 leading company fuel cell patent families (41% of their 10,824 families) are linked via citations to earlier DOE-funded fuel cell patents. Out of these 4,439 families, 3,322 (31% of the 10,824 leading company patent families) are linked to HFTO-funded fuel cell patents. Hence, more fuel cell patent families assigned to the leading companies are linked via citations to DOE-funded (and primarily HFTO-funded) fuel cell patents than are linked to the fuel cell patents assigned to any other leading company. This suggests that DOE-funded (and particularly HFTO-funded) research has helped form an important part of the foundation for fuel cell innovations associated with the leading companies in this technology.

Figure FC-E2 - Number of Leading Company Fuel Cell Patent Families Linked via Citations to Earlier Fuel Cell Patents from each Leading Company

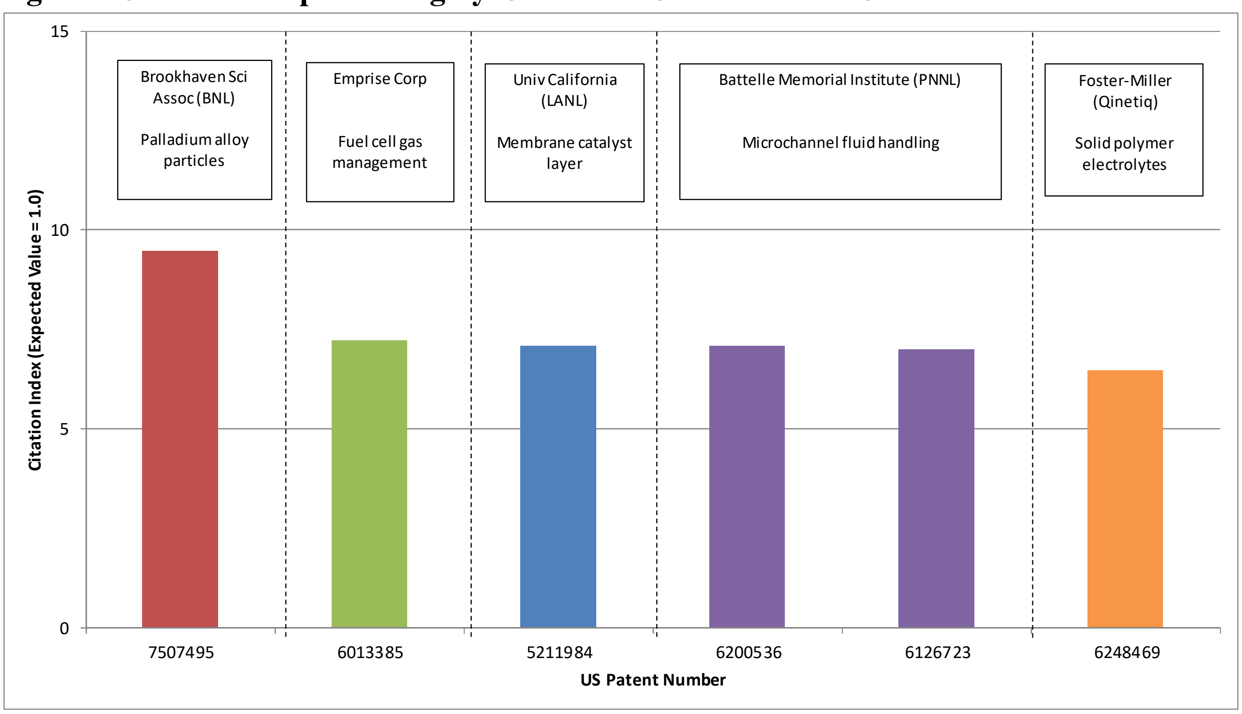


- Six of the twelve leading companies have more than 40% of their fuel cell patent families linked via citations to earlier DOE-funded fuel cell patents. They are headed by Ballard

Power, with over 75% of its patent families linked to DOE patents (59.4% linked to HFTO-funded patents). Ballard is followed by General Motors (60% of families linked via citations to DOE; 52.6% to HFTO), Doosan Holdings (57.7% linked to DOE; 43.8% to HFTO); Siemens (52.5% linked to DOE; 24.8% to HFTO); Samsung SDI (42.7% linked to DOE; 31.8% to HFTO) and Honda (42.5% linked to DOE; 31.5% to HFTO).

- HFTO-funded fuel cell patents have an average Citation Index of 1.75. The Citation Index is a normalized citation metric with an expected value of 1.0. A value of 1.75 shows that, based on their age and technology, HFTO-funded fuel cell patents have been cited as prior art by 75% more subsequent patents than expected. The Citation Index for Other DOE-funded fuel cell patents is slightly lower at 1.60, but this still means that these patents have been cited 60% more frequently than expected. These are impressive results, especially given that, out of the twelve leading companies, only two (Ballard Power and Doosan Holdings) have a Citation Index above one.
- There are a number of individual HFTO-funded fuel cell patents with high Citation Index values, examples of which are shown in Figure FC-E3. They include a Brookhaven National Laboratory patent (US #7,507,495) describing palladium alloy particles that can be used as electrocatalysts in fuel cells. Since being granted in 2009, this patent has been cited as prior art by 50 subsequent patents, almost ten times as many citations as expected given its age and technology. They also include a patent assigned to Emprise describing control of gas flow circuits in fuel cells that has been cited by 223 subsequent patents, over seven times as many citations as expected. This figure also includes highly-cited patents from the University of California (through its management of Lawrence Livermore National Laboratory), Battelle Memorial Institute (Pacific Northwest National Laboratory), and Foster-Miller (which is now owned by Qinetiq).

Figure FC-E3 – Examples of Highly-Cited HFTO-funded Fuel Cell Patents



Hydrogen Production

The main finding from the hydrogen production element of this report is:

- DOE-funded patenting in hydrogen production has increased over time, with HFTO-funded patents representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded hydrogen production patents have had a relatively strong influence on subsequent innovations associated with the leading companies in hydrogen production technology. Meanwhile, the forward tracing reveals that their influence also extends beyond hydrogen production into other technologies, such as fuel cells, waste gas treatment and bioenergy.

More detailed findings from the hydrogen production element of this report include:

- In hydrogen production, in the period 1976-2018, there are a total of 28,985 patents (11,174 U.S. patents, 8,661 EPO patents and 9,150 WIPO patents). These patents are grouped into 17,789 patent families, where each family contains all patents resulting from the same initial application (named the priority application). A patent family may include multiple patents from across patent systems, for example U.S., EPO, and WIPO patents.

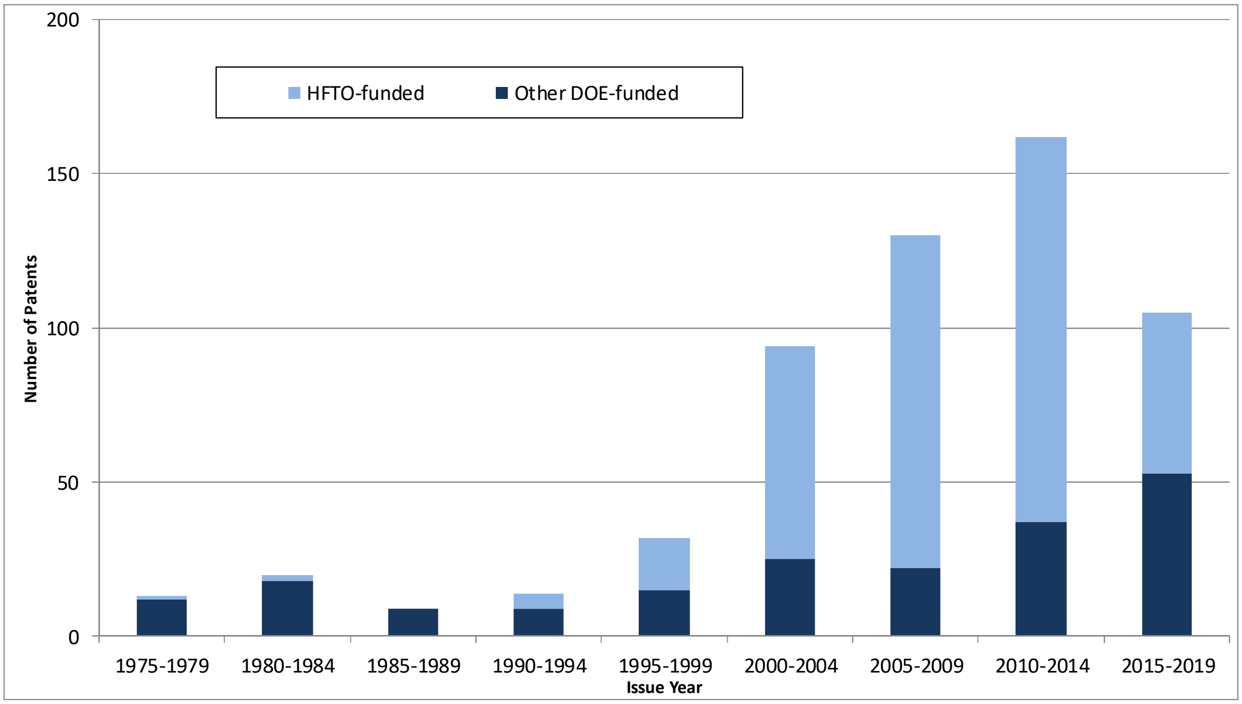
- 609 hydrogen production patents are confirmed to be associated with HFTO funding (380 U.S. patents, 117 EPO patents, and 112 WIPO patents). These HFTO-funded hydrogen production patents are grouped into 283 patent families, again by matching priority applications.

- In addition, there are a further 306 hydrogen production patents (200 U.S. patents, 44 EPO patents and 62 WIPO patents) that are associated with DOE funding from other offices or programs. These "Other DOE-funded" patents are grouped into 170 patent families.

- The total number of DOE-funded hydrogen production patents (HFTO-funded plus Other DOE-funded) is 915, corresponding to 453 patent families. This represents 2.5% of all hydrogen production patent families in the period 1976-2018.

- Figure PD-E1 shows the number of hydrogen production granted U.S. patents funded by DOE. This figure reveals that there was relatively little patent activity in the earlier time periods, with many of the patents defined as Other DOE-funded. Patenting then started to increase, particularly from 2000 onwards, with HFTO-funded patents representing an increasing percentage of the overall number. In 2000-2004, 94 DOE-funded U.S. hydrogen production patents were granted, 69 of which were funded by HFTO. These numbers increased to 130 DOE-funded U.S. patents in 2005-2009 (108 funded by HFTO) and 162 DOE-funded U.S. patents in 2010-2014 (125 funded by HFTO). DOE-funded hydrogen patenting appears to have declined in the most recent time period, with 105 DOE-funded patents granted in 2015-2019 (52 funded by HFTO). However, data from this time period are incomplete, since the primary data collection for this analysis only included patents issued through the end of the 2018.

Figure PD-E1 - Number of Hydrogen Production Granted U.S. Patents Funded by HFTO and Other DOE Sources by Issue Year (5-Year Totals)



Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

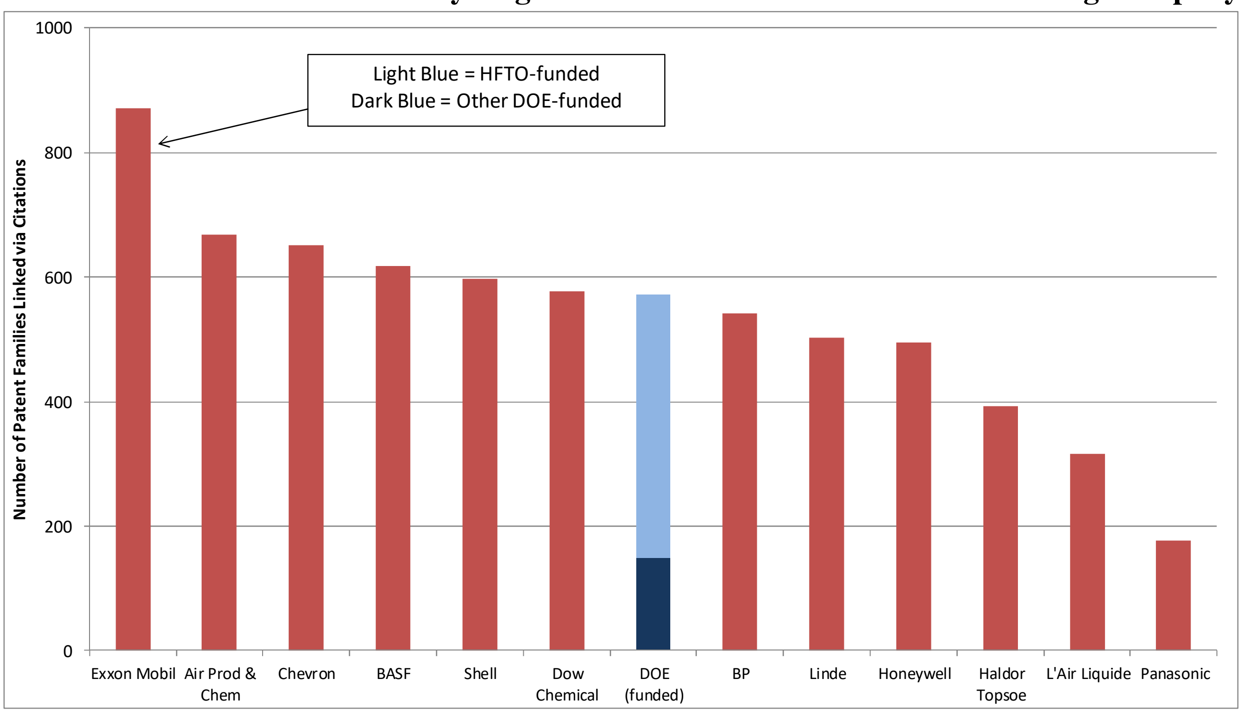
- The twelve organizations responsible for the highest percentage of HFTO-funded hydrogen production U.S. patents are: Air Products and Chemicals, Inc. (15.0%), University of Central Florida (9.2%), National Renewable Energy Laboratory (6.0%), Argonne National Laboratory (5.0%), Pacific Northwest National Laboratory (5.0%), Nuvera Fuel Cells, Inc. (3.4%), Intelligent Energy (3.2%), General Electric Company (2.4%), Virent Energy Systems Inc. (2.4%), Sandia National Laboratories (2.1%), Ohio State University (2.1%) and General Motors (1.8%). See Appendix PD-A for a list of HFTO-funded hydrogen production patents.

- HFTO-funded hydrogen production patents have a particular focus on steam reforming, water gas shifting and catalytic chemical production. They also have a greater concentration on the integration of hydrogen production with fuel cells than the patents assigned to the leading hydrogen production companies.

- The twelve companies with the largest number of hydrogen production patent families (overall, not just DOE-funded) are: ExxonMobil (474 families); Shell (354); BASF (350); Honeywell (329); Linde (302); L'Air Liquide (266); Dow Chemical (247); Chevron (243); Panasonic (229); Air Products & Chemicals (206); Haldor Topsoe (183); and BP (165). Six of these companies are based in Europe, five in North America, and one in Asia. The portfolio of 453 DOE-funded hydrogen production patent families (283 HFTO-funded; 170 Other DOE-funded) is the second largest when compared to the portfolios of the leading companies.

- Figure PD-E2 provides an indication of the influence of DOE research. It shows the number of hydrogen production patent families assigned to the leading companies that are linked via citations to earlier hydrogen production patent families assigned to each of these leading companies, plus patent families funded by DOE. As shown in the figure, 17.2% (571 out of 3,319) of the hydrogen production patent families assigned to the leading companies are linked via citations to earlier DOE-funded hydrogen production patents. Out of these 571 patent families, 423 (or 12.7% of the 3,319 leading company patent families) are linked to HFTO-funded patents. This finding puts DOE-funded patents in the center of the distribution in Figure PD-E2. ExxonMobil is at the head of the figure, with 871 leading company patent families linked via citations to its patents, followed by Air Products & Chemicals (669 families), Chevron (652) and BASF (618). Overall, most of the organizations in Figure PD-E2 (including DOE) have similar numbers of patent families linked to them via citations, suggesting this is a highly-connected technology without a single dominant patent portfolio.

Figure PD-E2 - Number of Leading Company Hydrogen Production Patent Families Linked via Citations to Earlier Hydrogen Production Patents from each Leading Company

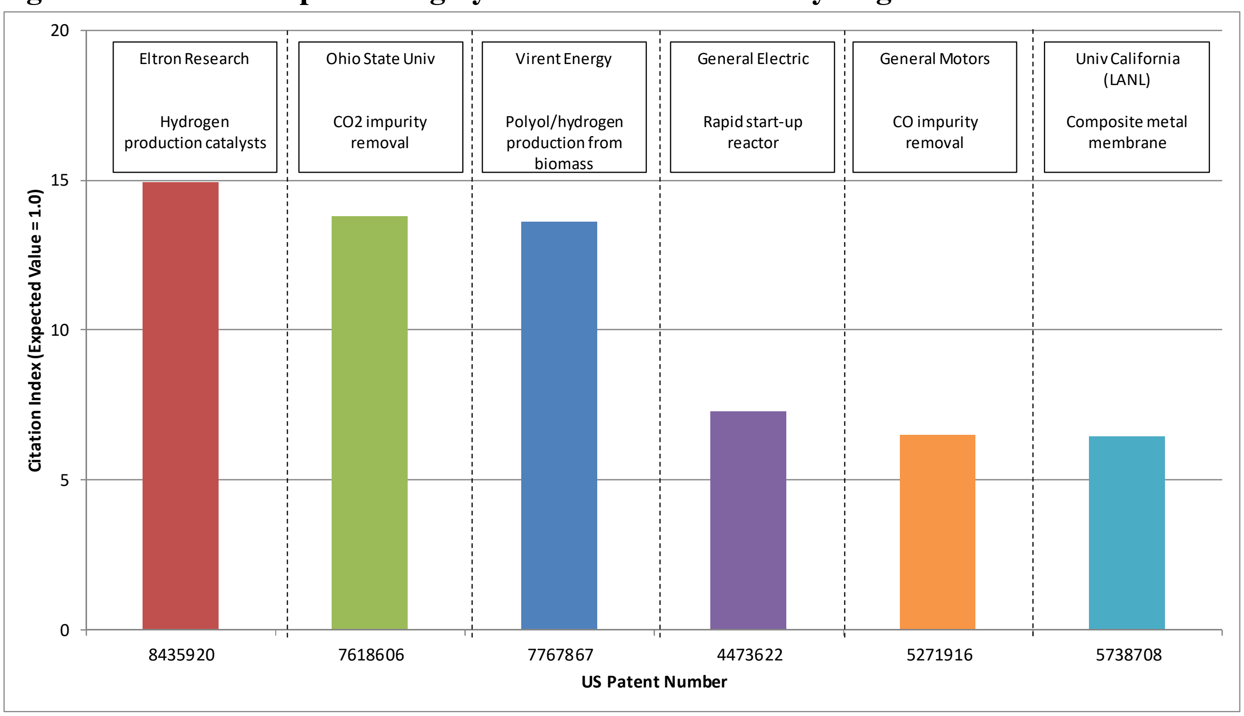


- Four of the twelve leading companies have more than 20% of their hydrogen production patent families linked via citations to earlier DOE-funded hydrogen production patents. Air Products & Chemical has 36.4% of its patent families linked via citations to DOE-funded patents (22.4% are linked to HFTO-funded patents), followed by Linde (33.1% linked to DOE; 25.8% to HFTO); Chevron (24.3% linked to DOE; 18.5% to HFTO) and Shell (20.3% linked to DOE; 12.7% to HFTO).

- Other DOE-funded hydrogen production patents have an average Citation Index of 1.80. The Citation Index is a normalized citation metric with an expected value of 1.0. A value of 1.81 shows that, based on their age and technology, Other DOE-funded hydrogen production patents have been cited by subsequent patents as prior art 80% more frequently than expected. This is a higher Citation Index than all twelve of the leading hydrogen production companies. The Citation Index for HFTO-funded hydrogen production patents is slightly lower at 1.45, but this still means that these patents have been cited 45% more frequently than expected. This Citation Index puts HFTO-funded patents at the center of the distribution among the leading companies.

- There are a number of individual HFTO-funded hydrogen production patents with high Citation Index values, examples of which are shown in Figure PD-E3. They include a patent (US #8,435,920) issued in 2013 and assigned to Eltron Research. This patent describes catalysts that can be used in hydrogen production, among other applications. It has been cited as prior art by 43 subsequent patents, which is almost fifteen times as many citations as expected for a patent of its age and technology. The second patent in this figure (US #7,618,606) is a 2009 Ohio State University patent describing a method for separating carbon dioxide in hydrogen production. This patent has been cited by 98 subsequent patents, almost fourteen times as many citations as expected. Other highly-cited patents in this figure are assigned to Virent Energy for polyol and hydrogen production from biomass, General Electric for hydrogen production designed for fuel cells, General Motors for carbon monoxide impurity removal, and the University of California (Los Alamos National Laboratory) for hydrogen-permeable membranes.

Figure PD-E3 – Examples of Highly-Cited HFTO-funded Hydrogen Production Patents



Hydrogen Storage

The main finding from the hydrogen storage element of this report is:

- DOE-funded patenting in hydrogen storage technology has increased over time, with HFTO-funded patents representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded hydrogen storage patents have had a particularly strong influence on subsequent innovations associated with the leading companies in hydrogen storage technology. Meanwhile, the forward tracing reveals that their influence can also be detected in related technologies including hydrogen production, nanocomposites and advanced materials.

More detailed findings from the hydrogen storage element of this report include:

- In hydrogen storage technology, in the period 1976-2018, there are a total of 7,653 patents (2,839 U.S. patents, 2,327 EPO patents and 2,487 WIPO patents). These patents are grouped into 4,825 patent families, where each family contains all patents resulting from the same initial application (named the priority application).

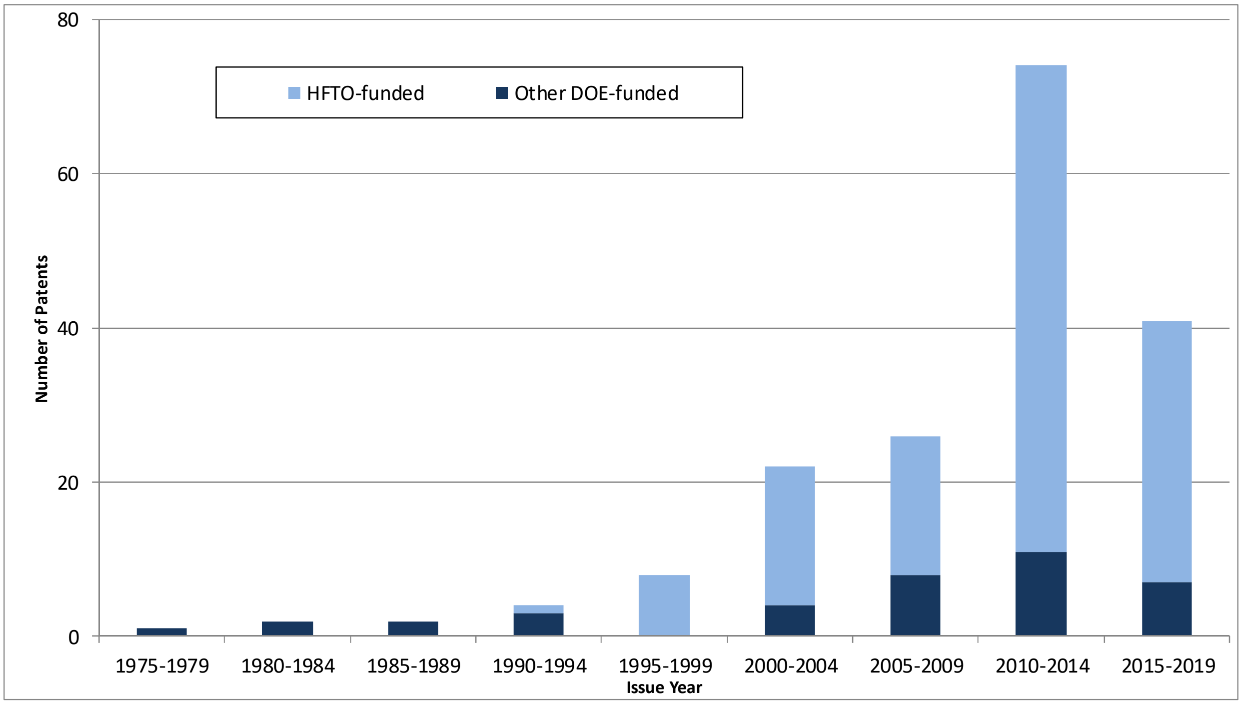
- 224 hydrogen storage patents are confirmed to be associated with HFTO funding (143 U.S. patents, 37 EPO patents, and 44 WIPO patents). These HFTO-funded hydrogen storage patents are grouped into 110 patent families, again by matching priority applications.

- In addition, there are a further 51 hydrogen storage patents (38 U.S. patents, four EPO patents and nine WIPO patents) that are associated with DOE funding from other offices or programs. These "Other DOE-funded" patents are grouped into 31 patent families.

- The total number of DOE-funded hydrogen storage patents (HFTO-funded plus Other DOE-funded) is 275, corresponding to 141 patent families. This represents 2.9% of all hydrogen storage patent families in the period 1976-2018.

- Figure ST-E1 shows the number of hydrogen storage granted U.S. patents funded by DOE. This figure reveals that there was very little DOE-funded patent activity prior to 1990, with all of the patents issued in this early period being defined as Other DOE-funded. The number of DOE-funded hydrogen storage patents then started to increase, peaking in 2010-2014 when 74 such patents were issued. HFTO-funded patents represent a high percentage of all DOE-funded hydrogen storage U.S. patents (79% overall; 81% among patents issued since 1990). The number of DOE-funded patents appears to have declined in 2015-2019, although these data only include patents awarded through the end of the 2018 study period.

Figure ST-E1 - Number of Hydrogen Storage Granted U.S. Patents Funded by HFTO and Other DOE Sources by Issue Year (5-Year Totals)



Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

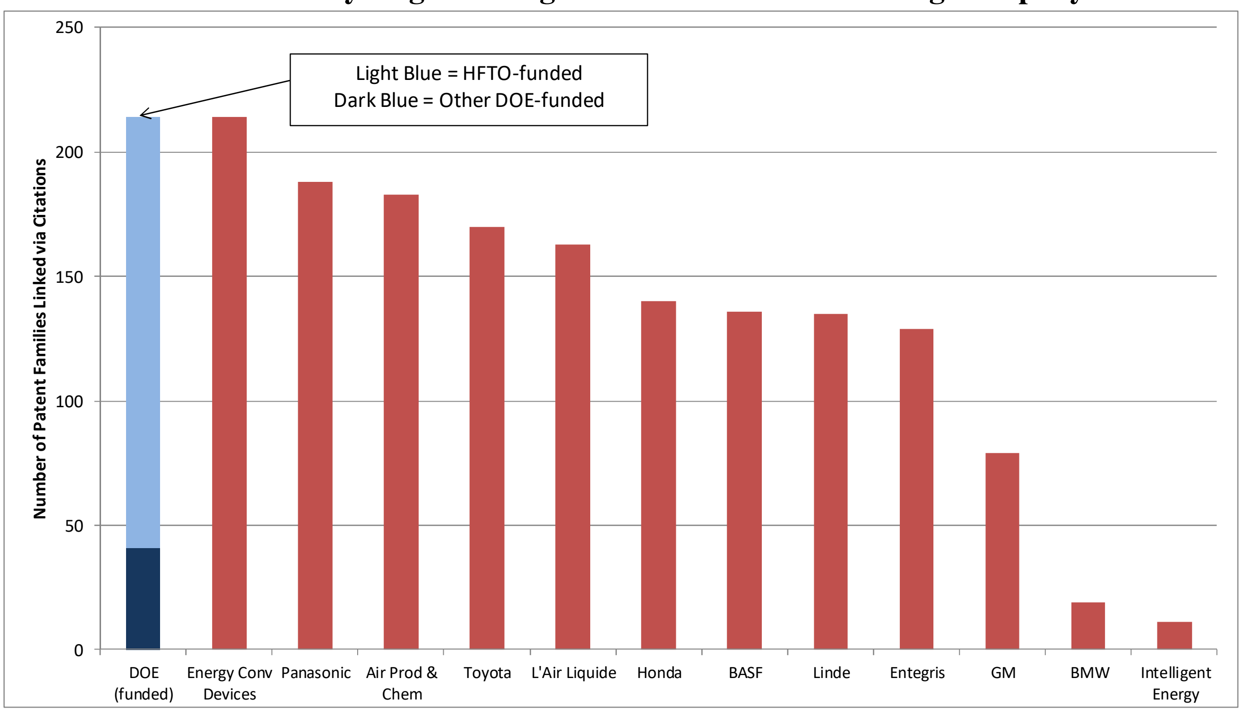
- The twelve organizations responsible for the highest percentage of HFTO-funded hydrogen storage U.S. patents are: Savannah River National Laboratory (21.7%), Los Alamos National Laboratory (7.0%), Lawrence Livermore National Laboratory (7.0%), Sandia National Laboratories (5.6%), Oak Ridge National Laboratory (4.2%), University of Michigan (3.5%), Rohm & Haas Company (3.5%), Safe Hydrogen, LLC (3.5%), Pacific Northwest National Laboratory (2.8%), Idaho National Laboratory (2.8%), Energy Conversion Devices, Inc. (2.8%) and University of Central Florida (2.1%). See Appendix ST-A for a list of HFTO-funded hydrogen storage patents.

- HFTO-funded hydrogen storage patents have a particular focus on technologies related to hydrogen storage in metals/alloys and solid composites (with a particular concentration on nanocomposites in more recent years). Meanwhile, the patents of the leading companies have a greater focus on physical structures for storing hydrogen, alongside specific hydrogen storage materials.

- The twelve companies with the largest number of hydrogen storage patent families (overall, not just DOE-funded) are: Toyota (187); Linde (181); L'Air Liquide (161); General Motors (129); Honda (116); Air Products & Chemicals (104); BASF (95); Panasonic (90); Energy Conversion Devices (71); BMW (61); Entegris (59); and Intelligent Energy (56). Five of these companies are based in Europe, four in North America and three in Asia. The portfolio of 141 DOE-funded hydrogen storage patent families (110 HFTO-funded; 31 Other DOE-funded) is the fourth largest when compared to the portfolios of the leading companies.

- Figure ST-E2 provides an indication of the influence of DOE research. It shows the number of hydrogen storage patent families assigned to the leading companies that are linked via citations to earlier hydrogen storage patent families assigned to each of these leading companies, plus patent families funded by DOE. As shown in the figure, 16.4% (214 out of 1,306) of the hydrogen storage patent families assigned to the leading companies are linked via citations to earlier DOE-funded hydrogen storage patents. Out of these 214 families, 173 (or 13.2% of the 1,306 leading company patent families) are linked to HFTO-funded hydrogen storage patents. Hence, more hydrogen storage patent families assigned to the leading companies are linked via citations to DOE-funded (and primarily HFTO-funded) hydrogen storage patents than are linked to the hydrogen storage patents assigned to any other leading company. This is an impressive result, especially since the DOE-funded patent portfolio is only the fourth largest compared to the leading companies.

Figure ST-E2 - Number of Leading Company Hydrogen Storage Patent Families Linked via Citations to Earlier Hydrogen Storage Patents from each Leading Company

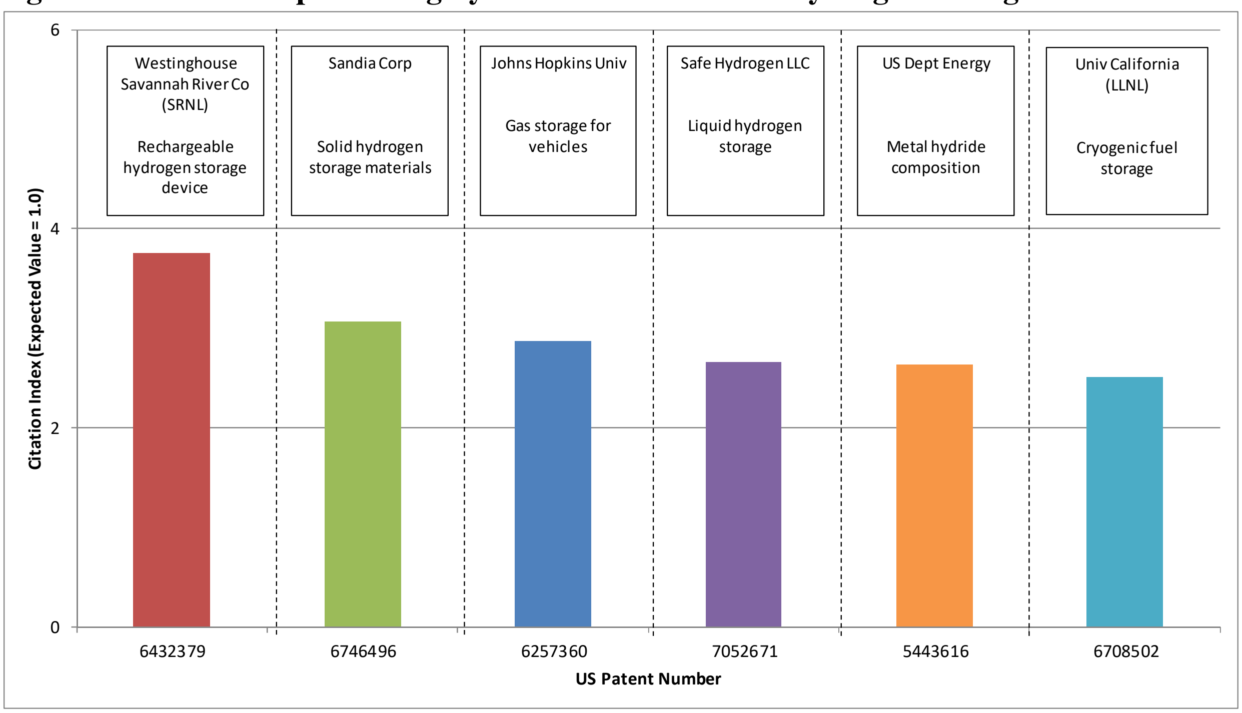


- Five of the twelve leading companies have more than 20% of their hydrogen storage patent families linked via citations to earlier DOE-funded hydrogen storage patents. They are headed by Energy Conversion Devices, with 39.4% of its patent families linked via citations to DOE patents (33.8% linked to HFTO-funded patents). BASF is next (37.9% of families linked to DOE; 30.5% to HFTO), followed by General Motors (29.5% linked to DOE; 26.4% to HFTO); Entegris (27.1% linked to DOE; 25.4% to HFTO); and Intelligent Energy (23.2% linked to DOE, all of which are linked to HFTO).

- HFTO-funded hydrogen storage patents have an average Citation Index of 1.0. The Citation Index is a normalized citation metric with an expected value of 1.0. A value of 1.0 thus shows that, based on their age and technology, HFTO-funded hydrogen storage patents have been cited as prior art by subsequent patents exactly as frequently as expected. The Citation Index for Other DOE-funded hydrogen storage patents is slightly lower at 0.97, meaning these patents have been cited 3% less frequently than expected.

- There are a number of individual HFTO-funded hydrogen storage patents with high Citation Index values, examples of which are shown in Figure ST-E3. This figure is headed by a patent (US #6,432,379) assigned to Westinghouse Savannah River Company, through its management of DOE's Savannah River National Laboratory (SRNL). This patent describes rechargeable devices for storing hydrogen. It has been cited as prior art by 55 subsequent patents, almost four times as many citations as expected. Sandia has the second-place patent in this figure (US #6,746,496) describing a storage source of hydrogen, particularly for micro fuel cells. This patent has been cited by 58 subsequent patents, over three times as many as expected. Other organizations with highly-cited HFTO-funded hydrogen storage patents in Figure ST-E3 include Johns Hopkins University, Safe Hydrogen LLC, DOE itself, and the University of California (through its management of Lawrence Livermore National Laboratory).

Figure ST-E3 – Examples of Highly-Cited HFTO-funded Hydrogen Storage Patents



1. Introduction

This report describes the results of an analysis tracing the technological influence of hydrogen and fuel cell research funded by the Hydrogen and Fuel Cell Technologies Office (HFTO) in the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and its precursor programs – as well as hydrogen and fuel cell research funded by other offices in DOE. These other offices include the Office of Fossil Energy, Office of Science, Office of Nuclear Energy, and the Advanced Research Projects Agency – Energy.[1]

The purpose of the report is to:

(i) Locate patents awarded for key HFTO-funded (and Other DOE-funded) innovations in hydrogen and fuel cell technologies; and

(ii) Determine the extent to which HFTO-funded (and Other DOE-funded) hydrogen and fuel cell research has influenced subsequent developments both within and beyond hydrogen and fuel cell technologies.

The report covers three distinct technologies – fuel cells, hydrogen production, and hydrogen storage. These are considered to be separate technologies. Each is analyzed individually, and the report contains separate results sections for the three technologies. However, note that the shorthand "hydrogen and fuel cells" is used in the Introduction, Project Design and Methodology sections of the report, rather than referring repeatedly to the more cumbersome "fuel cells, hydrogen production, and hydrogen storage."

The primary focus of the report is on the influence of HFTO-funded hydrogen and fuel cell patents. That said, patents that were determined to be funded by DOE but could not be linked definitively to HFTO funding are also included. There are both evaluative and practical reasons for extending the analysis in this way. From an evaluation perspective, it is interesting to examine the influence of HFTO itself upon the development of hydrogen and fuel cell technologies, while also tracing the influence of DOE more generally. Meanwhile, in practical terms, determining which patents were funded by HFTO versus other offices within DOE is often very difficult.

In the U.S. patent system, applicants are required to acknowledge any government funding they have received related to the invention described in their patent application. Typically, this government support is listed at the level of the agency (e.g., Department of Energy, Department of Defense, etc.). Hence, the only way to determine which office within DOE funded a given

[1] For more information on the history of DOE's hydrogen and fuel cell R&D budgets and programs see: (1) DOE Hydrogen and Fuel Cells Program Record: Historical Fuel Cell and Hydrogen Budgets, https://www.hydrogen.energy.gov/pdfs/17006_historical_fuel_cell_h2_budgets.pdf, (2) About the Hydrogen Program, https://www.hydrogen.energy.gov/about.html, and (3) *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000,* The National Academies Press. https://doi.org/10.17226/10165.

patent is via other data resources (e.g., iEdison)[2], or through direct input from offices, program managers and individual inventors. For older patents, such information is often unavailable, because records may be less comprehensive, and there is less access to the inventors and program managers involved. Also, the organizational structure of DOE in terms of its technology offices has changed from its current form over the period of the analysis.

Patents confirmed as DOE-funded but that could not be definitively categorized as HFTO-funded are thus included in the analysis under a separate "Other DOE-funded" category. Some of these Other DOE-funded patents are confirmed as being linked to funding from other DOE offices, while for other patents the source of funding within DOE is unknown.

This report contains three main sections. The first of these sections describes the project design. This section includes a brief overview of patent citation analysis, and outlines its use in the multi-generation tracing employed in this project. The second section outlines the methodology, and includes a description of the various data sets used in the analysis, and the processes through which these data sets were constructed and linked.

The third section of the report presents the results of the analysis.[3] This section is divided into three sub-sections, in turn containing the findings related to fuel cells, hydrogen production, and hydrogen storage. Within each sub-section, results are presented at the organizational level for both HFTO-funded and Other DOE-funded patents. These results show the distribution of HFTO-funded (and Other DOE-funded) patents across hydrogen and fuel cell technologies (as defined by Cooperative Patent Classifications). They also evaluate the extent of HFTO's influence (and DOE's influence in general) on subsequent developments in hydrogen, fuel cell and other technologies. Patent level results are then presented to highlight individual HFTO-funded hydrogen and fuel cell patents that have been particularly influential, as well as to reveal key patents from other organizations that build extensively on HFTO-funded hydrogen and fuel cell research.

2. Project Design

This section of the report outlines the project design. It begins with a brief overview of patent citation analysis, which forms the basis for much of the evaluation presented in this report. This overview is followed by a description of the techniques used to link the various patent sets in the analysis, along with a listing and description of the metrics employed in the study.

The analysis described in this report is based largely upon tracing citation links between successive generations of patents. This tracing is carried out both backwards and forwards in time. The primary purpose of the backward tracing is to determine the extent to which

[2] iEdison (Interagency Edison) is a U.S. government information system used by over thirty federal agency offices for grantees and contractors to report government-funded inventions and patents - https://public.era.nih.gov/iedison/.

[3] This is one of a series of similar reports examining research portfolios across a range of EERE offices. Note that the results are not designed to be compared across portfolios, for example in terms of numbers of patents granted, number of citations received etc. The portfolios have very different profiles with respect to research risks, funding levels and time periods covered, plus there are wide variations in the propensity to patent across technologies. Hence, the results reported in the various reports should not be used for comparative analyses across portfolios.

innovations associated with leading companies in the hydrogen and fuel cell industries have used HFTO-funded research as a foundation. Meanwhile, the primary purpose of the forward tracing is to examine how HFTO-funded hydrogen and fuel cell patents have influenced subsequent technological developments more broadly, both within and outside hydrogen and fuel cell technologies. Many elements of both the backward and forward tracing are also extended to the Other DOE-funded patents, in order to trace their influence, both overall and upon the leading hydrogen and fuel cell companies.

It should be noted that the influence tracing was carried out separately for the HFTO-funded and Other DOE-funded patent portfolios in each of the three technologies. However, for simplicity, the collective terms "DOE-funded patents" and "DOE-funded research" are used hereafter in this section and the Methodology section.

This analysis covers patents filed in three systems: the U.S. Patent & Trademark Office (U.S. patents); the European Patent Office (EPO patents); and the World Intellectual Property Organization (WIPO patents). By covering multiple generations of citations across patent systems, this analysis allows for a wide variety of possible linkages between DOE-funded hydrogen and fuel cell research and subsequent technological developments. Examining all of these linkage types at the level of entire technologies involves a significant data processing effort, and requires access to specialist citation databases, such as those maintained at 1790 Analytics. As a result, this project is more ambitious than many previous attempts to trace through multiple generations of research, which have often been based on studying very specific technologies or individual products.

Patent Citation Analysis

In many patent systems, patent documents contain a list of references to prior art. The purpose of these prior art references is to detail the state of the art at the time of the patent application, and to demonstrate how the new invention is original over and above this prior art. Prior art references may include many different types of public documents. A large number of the references are to earlier patents, and these references form the basis for this study. Other references (not covered in this study) may be to scientific publications and other types of documents, such as technical reports, magazines and newspapers.

The responsibility for adding prior art references differs across patent systems. In the U.S. patent system, it is the duty of patent applicants to reference (or "cite") all prior art of which they are aware that may affect the patentability of their invention. Patent examiners may then reference additional prior art that limits the claims of the patent for which an application is being filed. In contrast to this, in patents filed at the European Patent Office (EPO) and World Intellectual Property Organization (WIPO), prior art references are added solely by the examiner, rather than by both the applicant and examiner. The number of prior art references on EPO and WIPO patents thus tends to be much lower than the number on U.S. patents.[4]

[4] Note that this analysis does not cover patents from other systems, notably patents from the Chinese, Japanese and Korean patent offices. This is because patents from these systems do not typically list any prior art. Hence, it is not possible to use citation links to trace the influence of DOE research on patents from these systems. Having said this,

Patent citation analysis focuses on the links between generations of patents that are made by these prior art references. In simple terms, this type of analysis is based upon the idea that the prior art referenced by patents has had some influence, however slight, upon the development of these patents. The prior art is thus regarded as part of the foundation for the later inventions.

In assessing the influence of individual patents, citation analysis centers on the idea that highly cited patents (i.e., those cited by many later patents) tend to contain technological information of particular interest or importance. As such, they form the basis for many new innovations and research efforts, and so are cited frequently by later patents. While it is not true to say that every highly cited patent is important, or that every infrequently cited patent is necessarily trivial, many research studies have shown a correlation between patent citations and measures of technological and economic importance.[5]

Patent citation analysis has also been used extensively to trace technological developments over time. For example, in the analysis presented in this report, citations from patents to earlier patents are used to trace the influence of DOE-funded hydrogen and fuel cell research. Specifically, cases are identified where patents cite DOE-funded hydrogen and fuel cell patents as prior art. These represent first-generation links between DOE-funded patents and subsequent technological developments. Cases are also identified where patents cite patents that in turn cite DOE-funded hydrogen and fuel cell patents. These represent second-generation links between technological developments and DOE-funded research.

The idea behind this analysis is that the later patents have built in some way on the earlier DOE-funded hydrogen and fuel cell research. By determining how frequently DOE-funded hydrogen and fuel cell patents have been cited by subsequent patents, it is thus possible to evaluate the extent to which DOE-funded research forms a foundation for various technologies both within and beyond hydrogen and fuel cells.

Backward and Forward Tracing

As noted above, the purpose of this analysis is to trace the influence of DOE-funded hydrogen and fuel cell research upon subsequent developments both within and beyond hydrogen and fuel cell technologies. There are two approaches to such a tracing study – backward tracing and forward tracing – each of which has a slightly different objective.

Backward tracing, as the name suggests, looks backwards over time. The idea of backward tracing is to take a particular technology, product, or industry, and to trace back to identify the earlier technologies upon which it has built. In the context of this project, the leading hydrogen and fuel cell organizations in terms of patent portfolio size are identified. The analysis then traces backwards in time from the patents owned by these organizations. This makes it possible

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Chinese, Japanese and Korean organizations are among the most prolific applicants in the WIPO system. This analysis thus picks up the role of organizations from these countries via their WIPO filings.

[5] For background on the use of patent citation analysis, including a summary of validation studies supporting its use, see: Breitzman A. & Mogee M. "The many applications of patent analysis", *Journal of Information Science*, 28(3), 2002, 187-205; and Jaffe A. & de Rassenfosse G. "Patent Citation Data in Social Science Research: Overview and Best Practices", NBER Working Paper No. 21868, January 2016.

to determine the extent to which innovations associated with these leading hydrogen and fuel cell organizations build on earlier HFTO-funded and Other DOE-funded research.

The idea of forward tracing is to take a given body of research, and to trace the influence of this research upon subsequent technological developments. In the context of the current analysis, forward tracing involves identifying all hydrogen and fuel cell patents resulting from research funded by DOE (i.e., HFTO plus Other DOE). The influence of these patents on later generations of technology is then evaluated. This tracing is not restricted to subsequent hydrogen and fuel cell patents, since the influence of a body of research may extend beyond its immediate technology. Hence, the purpose of the forward tracing element of this project is to determine the influence of DOE-funded hydrogen and fuel cell patents upon developments both inside and outside these technologies. As noted previously, the forward and backward tracing were carried out separately for HFTO-funded and Other DOE-funded hydrogen and fuel cell patents. The references in this section to "DOE patents" are shorthand, and do not mean that the tracing was carried out for all DOE-funded hydrogen and fuel cell patents as a single portfolio.

Tracing Multiple Generations of Citation Links

The simplest form of tracing study is one based on a single generation of citation links between patents. Such a study identifies patents that cite, or are cited by, a given set of patents as prior art. The analysis described in this report extends the tracing by adding a second generation of citation links. The backward tracing starts with hydrogen and fuel cell patents owned by leading organizations. It then traces backwards in time through two generations of patents to identify the earlier innovations (including those funded by DOE) upon which these leading organization patents were built. The first generation contains the patents that are cited as prior art by the leading company patents. The second generation contains patents that are in turn cited as prior art by these first generation patents.

The forward tracing starts with DOE-funded patents in hydrogen and fuel cell technologies. It then traces forwards in time through two generations of patents to identify the later innovations that are linked to these DOE-funded patents. The first generation contains the patents that cite these DOE-funded patents as prior art. The second generation contains the patents that in turn cite these first-generation patents.

This means that the tracing is carried out forwards in time through two generations of citations starting from DOE-funded hydrogen and fuel cell patents; and backwards in time through two generations starting from the patents owned by leading hydrogen and fuel cell organizations. Hence there are two types of links between DOE-funded patents and later generations of patents:

1. **Direct Links**: a patent cites a DOE-funded hydrogen and fuel cell patent as prior art.
2. **Indirect Links**: a patent cites an earlier patent, which in turn cites a DOE-funded hydrogen and fuel cell patent. The DOE patent is linked indirectly to the later patent.

The idea behind adding the second generation of citations is that agencies such as DOE often support basic scientific research. It may take time, and numerous generations of research, for this basic research to be used in an applied technology, for example that described in a patent owned by a leading company. Introducing a second generation of citations provides greater access to these indirect links between basic research and applied technology.

One potential problem with adding generations of citations must be acknowledged. Specifically, if one uses enough generations of links, eventually almost every node in the network will be linked. This is a problem common to many networks, whether these networks consist of people, institutions, or scientific documents, as in this case. The most famous example of this is the idea that every person is within six degrees of separation from any other person in the world. By the same logic, if one takes a starting set of patents, and extends the network of prior art references far enough, almost all patents will be linked to this starting set. Hence, while including a second generation of citations provides insights into indirect links between basic research and applied technologies, adding further generations may bring in too many patents with little connection to the starting patent set.

Constructing Patent Families

The coverage of a patent is limited to the jurisdiction of its issuing authority. For example, a patent granted by the U.S. Patent & Trademark Office (a 'U.S. patent') provides protection only within the United States. If an organization wishes to protect an invention in multiple countries, it must file patents in each of those countries' systems. For example, a company may file to protect a given invention in the U.S., China, Germany, Japan and many other countries. This would result in multiple patent documents for the same invention.[6] In addition, in some systems – notably the U.S. – inventors may apply for a series of patents based on the same underlying invention.

In the case of this study, one or more U.S., EPO and WIPO patents may result from a single invention. To avoid counting the same inventions multiple times, it is necessary to construct "patent families". A patent family contains all of the patents and patent applications that result from the same original patent application (named the "priority application"). A family may include patents from multiple countries, and also multiple patents from the same country. In this project, patent families are constructed for DOE-funded hydrogen and fuel cell patents, and also for the patents owned by the leading hydrogen and fuel cell organizations (which are discussed below in Section 3). Patent families are also assembled for all patents linked via citations to DOE-funded hydrogen and fuel cell patents.

To construct these patent families, the priority documents of the U.S., EPO and WIPO patents were matched, in order to group them into the appropriate families. It should be noted that the priority document need not necessarily be a U.S., EPO or WIPO application. For example, a Japanese patent application may result in U.S., EPO and WIPO patents, which are grouped in the same patent family because they share the same Japanese priority document.

[6] It also means that patents from a given country's system are not synonymous with inventions made in that country. Indeed, roughly half of all U.S. patent applications are from overseas inventors – see https://www.uspto.gov/web/offices/ac/ido/oeip/taf/st_co_20.htm

Metrics Used in the Analysis

Table 2-1 contains a list of the metrics used in the analysis. These metrics are divided into three main groups – technology landscape metrics (trends, assignees, and technology distributions), backward tracing metrics, and forward tracing metrics. Findings for each of these three groups of metrics can be found in the Results section of the report.

Table 2-1 – List of Metrics Used in the Analysis

Metric
Trends
• Number of HFTO/Other DOE-funded hydrogen and fuel cell patent families by year of priority application
• Number of HFTO/Other DOE-funded granted U.S. hydrogen and fuel cell patents by issue year
• Overall number of hydrogen and fuel cell patent families by priority year
• Percent of hydrogen and fuel cell patents families funded by HFTO/Other DOE by priority year
Assignee Metrics
• Number of hydrogen and fuel cell patent families for leading patenting organizations
• Assignees with largest no. of hydrogen and fuel cell patent families funded by HFTO/Other DOE
Technology Metrics
• Patent classification (CPC) distribution for HFTO-funded hydrogen and fuel cell patent families (vs Other DOE-funded, leading hydrogen and fuel cell companies, all hydrogen and fuel cell patents)
Backward Tracing Metrics
• Number of leading company hydrogen and fuel cell patent families linked via citations to earlier patent families from HFTO/Other DOE and other leading companies
• Number of hydrogen and fuel cell patent families for each leading company linked via citations to earlier HFTO/Other DOE-funded patent families
• Total citation links from each leading company to HFTO/Other DOE-funded patent families
• Percentage of leading company hydrogen and fuel cell patent families linked via citations to earlier HFTO/Other DOE-funded patent families
• HFTO/Other DOE-funded hydrogen and fuel cell patent families linked via citations to largest number of leading company hydrogen and fuel cell patent families
• Leading company hydrogen and fuel cell patent families linked via citations to largest number of HFTO-funded hydrogen and fuel cell patent families
• Highly cited leading company hydrogen and fuel cell patent families linked via citations to earlier HFTO-funded hydrogen and fuel cell patent families
Forward Tracing Metrics
• Citation Index for hydrogen and fuel cell patent portfolios owned by leading companies, plus portfolios of HFTO/Other DOE-funded hydrogen and fuel cell patents
• Number of patent families linked via citations to HFTO/Other DOE-funded hydrogen and fuel cell patents by patent classification
• Organizations (beyond leading hydrogen and fuel cell companies) linked via citations to largest number of HFTO/Other DOE funded hydrogen and fuel cell patent families
• Highly cited HFTO-funded hydrogen and fuel cell U.S. patents
• HFTO/Other DOE-funded hydrogen and fuel cell patent families linked via citations to largest number of subsequent hydrogen and fuel cell/other patent families
• Highly cited patents (not owned by leading companies) linked via citations to earlier HFTO-funded hydrogen and fuel cell patents families

3. Methodology

The previous section of the report outlines the objective of this analysis – that is, to determine the influence of HFTO-funded (and Other DOE-funded) hydrogen and fuel cell research on subsequent developments both within and outside hydrogen and fuel cell technologies. This section of the report describes the methodology used to implement the analysis. Particular emphasis is placed on the processes employed to construct the various data sets required for the analysis. Specifically, the backward tracing starts from the set of all hydrogen and fuel cell patents owned by leading patenting organizations in these technologies (these organizations are defined later in this section). Meanwhile, the forward tracing starts from the sets of hydrogen and fuel cell patents funded by HFTO and Other DOE. Various data sets thus had to be defined – HFTO-funded hydrogen and fuel cell patents; Other DOE-funded hydrogen and fuel cell patents; and hydrogen and fuel cell patents assigned to the leading organizations in these technologies.

Identifying HFTO-funded and Other DOE-funded Hydrogen and Fuel Cell Patents

The objective of this analysis is to trace the influence of hydrogen and fuel cell research funded by HFTO (plus hydrogen and fuel cell research funded by the remainder of DOE) upon subsequent developments both within and outside hydrogen and fuel cell technologies. Outlined below are the three steps used to identify HFTO-funded and Other DOE-funded hydrogen and fuel cell patents. These three steps are:

(i) Define the universe of DOE funded patents;
(ii) Determine which of these DOE funded patents are relevant to hydrogen and fuel cells; and
(iii) Categorize these DOE-funded hydrogen and fuel cell patents according to whether or not they can be linked definitively to HFTO funding.

Defining the Universe of DOE-Funded Patents

Identifying patents funded by government agencies is often more difficult than locating patents funded by companies. When a company funds internal research, any patented inventions emerging from this research are likely to be assigned to the company itself. In order to construct a patent set for a company, one simply has to identify all patents assigned to the company, along with all of its subsidiaries, acquisitions, etc.

Constructing a patent list for a government agency is more complicated, because the agency may fund research carried out at many different organizations. For example, DOE operates seventeen national laboratories. Patents emerging from these laboratories may be assigned to DOE. However, they may also be assigned to the organization that manages a given laboratory. For example, many patents from Sandia National Laboratory are assigned to Lockheed Martin (Sandia's former lab manager), while many Lawrence Livermore National Laboratory patents are assigned to the University of California. Lockheed Martin and the University of California are large organizations with many interests beyond managing DOE labs, so one cannot simply define all of the patents assigned to them as DOE-funded.

A further complication is that DOE does not only fund research in its own labs and research centers, it also funds extramural research carried out by other organizations. If this research results in patented inventions, these patents are likely to be assigned to the organizations carrying out the research, rather than to DOE.

A database containing all DOE-funded patents was therefore constructed for this analysis. The database includes patents assigned to DOE itself, and also patents assigned to individual labs, lab managers, and other organizations and companies funded by DOE. This "All DOE" patent database was constructed using a number of sources:

1. ***DOEPatents Database*** – The first source is a database of DOE-funded patents put together by DOE's Office of Scientific & Technical Information (OSTI), and available on the web at www.osti.gov/doepatents/. This database contains information on research grants provided by DOE. It also links these grants to the organizations or DOE labs that carried out the research, the sponsor organization within DOE, and the patents that resulted from these DOE grants.

2. ***iEdison Database*** – EERE staff provided an output from the iEdison database, which is used by government grantees and contractors to report government-funded subject inventions, patents, and utilization data to the government agency that issued the funding award.

3. ***Visual Patent Finder Database*** – EERE also provided an output from its Visual Patent Finder tool. This tool takes DOE-funded patents and clusters them based on word occurrence patterns. In this case, the output was a flat file of DOE-funded patents.

4. ***Patents assigned to DOE*** – in the USPTO database, there are a small number of U.S. patents assigned to DOE itself that are not in the any of the sources above. These patents were added to the list of DOE patents.

5. ***Patents with DOE Government Interest*** – A U.S. patent has on its front page a section entitled 'Government Interest', which details the rights that the government has in a particular invention. For example, if a government agency funds research at a private company, the government may have certain rights to patents granted based on this research. All patents that refer to 'Department of Energy' or 'DOE' in their Government Interest field, including different variants of these strings, were therefore identified. Also located were patents that refer to government contracts beginning with 'DE-' or containing the string '-ENG-'. The former string typically denotes DOE contracts and financial assistance projects, while the latter is a legacy code listed on a number of older DOE-funded patents. Patents containing these strings that were not already in any of the sources above were then checked manually, to make sure that they are indeed DOE-funded (e.g., '-ENG-' is also used in a small number of NSF contracts). Any additional DOE-funded patents were then included in the database.

The "All DOE" patent database constructed from these five sources contains more than 31,000 U.S. patents issued between January 1976 and December 2018 (the end-point of the primary data collection for this analysis).

Identifying DOE-Funded Hydrogen and Fuel Cell Patents

Having defined the universe of DOE-funded patents, the next step was to determine which of these patents are relevant to hydrogen and fuel cell technologies. As an initial data set, HFTO technology managers supplied a list of patents that they believed HFTO had funded in each technology. Custom patent filters were then designed to identify additional hydrogen and fuel cell patents that may be funded by either HFTO or a different office within DOE. These filters consist of a combination of Cooperative Patent Classifications (CPCs) and keywords (with the original HFTO-supplied patents acting as a starting point to help in selecting these classifications and keywords). Details of the patent filters are shown in Table 3-1.

Table 3-1 – Filters used to Identify Hydrogen and Fuel Cell Patents

Filter A (Fuel Cells)
Cooperative Patent Classification
H01M 8 – Fuel cell manufacturing
H01M 2008 – Fuel cell manufacturing
H01M 2250 – Fuel cell applications
Y02B 90/10-18 – Fuel cell application in buildings
Y02E 60/50-566 – Fuel cells for climate change applications
Y02E 70/20 – Combining fuel cells with fuel production
Y02P 70/56 – Fuel cell manufacturing
Y02P 90/40 – Fuel cells for emissions mitigation
Y02T 90/30-40 – Fuel cells for transportation
OR
Title/Abstract
Fuel(-)cell*
Filter B (Hydrogen Production)
Cooperative Patent Classification
Y02E 60/36-368 – Hydrogen production from non-carbon sources
Y02E 70/10 – Hydrogen production from electrolysis
OR
Cooperative Patent Classification = C01B 2203 (hydrogen/syngas production) or C01B 3/02-586 (production of hydrogen or hydrogen-containing gases) or Y02P 20/50-59 (production of bulk chemicals) **AND Title/Abstract =** hydrogen* or syn(-)gas* or synthesis gas*
Filter C (Hydrogen Storage)
Cooperative Patent Classification
C01B 3/0005-0096 – Hydrogen uptake for storage
F17C 11/005 – Gas solvents/sorbents for hydrogen storage
F17C 2221/012 – Storage of hydrogen
Y02E 60/32-328 – Hydrogen storage for emissions mitigation
OR
Cooperative Patent Classification = F17C (gas storage containers) **AND Title/Abstract =** hydrogen*

There are three different filters in Table 3-1, each directed to a different technology area – fuel cells, hydrogen production, and hydrogen storage. As an initial step, all patents in the "All DOE" database patent database that qualified under each of the three filters were selected, along with patents from the original lists supplied by HFTO. The resulting patent lists were sent to HFTO for review. After incorporating feedback from HFTO, the patent sets were adjusted, resulting in the initial lists of hydrogen and fuel cell granted U.S. patents funded by DOE. The initial fuel cell list contained 1,161 U.S. patents, while the hydrogen production list contained 552 U.S. patents and the hydrogen storage list 167 U.S. patents.

Defining HFTO-funded vs. Other DOE-funded Hydrogen and Fuel Cell Patents

As noted above, linking DOE-funded patents to individual offices is often a difficult task. For this analysis, EERE staff undertook an exhaustive process to determine which of the 1,161 DOE-funded fuel cell patents, 552 hydrogen production patents and 167 hydrogen storage patents in the initial lists could be linked definitively to HFTO funding. This process involved a number of steps, which are listed below:

(i) Linking contract numbers listed in patents to EERE project contract numbers, for financial assistance projects,
(ii) Linking contract numbers listed in patents to EERE SBIR project agreement numbers,
(iii) Asking HFTO technology managers to verify individual patents,
(iv) Asking HFTO technology managers to send lab patents to lab POCs to get direct verification of these patents,
(v) Contacting individual inventors listed on patents to ask them to confirm whether individual patents were funded by HFTO, and
(vi) Locating references to patents in available office annual project progress reports or patent disclosure documents with accomplishments reported by PIs.

Final Lists of HFTO-funded and Other DOE-funded Hydrogen and Fuel Cell Patents

Based on the process described above, the initial lists of DOE-funded hydrogen and fuel cell U.S. patents were divided into two categories – HFTO-funded and Other DOE-funded. A search was then carried out for equivalents of each of these patents in the EPO and WIPO systems. An equivalent is a patent filed in a different patent system covering essentially the same invention. A search was also implemented for U.S. patents that are continuations, continuations-in-part, or divisional applications of each of the patents in the final set. The patents were then grouped into families by matching priority documents (see earlier discussion of patent families). Table 3-2 contains a summary of the number of HFTO-funded and Other DOE-funded fuel cell, hydrogen production, and hydrogen storage patents and patent families. In each of these three technologies, the oldest patent families in the DOE-funded portfolios date back to 1975-1979, the earliest time period in the analysis.

Table 3-2 shows that there are a total of 456 HFTO-funded fuel cell patent families, containing 571 U.S. patents, 154 EPO patents, and 181 WIPO patents (see Appendix FC-A for patent list). There are also 541 Other DOE-funded fuel cell patent families, containing 629 U.S. patents, 205 EPO patents, and 166 WIPO patents (see Appendix FC-B for patent list).

In addition, Table 3-2 shows that there are a total of 283 HFTO-funded hydrogen production patent families, containing 380 U.S. patents, 117 EPO patents, and 112 WIPO patents (see

Appendix PD-A for patent list). There are also 170 Other DOE-funded hydrogen production patent families, containing 200 U.S. patents, 44 EPO patents, and 62 WIPO patents (see Appendix PD-B for patent list).

Table 3-2 also shows that there are a total of 110 HFTO-funded hydrogen storage patent families, containing 143 U.S. patents, 37 EPO patents, and 44 WIPO patents (see Appendix ST-A for patent list). There are also 31 Other DOE-funded hydrogen storage patent families, containing 38 U.S. patents, four EPO patents, and nine WIPO patents (see Appendix ST-B for patent list).

Table 3-2 – Number of HFTO-funded and Other DOE-funded Hydrogen and Fuel Cell Patents and Patent Families[7]

	# Patent Families	# U.S. Patents	# EPO Patents	# WIPO Patents
Fuel Cells				
HFTO-funded	456	571	154	181
Other DOE-funded	541	629	205	166
Total DOE-funded	997	1200	359	347
Hydrogen Production				
HFTO-funded	283	380	117	112
Other DOE-funded	170	200	44	62
Total DOE-funded	453	580	161	174
Hydrogen Storage				
HFTO-funded	110	143	37	44
Other DOE-funded	31	38	4	9
Total DOE-funded	141	181	41	53

Identifying Leading Hydrogen and Fuel Cell Patenting Organizations

The purpose of the backward tracing element of this analysis is to evaluate the influence of HFTO-funded (and Other DOE-funded) research upon hydrogen and fuel cell innovations produced by leading organizations in these technologies. To identify such organizations, the universes of fuel cell, hydrogen production, and hydrogen storage patents in the period 1976-2018 were first defined by applying the patent filters detailed earlier in Table 3-1 to all U.S., EPO and WIPO patents (i.e., not just those patents in the all-DOE database).

Based on Filter A in Table 3-1, there are a total of 22,039 fuel cells U.S. patents, 19,763 fuel cells WIPO patents, and 15,232 fuel cells EPO patents. These patents are grouped into 36,694

[7] These counts are somewhat higher than those reported by Pacific Northwest National Laboratory (PNNL) in its annual patent analysis reports prepared for HFTO, which focus on granted U.S. patents only and do not incorporate patent family data (see PNNL reports published in 2009 – 2019 at https://www.energy.gov/eere/fuelcells/market-analysis-reports#mkt-pathways). Also, in this analysis, all members of patent families containing an HFTO-funded patent are considered to be HFTO-funded (with the same approach also used for Other DOE-funded patent families).

patent families. The twelve organizations with the largest number of patent families in this overall fuel cells universe are shown in Table 3-3.

Table 3-3 – Top 12 Patenting Fuel Cells Companies

Company	# Fuel Cells Patent Families
Toyota	2158
General Motors	1397
Honda	1274
Panasonic	1106
Nissan	917
Doosan Holdings	914
Daimler	602
Samsung SDI	588
Ballard Power	579
Siemens	495
Hyundai	456
Toshiba	401

Based on Filter B in Table 3-1, there are a total of 11,174 hydrogen production U.S. patents, 9,150 hydrogen production WIPO patents, and 8,661 hydrogen production EPO patents. These patents are grouped 17,789 patent families. The twelve organizations with the largest number of patent families in this overall hydrogen production universe are shown in Table 3-4.

Table 3-4 – Top 12 Patenting Hydrogen Production Companies

Company	# Hydrogen Production Patent Families
Exxon Mobil	474
Shell	354
BASF	350
Honeywell	329
Linde	302
L'Air Liquide	266
Dow Chemical	247
Chevron	243
Panasonic	229
Air Products & Chemicals	206
Haldor Topsoe	183
BP	165

Based on Filter C in Table 3-1, there are a total of 2,839 hydrogen storage U.S. patents, 2,487 hydrogen storage WIPO patents, and 2,327 hydrogen storage EPO patents. These patents are grouped into 4,825 patent families. The twelve organizations with the largest number of patent families in this overall hydrogen storage universe are shown in Table 3-5.

The numbers of patent families listed in Tables 3-3 – 3-5 include all variant names under which each organization has patents, taking into account including all subsidiaries and acquisitions.[8] The fuel cell, hydrogen production, and hydrogen storage patent families of these companies form the starting point for the backward tracing element of the analysis in the respective technologies. As such, this analysis evaluates the influence of HFTO-funded and Other DOE-funded hydrogen and fuel cell research on technologies developed by leading companies in the hydrogen and fuel cell industries.

Table 3-5 – Top 12 Patenting Hydrogen Storage Companies

Company	# Hydrogen Storage Patent Families
Toyota	187
Linde	181
L'Air Liquide	161
General Motors	129
Honda	116
Air Products & Chemicals	104
BASF	95
Panasonic	90
Energy Conversion Devices	71
BMW	61
Entegris	59
Intelligent Energy	56

Constructing Citation Links

Through the processes described above, the starting patent sets for both the backward and forward tracing elements of the analysis were constructed. The patent sets for the backward tracing consisted of patent families assigned to the leading patenting organizations in fuel cell, hydrogen production, and hydrogen storage technologies. The patent sets for the forward tracing consisted of HFTO-funded (and, separately, Other DOE-funded) fuel cell, hydrogen production, and hydrogen storage patent families.

Having defined these patent sets, two separate tracing exercises were carried out. The first was backwards in time through two generations of citations starting from the leading organizations' hydrogen and fuel cell patents. The second was forwards in time through two generations of citations starting from the HFTO/Other DOE-funded hydrogen and fuel cell patents. These included citations listed on U.S., EPO and WIPO patents, and required extensive data cleaning to account for differences in referencing formats across these systems. The citation linkages identified, along with characteristics of the starting patent sets, form the basis for the results described in the next section of this report. These results are reported first for fuel cells, followed by hydrogen production and then hydrogen storage.

[8] All twelve of the organizations in each of Tables 3-3 – 3-5 are companies. For clarity, they are referred to in the results section of the report as the leading fuel cell, hydrogen production, and hydrogen storage companies, rather than organizations. Also, note that they are selected based on patent portfolio size, which does not necessarily reflect number of units sold or revenues, profits etc. A fuller description would be the leading patenting hydrogen and fuel cell companies, but this is a cumbersome description to use throughout the results section of the report.

4. Results – Fuel Cells

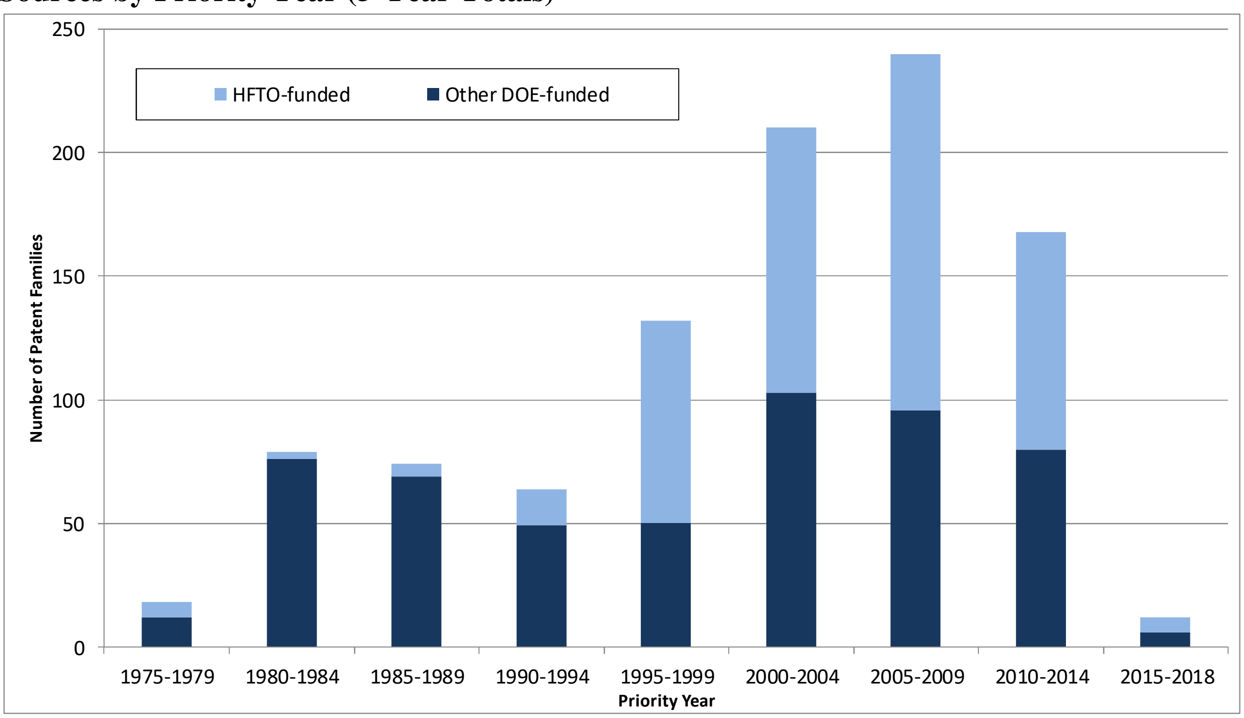
This section of the report outlines the results of an analysis tracing the influence of HFTO-funded and Other DOE-funded fuel cell research on subsequent developments both within and beyond fuel cell technology. The results are divided into three main sections. The first section examines trends in patenting over time in fuel cells, and assesses the distribution of HFTO-funded and Other DOE-funded patents across fuel cell technologies. The second section then reports the results of an analysis tracing backwards from fuel cell patents owned by the leading companies in this technology. The purpose of this analysis is to determine the extent to which fuel cell innovations developed by leading companies build upon earlier fuel cell research funded by HFTO (plus fuel cell research funded by the remainder of DOE). The third section reports the results of an analysis tracing forwards from HFTO-funded (and Other DOE-funded) fuel cell patents. The purpose of this analysis is to assess the broader influence of DOE-funded research upon subsequent developments within and beyond fuel cell technology.

Overall Trends in Fuel Cell Patenting

Trends in Fuel Cell Patenting over Time

Figure 4-1 shows the number of DOE-funded fuel cell patent families by priority year – i.e., the year of the first application in each patent family.

Figure 4-1 - Number of Fuel Cell Patent Families funded by HFTO and Other DOE Sources by Priority Year (5-Year Totals)

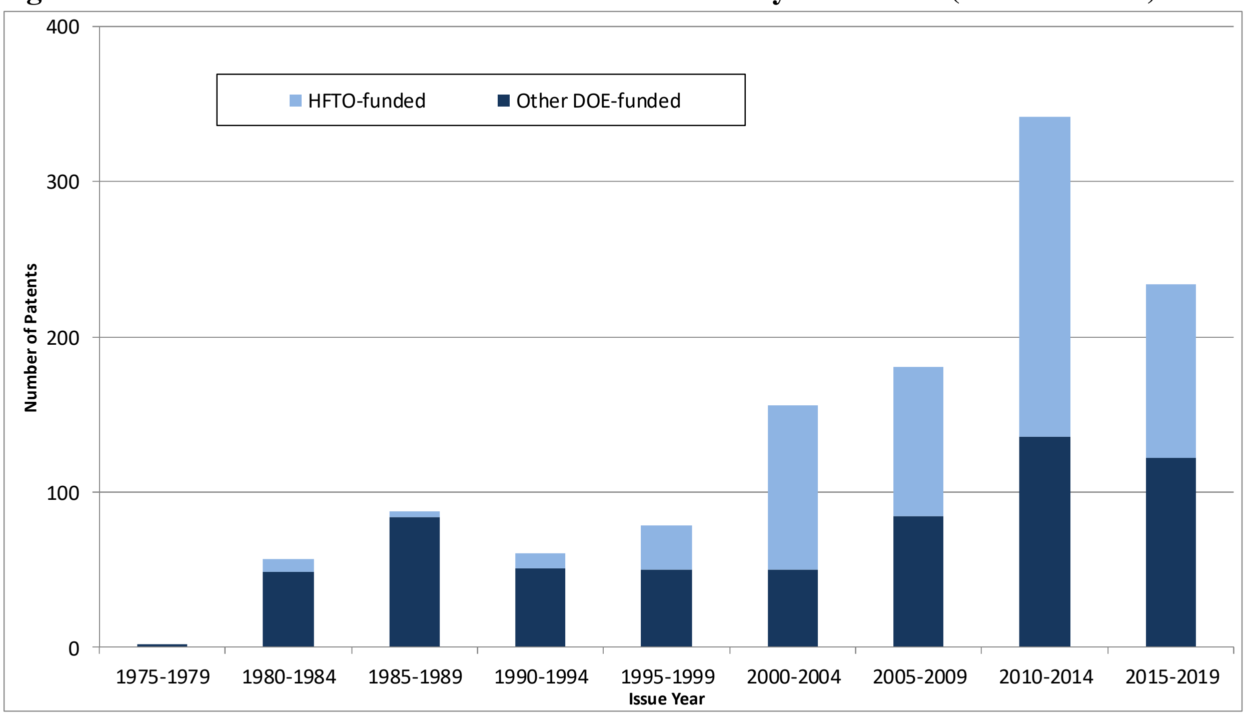


Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 4-1 separates HFTO-funded and Other DOE-funded patent families, and reveals an interesting pattern in terms of DOE-funded patent activity in fuel cell technology. This activity started in earnest from 1980 onwards, with 79 DOE-funded fuel cell patent families filed in 1980-1984, followed by 74 patent families in 1985-1989. There was then a slight decline, with 64 patent families filed in 1990-1994. These early time periods were dominated by Other DOE-funded patents. Out of the 235 DOE-funded fuel cell patent families filed between 1975 and 1994, 206 are defined as Other DOE-funded, versus only 29 HFTO-funded patent families. After 1994, there was a marked increase in DOE-funded fuel cell patenting, with 132 patent families filed in 1995-1999, 210 filed in 2000-2004 and 240 filed in 2005-2009. There was then a decline in 2010-2014 to 168 patent families. The final time period, 2015-2018, contains only partial data due to time lags associated with the patenting process. Throughout this post-1994 time period, HFTO-funded patent families represented a higher percentage of the total number of DOE-funded fuel cell patent families. Out of the 762 DOE-funded patent families filed from 1995 onwards, 427 (56%) are defined as HFTO-funded.

Figure 4-2 shows the number of fuel cell granted U.S. patents funded by DOE. This figure follows a similar pattern to Figure 4-1, which is based on patent family priority dates.

Figure 4-2 - No. of DOE-Funded Fuel Cell U.S. Patents by Issue Year (5-Year Totals)

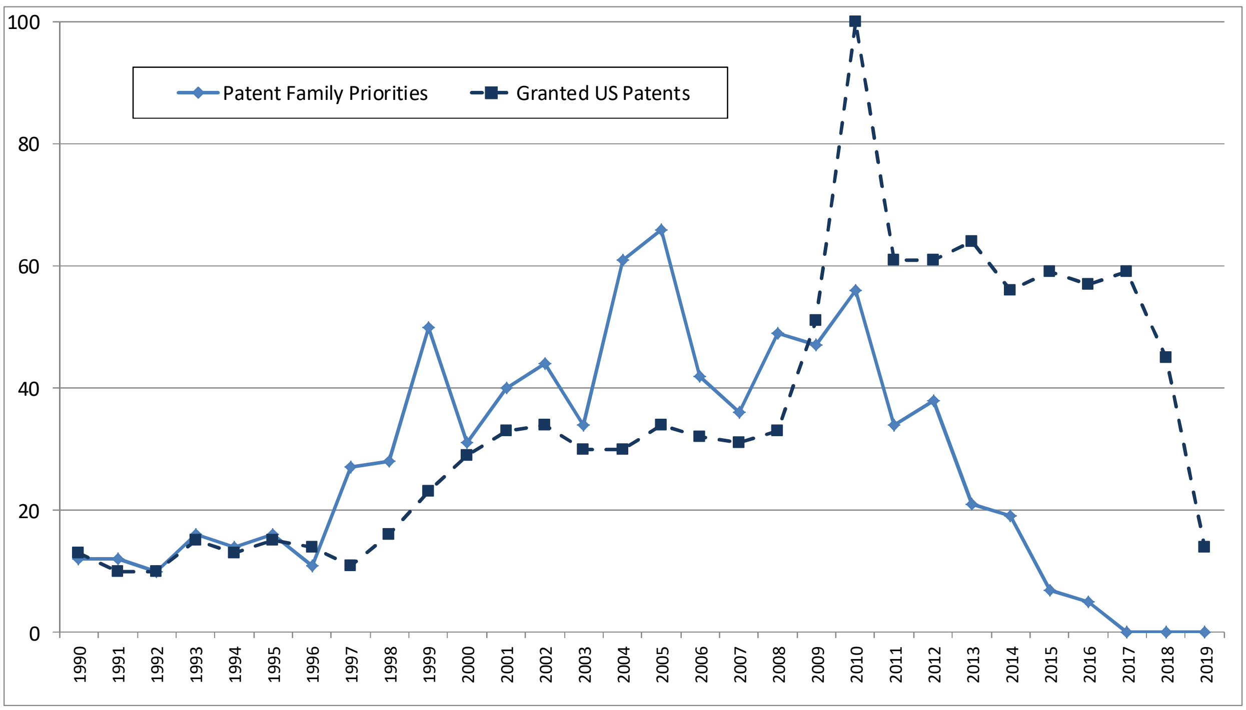


Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

Figure 4-2 reveals that the number of DOE-funded fuel cell U.S. patents was below 100 in each five year period through 1999, peaking at 88 patents in 1985-1989. Other DOE-funded patents represented a high percentage of the total throughout these early time periods. From 2000 onwards, the number of DOE-funded fuel cell U.S. patents increased sharply, reaching 342 patents granted in 2010-2014. HFTO-funded patents account for a higher percentage of DOE-funded patents in the post-2000 time period. Out of the 913 DOE-funded fuel cell U.S. patents granted since 2000, 520 (57%) are confirmed as HFTO-funded. The data for 2015-2019 indicate a decline in DOE-funded fuel cell patents during that period. However, data for this time period are incomplete, since the primary data collection only included patents issued through the end of the 2018 study period.

Comparing Figures 4-1 and 4-2 shows the effect of time lags in the patenting process, with many of the patent families with priority dates in 2005-2009 and 2010-2014 (Figure 4-1) resulting in granted U.S. patents in 2010-14 and 2015-19 (Figure 4-2). These time lags can also be seen in Figure 4-3, which shows patent family priorities alongside granted U.S. patents (HFTO and Other DOE are combined in this figure, in order to simplify the presentation).

Figure 4-3 - Number DOE-funded Fuel Cell Patent Families (by Priority Year) and Granted U.S. Patents (by Issue Year)

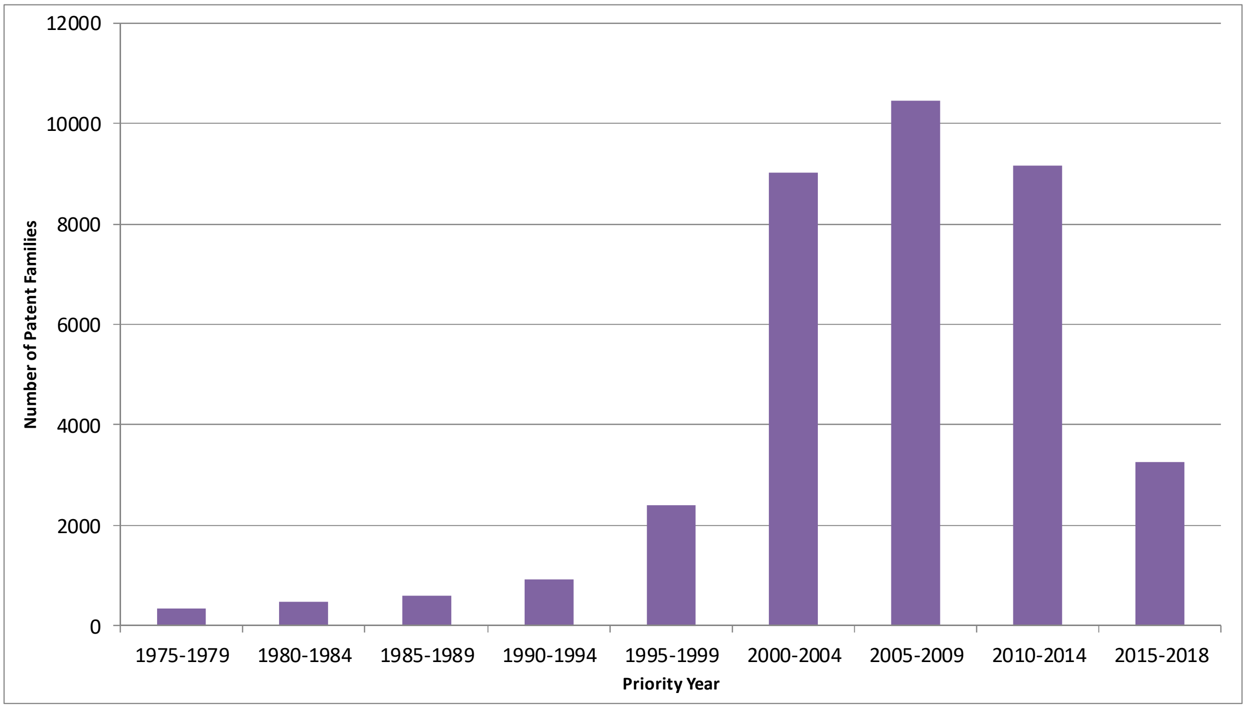


Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

In Figure 4-3, the peak in patent family priorities occurred in 2004-2005, with a corresponding peak in granted U.S. patents occurring in 2010. After 2004-2005, the number of patent families remained at a relatively high level, before dropping sharply from 2011 onwards. This in turn feeds through to granted U.S. patents, which remained at a consistently high level after 2010, before decreasing in 2018. Note that, due to the primary data collection for this analysis ending in 2018, the number of granted U.S. patents declines sharply in 2019, and the number of patent families is zero.

Figures 4-1 – 4-3 focus on DOE-funded fuel cell patent families. Figure 4-4 broadens the scope, and shows the overall number of fuel cell patent families by priority year (based on USPTO, EPO, and WIPO filings). This figure reveals that the number of fuel cell patent families increased gradually from 1975 through 1994, growing from 331 patent families filed in 1975-1979 to 909 in 1990-1994. The number of patent families then increased much more rapidly, with 2,407 filed in 1995-1999 and 9,019 in 2000-2004 (i.e., there were almost ten times as many patent families filed in 2000-2004 as there were in 1990-1994). The number of patent families peaked at 10,448 in 2005-2009, before declining slightly to 9,170 in 2010-2014. This decline continued from 2015 onwards, although data for this most recent time period are incomplete.

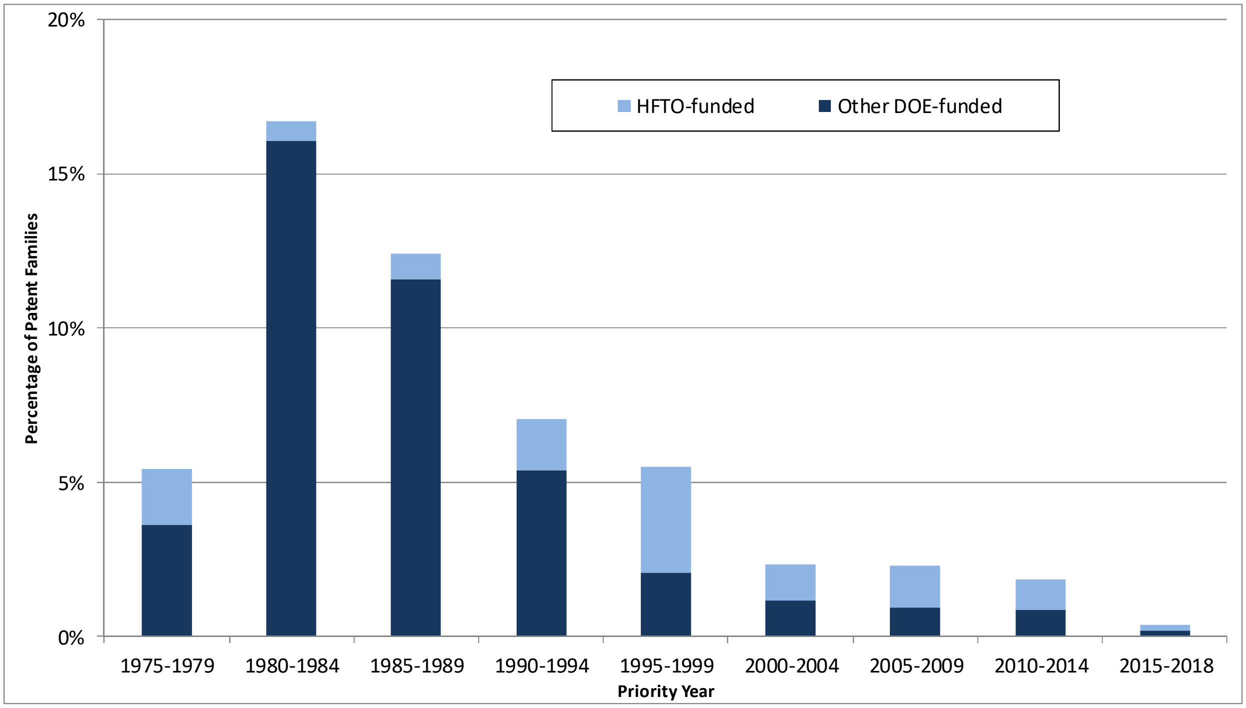
Figure 4-4 - Total Number of Fuel Cell Patent Families by Priority Year (5-Year Totals)



Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 4-5 shows the percentage of fuel cell patent families in each time period that were funded by DOE (HFTO plus Other DOE). This figure reveals that more than 5% of all fuel cell patent families were funded by DOE in every 5-year period between 1975 and 1999. Indeed over 16% of fuel cell patent families filed in 1980-1984, and more than 12% of patent families filed in 1985-1989, were funded by DOE. As such, Figure 4-5 suggests that DOE funding played an important role in the early stages of the development of the fuel cell industry. The percentage of fuel cell patents funded by DOE has dropped since 2000, even as the absolute number of DOE-funded fuel cell patent families has increased. This is due to the rapid growth in overall fuel cell patenting from 2000 onwards, with DOE representing only one source of funding, alongside the R&D budgets of numerous very large companies. Overall, 2.7% of fuel cell patent families in the period 1976-2018 were funded by DOE.

Figure 4-5 - Percentage of Fuel Cell Patent Families Funded by DOE by Priority Year



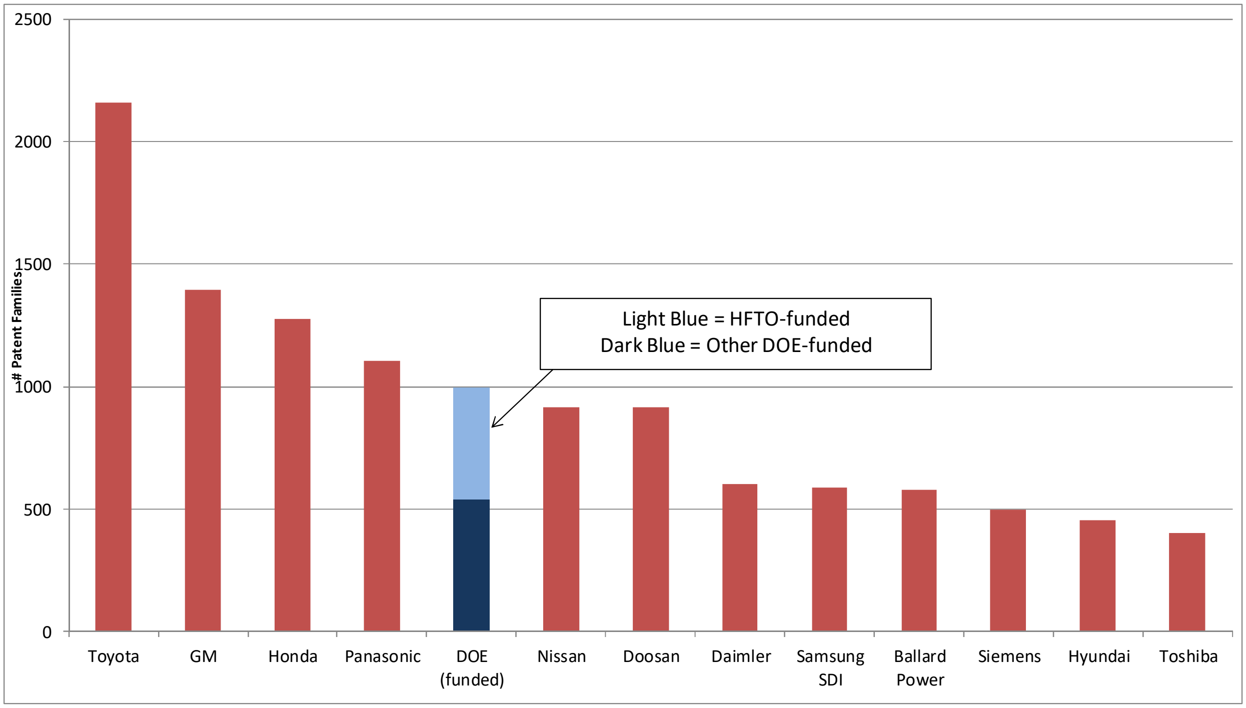
Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Leading Fuel Cell Patenting Companies

The twelve leading patenting companies overall in fuel cell technology are listed earlier in Table 3-3, along with their number of fuel cell patent families. These twelve companies are the basis for the backward tracing element of the analysis, as outlined below. Figure 4-6 shows the same information in graphical form, while also including DOE-funded patent families. This figure reveals that the Toyota has the largest fuel cell patent portfolio, containing 2,158 patent families. Three other companies in Figure 4-6 have more than 1,000 fuel cell patent families: General Motors (1,397 families); Honda (1,274); and Panasonic (1,106). One notable feature of Figure 4-6 is the geographical distribution of the leading companies, with eight based in Asia, two in Europe, and two in North America. This reinforces the earlier point that, while the analysis does not include patents from Asian systems, this does not mean that patents associated with Asian companies are excluded.

The DOE-funded fuel cell patent portfolio of 997 patent families (456 HFTO-funded; 541 Other DOE-funded) is the fifth largest in Figure 4-6. It should be noted that there is a small amount of double-counting of patent families in this figure. Specifically, out of the 10,824 fuel cell patent families assigned to the twelve leading companies, 108 (1%) were funded at least in part by DOE (57 by HFTO; 51 by Other DOE). These 108 patent families are counted in both the associated segments of the DOE-funded column in Figure 4-6 and in the respective company columns. This double-counting is appropriate, since these patent families are both funded by DOE and assigned to a leading company.

Figure 4-6 – Leading Fuel Cell Companies (based on number of patent families)



Leading Assignees of HFTO/Other DOE Fuel Cell Patents

The DOE-funded fuel cell patent portfolios are constructed somewhat differently from the portfolios of the leading companies listed in Figure 4-6. Specifically, DOE's 997 patent families are those funded by DOE, but they are not necessarily assigned to the agency. For example, HFTO (or another DOE office) may have funded research projects at DOE labs or companies. In such cases, the assignees of any resulting patents may be the respective companies or DOE lab managers (for example, the 108 leading company patent families referred to above).

Figure 4-7 shows the leading assignees on HFTO-funded fuel cell patent families. This chart is headed by the University of California with 38 patent families, resulting primarily from its management of Los Alamos National Laboratory (LANL) and Lawrence Berkeley National Laboratory (LBL). It is one of a number of DOE lab managers in Figure 4-7. Others include Brookhaven Science Associates (Brookhaven National Laboratory); UChicago Argonne (Argonne National Laboratory); Los Alamos National Security LLC (LANL); and UT-Battelle (Oak Ridge National Laboratory). This reflects the breadth of HFTO funding of fuel cell research across DOE laboratories. Figure 4-7 also includes a number of large companies, including General Motors (37 HFTO-funded patent families), 3M (29), General Electric (16) and DuPont (13). This reflects the extent of HFTO funding of fuel cell research carried out by external organizations.

Figure 4-7 - Assignees with Largest No. of HFTO-Funded Fuel Cell Patent Families

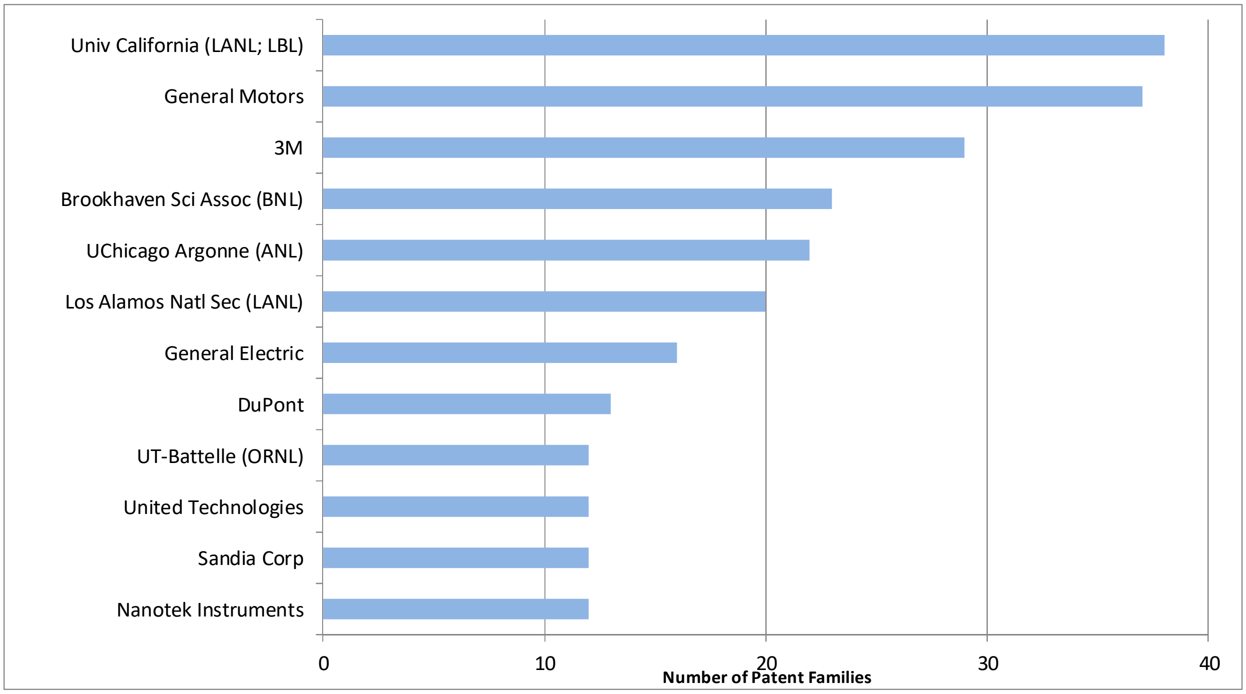


Figure 4-8 - Assignees with Largest No. of Other DOE-funded Fuel Cell Patent Families

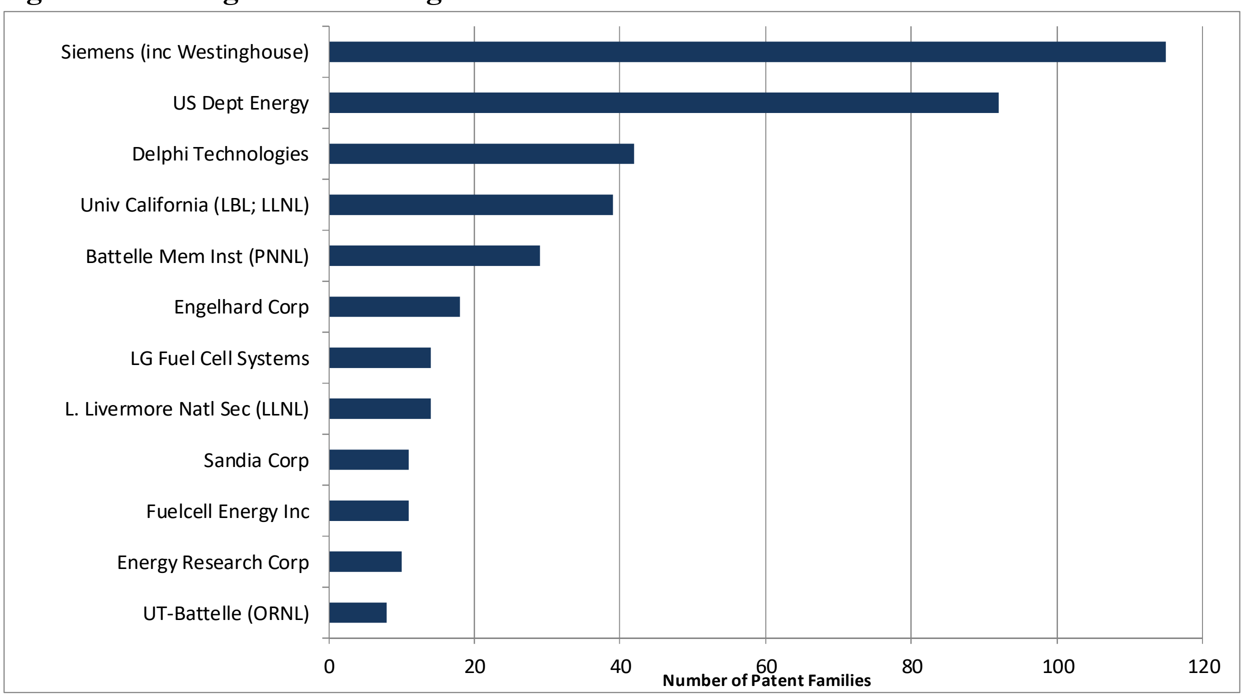
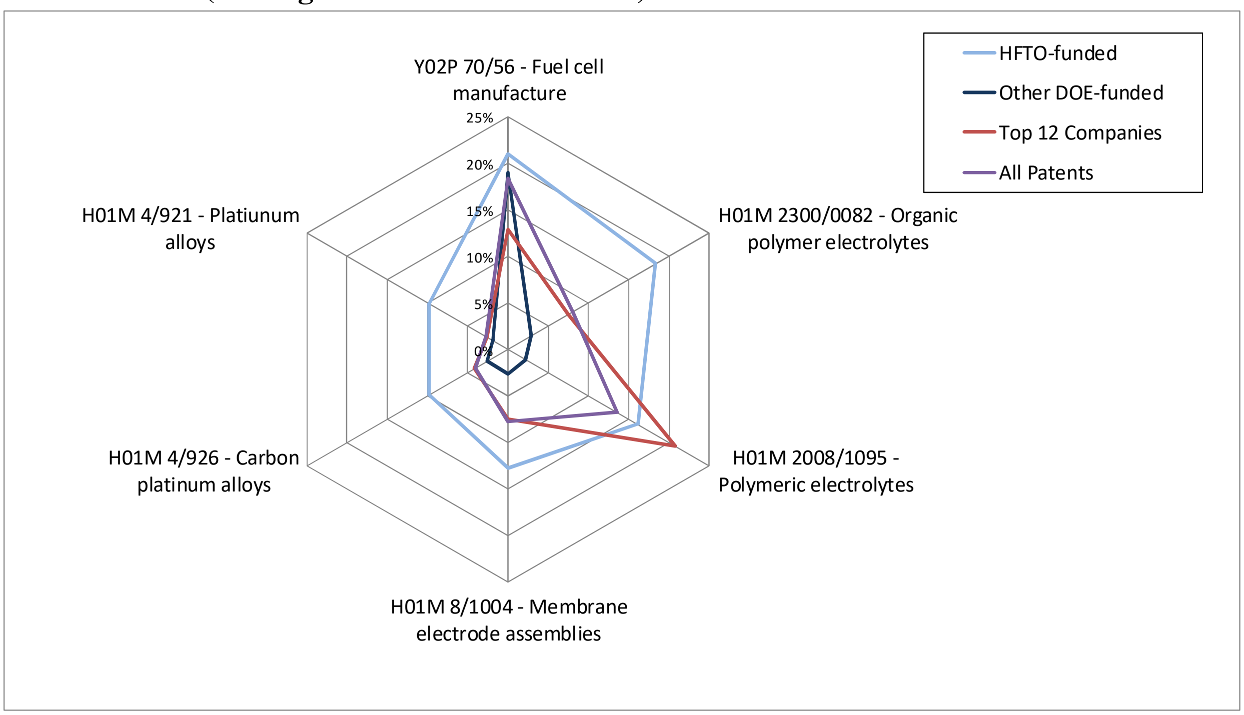


Figure 4-8 shows the leading assignees on Other DOE-funded fuel cell patent families. This figure is headed by Siemens with 115 patent families. Many of these patent families date from the earliest time periods in the analysis, and were originally assigned to Westinghouse Electric Corporation (Siemens acquired the non-nuclear power generation businesses of Westinghouse in 1997). Following Siemens in Figure 4-8 is DOE itself, with 92 Other DOE-funded patent families. Patents may be assigned to DOE for various reasons, including where the inventors are federal employees; where the funding recipient elects not to pursue patent protection for, or take title to, the invention; or where the funding recipient does not have the right to take title to the invention. Figure 4-8 also includes a number of DOE lab managers, notably the University of California (Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory) and Battelle Memorial Institute (Pacific Northwest National Laboratory). It also includes a number of large companies, including Delphi, Engelhard and LG Fuel Cell Systems.

Distribution of Fuel Cell Patents across Patent Classifications

This section examines the distribution of HFTO-funded fuel cell U.S. patents across Cooperative Patent Classifications (CPCs).[9] The distribution is compared to those associated with Other DOE-funded fuel cell patents; fuel cell patents assigned to the twelve leading companies; and the universe of all fuel cell patents. The results from this CPC analysis are shown in two separate charts, each from a different perspective. The first chart (Figure 4-9) is based on the six CPCs that are most prevalent among HFTO-funded fuel cell patents.

Figure 4-9 - Percentage of Fuel Cell U.S. Patents in Most Common Cooperative Patent Classifications (Among HFTO-Funded Patents)



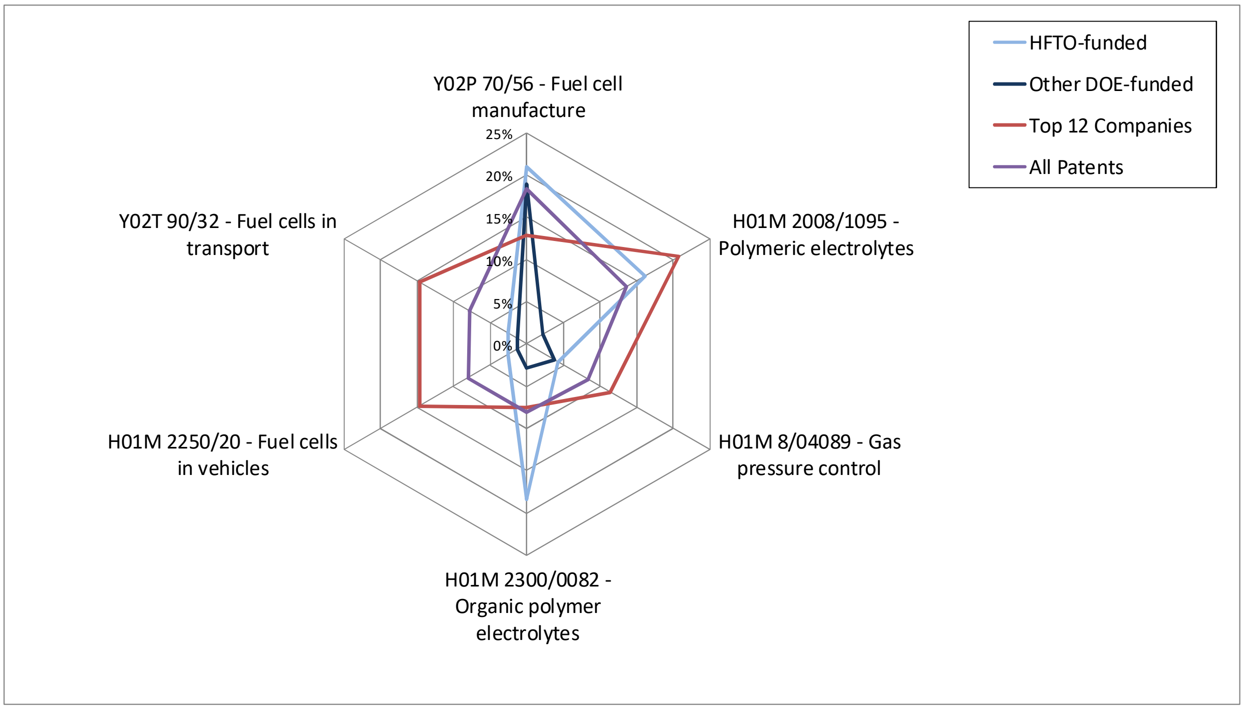
The purpose of Figure 4-9 is to show the main focus areas of HFTO-funded fuel cell research, and the extent to which these areas translate to other portfolios (Other DOE-funded; leading fuel cell companies; all fuel cells). This figure reveals that HFTO-funded research includes relatively balanced coverage across the six CPCs (which is not particularly surprising, since the HFTO-

[9] The CPC is a patent classification system. Patent offices attach numerous CPC classifications to a patent, covering the different aspects of the subject matter in the claimed invention. In generating these charts, all CPCs associated with each patent are included.

funded patent portfolio forms the basis for the CPCs included in the chart). Beyond the generic fuel cell manufacturing CPC (Y02P 70/56), the three most common CPCs among HFTO-funded fuel cell patents are H01M 2300/0082 (Organic polymer electrolytes), H01M 2008/1095 (Polymeric electrolytes) and H01M 8/1004 (Membrane electrode assemblies). The patent portfolios associated with the leading fuel cell companies, and all fuel cell patents combined, also have a strong focus on polymer electrolytes (CPC H01M 2008/1095). However, they are less focused on platinum alloys (CPC H01M 4/921) and carbon platinum alloys (CPC H01M 4/926), areas where HFTO-funded patents have a greater presence.

Figure 4-10 is similar to Figure 4-9, except that it is from the perspective of the most common CPCs among all fuel cell patents. Hence, the purpose of this chart is to show the main research areas within fuel cells as a whole, and how these areas are represented in selected fuel cell portfolios (HFTO-funded; Other DOE-funded; leading fuel cell companies).

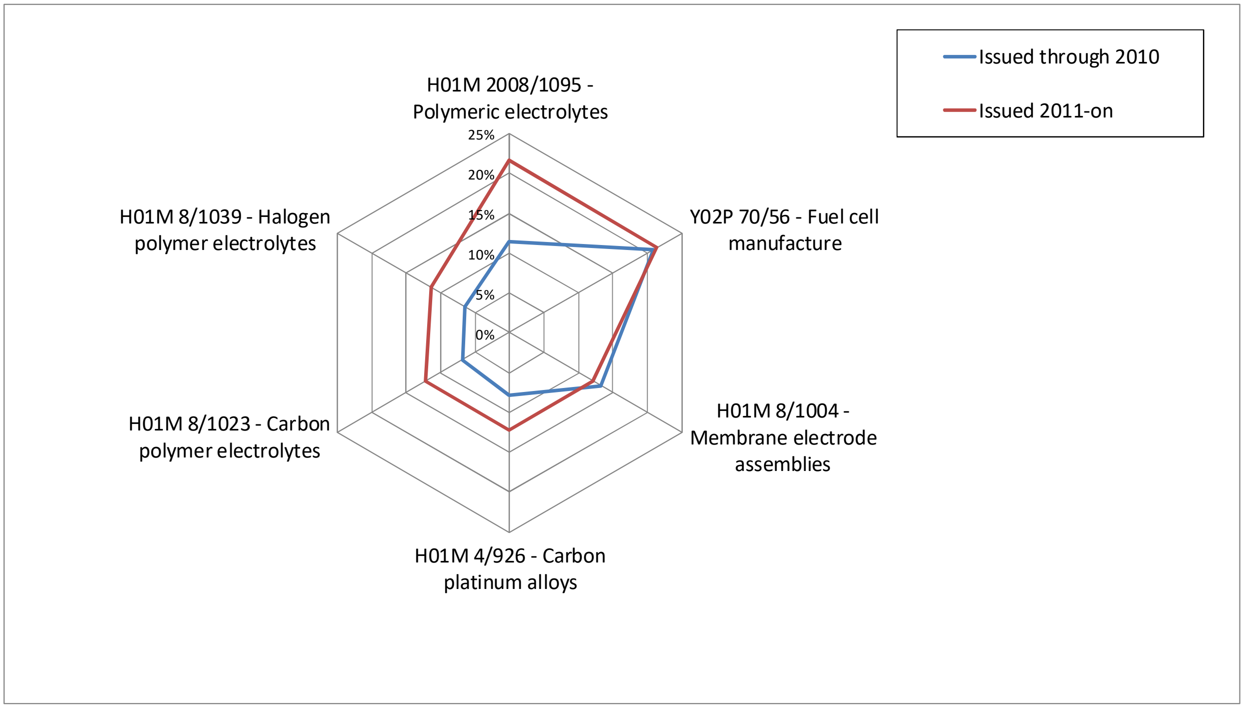
Figure 4-10 - Percentage of Fuel Cell U.S. Patents in Most Common Cooperative Patent Classifications (Among All Fuel Cell Patents)



Three out of the six CPCs in Figure 4-9 also appear in Figure 4-10. The three new CPCs are H01M 8/04089 (Gas pressure control), Y02T 90/32 (Fuel cells in transport), and H01M 2250/20 (Fuel cells in vehicles). It is interesting to note that patents assigned to the leading companies have a strong presence in the latter two CPCs, which relate to the practical application of fuel cells in vehicles. Meanwhile, HFTO-funded and Other DOE-funded patents have less presence in these CPCs, suggesting that they are more concerned with advancements in the various fuel cell elements, rather than their practical application.

Figure 4-11 compares the CPC distribution of HFTO-funded fuel cell U.S. patents across two time periods – patents issued through 2010, and those issued from 2011 onwards. This figure reveals that membrane electrode assemblies (CPC H01M 8/1004) were a common focus across both time periods. Meanwhile, after 2010 there was an increase in the number of patents in CPCs related to various types of polymer electrolytes, suggesting that this was an area of increasing focus for recipients of HFTO fuel cell funding.

Figure 4-11 - Percentage of HFTO-funded Fuel Cell U.S. Patents in Most Common Cooperative Patent Classifications across Two Time Periods



Tracing Backwards from Fuel Cell Patents Owned by Leading Companies

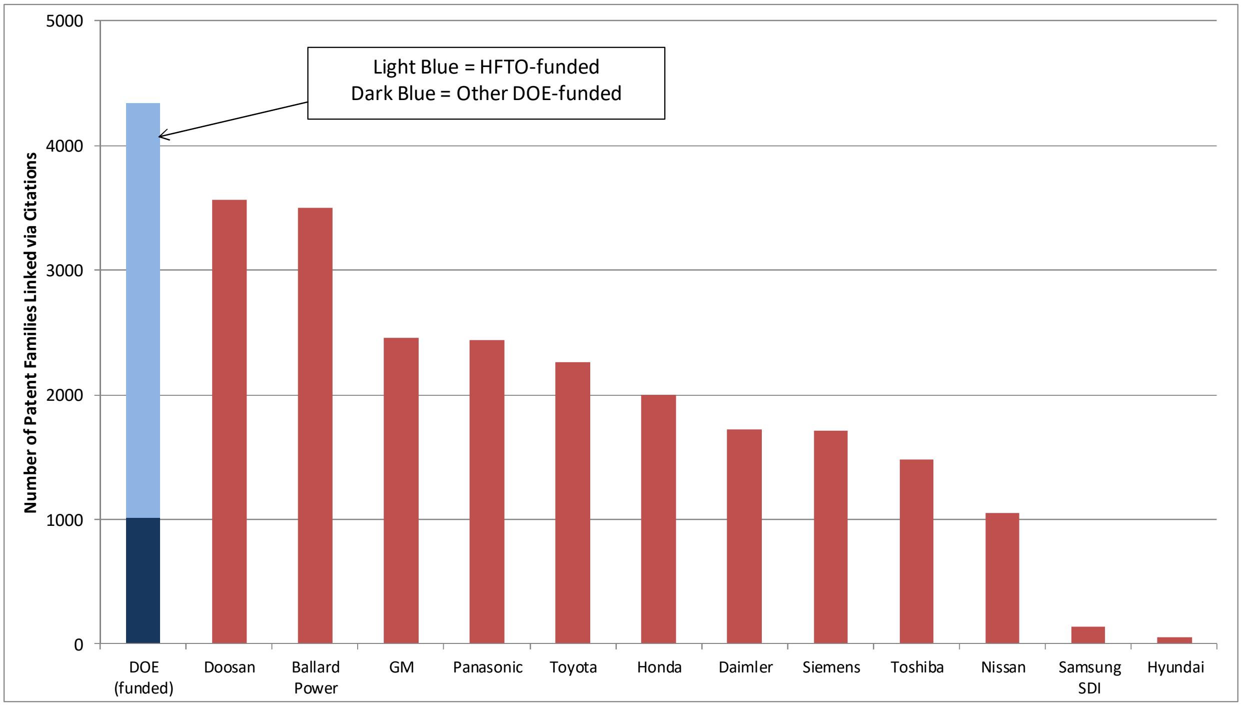
This section reports the results of an analysis tracing backwards from fuel cell patents owned by leading companies in this technology to earlier research, including that funded by HFTO (and by DOE in general). The results in this section are presented at two levels. First, results are reported at the organizational level. These results reveal the extent to which HFTO-funded (and Other DOE-funded) research forms a foundation for subsequent innovations associated with leading fuel cell companies. Second, there is a drill-down to the level of individual patents, with a particular focus on HFTO-funded fuel cell patents. These patent-level results highlight specific HFTO-funded patents that have had a particularly strong influence on subsequent patents owned by leading companies. They also highlight which fuel cell patents owned by these leading companies are linked particularly extensively to earlier HFTO-funded research.

Organizational Level Results

The organizational level results first compare the influence of HFTO-funded and Other DOE-funded fuel cell research against the influence of leading companies in this technology. The results then look at which of these leading companies build particularly extensively on DOE-funded fuel cell research.

Figure 4-12 compares the influence of HFTO-funded and Other DOE-funded fuel cell research to the influence of research carried out by the top twelve fuel cell companies. Specifically, this figure shows the number of fuel cell patent families assigned to the leading companies that are linked via citations to earlier fuel cell families assigned to each of these leading companies (plus families funded by DOE). In other words, this figure shows the companies whose patents have had the strongest influence upon subsequent innovations from leading fuel cell companies.[10]

Figure 4-12 - Number of Leading Company Fuel Cell Patent Families Linked via Citations to Earlier Fuel Cell Patents from each Leading Company



In total, 4,439 leading company fuel cell patent families (i.e., 41% of their 10,824 families) are linked via citations to earlier DOE-funded fuel cell patents. Out of these 4,439 families, 3,322 (i.e., 31% of the 10,824 leading company families) are linked to HFTO-funded fuel cell patents. This puts DOE-funded patents at the head of Figure 4-12. It means that more fuel cell patent families owned by the leading companies are linked via citations to DOE-funded fuel cell patents than are linked to the fuel cell patents assigned to any other leading company. As such, it suggests that DOE-funded research (and particularly HFTO-funded research, which is responsible for many of the citation links) has helped form an important part of the foundation for fuel cell innovations associated with leading companies in this technology.

[10] This figure compares the influence of patents *funded* by HFTO/Other DOE against patents *owned* by (i.e. assigned to) organizations. Such a comparison is reasonable, since patents funded by organizations through their R&D budgets will be assigned to those organizations. Also, organizations cannot choose to reference the patents of a non-competitor (such as DOE) rather than the patents of a competitor in order to reduce the "credit" given to that competitor. Such an omission could lead to the invalidation of their patents. Note that, as in Figure 4-6, there is a small amount of double-counting in Figure 4-12, as around 1% of the patent families assigned to the leading companies were funded by DOE. Also, in Figures 4-12 – 4-15, leading company patent families linked to both HFTO-funded and Other DOE-funded patents are allocated to the HFTO-funded segment of the DOE column, in order to avoid double-counting these families.

Figures 4-13 through 4-15 examine which of the leading companies build particularly extensively on earlier HFTO-funded and Other DOE-funded fuel cell patents. Figure 4-13 shows how many fuel cell patent families assigned to each of the leading companies are linked via citations to at least one earlier DOE-funded fuel cell patent. General Motors is at the head of this figure, with 837 fuel cell patent families linked via citations to earlier DOE-funded patents, 735 of which are linked to HFTO-funded patents. Honda is second in Figure 4-13, with 541 patent families linked to DOE-funded patents (401 linked to HFTO-funded patents), followed by Doosan (527 families linked to DOE; 400 to HFTO), Toyota (504 linked to DOE; 382 to HFTO) and Ballard Power (438 linked to DOE; 344 to HFTO).

Figure 4-13 - Number of Patent Families Assigned to Leading Fuel Cell Companies Linked via Citations to Earlier HFTO/Other DOE-funded Fuel Cell Patents

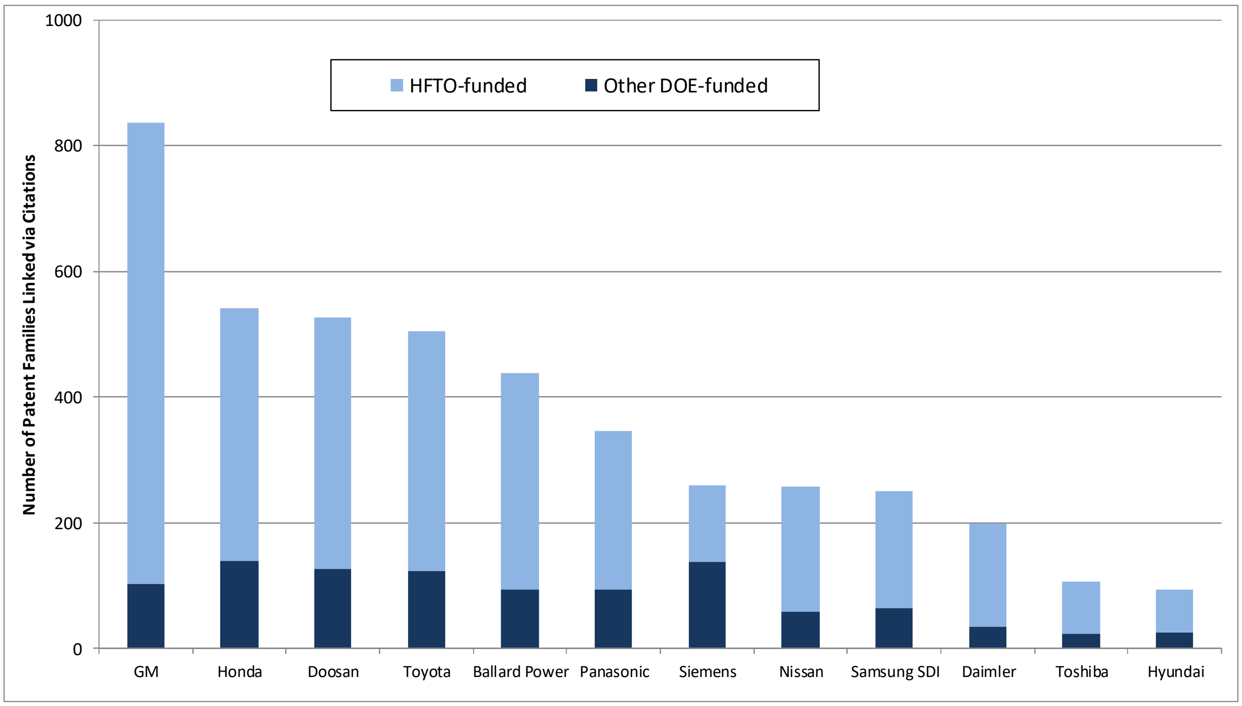


Figure 4-14 counts the total number of citation links from leading companies to earlier DOE-funded patents. This differs slightly from the count of linked families in Figure 4-13, since a single patent family may be linked to multiple earlier DOE-funded patents. General Motors is again at the head of Figure 4-14, with a total of 4944 citation links to DOE-funded patents, 2971 of which are links to HFTO-funded patents. The biggest difference in Figure 4-14 versus Figure 4-13 is the greater prominence of Ballard Power, which has 4,714 citation links to DOE-funded patents, 1,473 of which are links to HFTO-funded patents.

There is an element of portfolio size bias in the patent family counts in Figures 4-13 and 4-14. Companies with larger fuel cell patent portfolios are likely to have more patent families linked to DOE, simply because they have more families overall. Figure 4-15 accounts for this portfolio size bias by calculating the percentage of each leading company's fuel cell patent families that are linked via citations to earlier DOE-funded fuel cell patents, rather than their absolute number. This is a measure of how extensively each company builds on DOE-funded research, relative to their overall patent output.

Figure 4-14 - Total Number of Citation Links from Leading Fuel Cell Company Patent Families to Earlier HFTO/Other DOE-funded Fuel Cell Patents

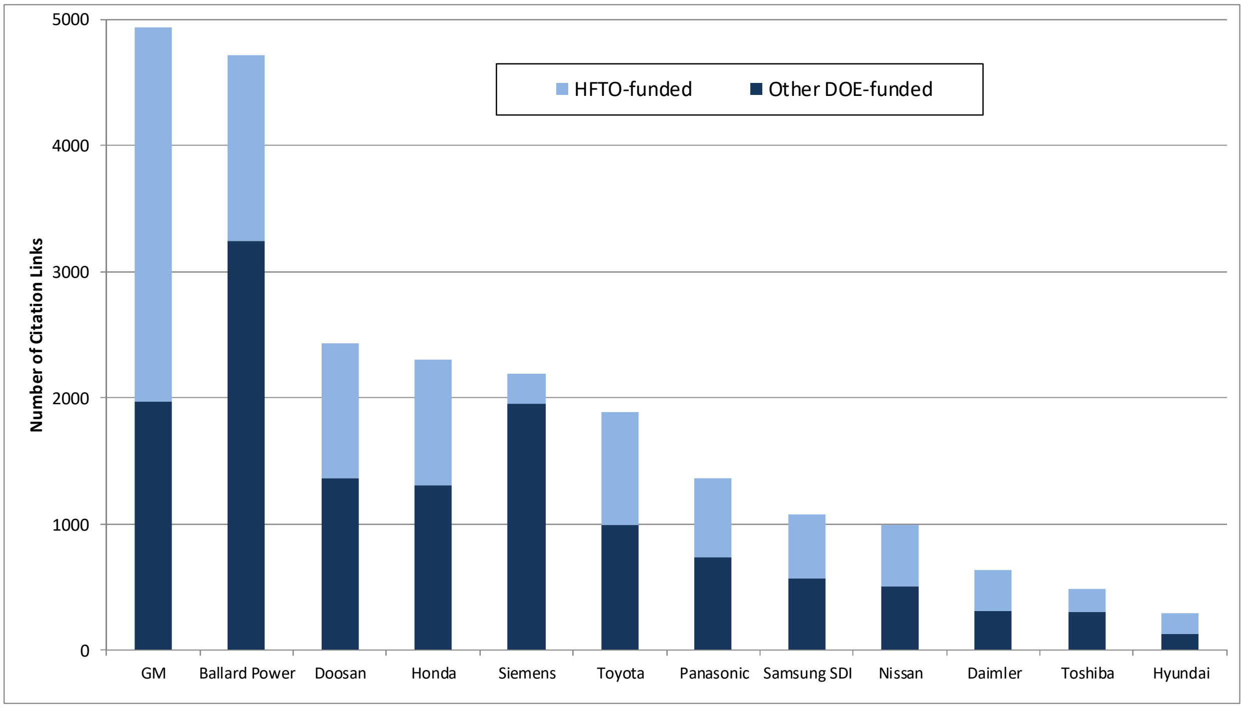


Figure 4-15 - Percentage of Leading Fuel Cell Company Patent Families Linked via Citations to Earlier HFTO/Other DOE-funded Fuel Cell Patents

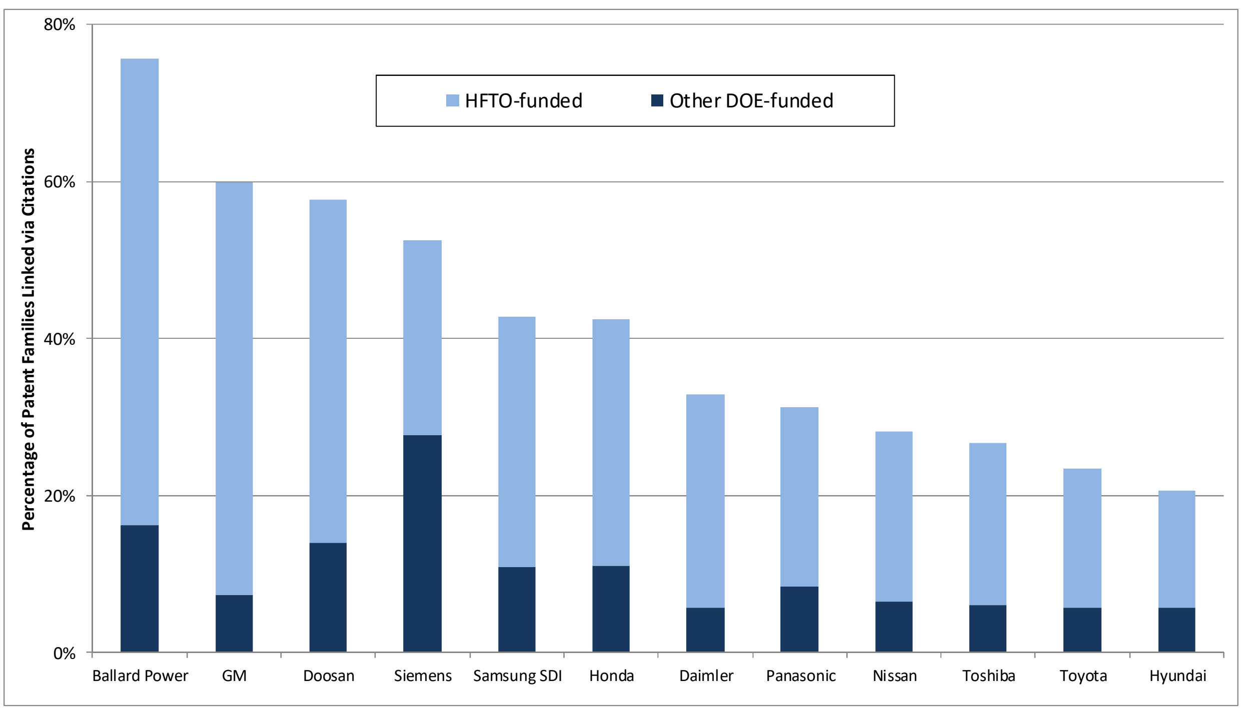


Figure 4-15 reveals that six of the twelve leading companies have more than 40% of their fuel cell patent families linked via citations to earlier DOE-funded fuel cell patents. They are headed by Ballard Power, with over 75% of its patent families linked to DOE patents (59.4% linked to HFTO-funded patents). Ballard is followed by General Motors (60% of families linked via citations to DOE; 52.6% to HFTO), Doosan Holdings (57.7% linked to DOE; 43.8% to HFTO); Siemens (52.5% linked to DOE; 24.8% to HFTO); Samsung SDI (42.7% linked to DOE; 31.8% to HFTO) and Honda (42.5% linked to DOE; 31.5% to HFTO).

Patent Level Results

The previous section of the report examined results at the level of entire patent portfolios. The purpose of this section is to drill down to identify individual DOE-funded fuel cell patent families (in particular HFTO-funded families) that have had an especially strong influence on subsequent fuel cell patents owned by leading companies in this technology. Looking in the opposite direction, it also identifies individual fuel cell patents owned by leading companies that have extensive links to earlier HFTO-funded research.

Table 4-1 shows the HFTO-funded fuel cell patent families linked via citations to the largest number of subsequent patent families owned by leading companies in this technology.

Table 4-1 – HFTO-Funded Fuel Cell Patent Families Linked via Citations to Most Subsequent Leading Company Fuel Cell Patent Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
25339073	5316871	1992	689	General Motors	Membrane-electrode assemblies for electrochemical cells
24823046	5763113	1996	517	General Motors	PEM fuel cell monitoring system
25413131	6013385	1997	427	Emprise Corp	Fuel cell gas management system
25169550	5248566	1991	423	US Dept Energy (ANL)	Fuel cell system for transportation applications
27097172	5234777	1991	408	Univ California (LANL)	Membrane catalyst layer for fuel cells
25097626	5776624	1996	355	General Motors	Brazed bipolar plates for PEM fuel cells
25239061	4650727	1986	349	US Dept Energy (LANL)	Fuel processor for fuel cell power system
23070037	4910099	1988	336	US Dept Energy (LANL)	Preventing CO poisoning in fuel cells
24269885	5641586	1995	270	Univ California (LANL)	Fuel cell with interdigitated porous flow-field
25527356	6077620	1997	260	General Motors	Fuel cell system with combustor-heated reformer

The patent family at the head of this table (whose representative patent[11] is US #5,316,871) was filed in 1992 and is assigned to General Motors. It describes membrane-electrode assemblies for electromechanical cells, particularly fuel cells. This family is linked via citations to 689 patent families assigned to the leading companies, including multiple families from each of these twelve companies. The second-place patent family in Table 4-1 (representative patent US #8,987,162) is also assigned to General Motors. This patent family was filed in 1996, and describes a method for monitoring the performance of a fuel cell, and alerting the operator if the

[11] The representative patent is a single patent from a family, but it is not necessarily the priority filing.

performance has degraded. It is linked to 517 patent families owned by the leading companies, including multiple families from each of these companies. Table 4-1 also includes patent families assigned to Emprise for controlling gas flow circuits in fuel cells (representative patent US #6,013,385), DOE for a vehicle propulsion system using fuel cells (representative patent US #5,248,566), and the University of California (through its management of LANL) describing catalysts for solid polymer electrolyte fuel cells (representative patent US #5,234,777).

Table 4-1 lists HFTO-funded patents linked to the most subsequent fuel cell patent families owned by leading companies. Table 4-2 looks in the opposite direction, and lists fuel cell patent families owned by leading companies that are linked via citations to multiple HFTO families.

Table 4-2 - Leading Company Fuel Cell Patent Families Linked via Citations to Largest Number of HFTO-Funded Fuel Cell Patent Families

Patent Family #	Representative Patent #	Priority Year	# HFTO Fams	Assignee	Title
34826639	8486575	2004	24	General Motors	Passive hydrogen vent for a fuel cell
38336232	7955750	2006	20	General Motors	Controlled electrode overlap architecture for improved MEA durability
38885151	7569299	2006	20	General Motors	Multi-component fuel cell gasket for low temperature sealing and minimal membrane contamination
40577300	8168340	2007	20	General Motors	Water removal features for PEMfc stack manifolds
38922322	7749632	2006	20	General Motors	Flow shifting coolant during freeze start-up to promote stack durability and fast start-up
24509866	6979507	2002	18	Ballard Power	Fuel cell system controller
33416341	7632583	2003	18	Ballard Power	Apparatus for improving the performance of a fuel cell electric power system
29424526	7341800	2003	17	Honda	Fuel cell
27800686	7655335	2002	15	Samsung SDI	Air breathing direct methanol fuel cell pack

Table 4-2 is headed by a series of General Motors patent families related to various different fuel cell technologies, including hydrogen vents, electrode architectures, fuel cell gaskets and auxiliary cooling systems for improved start-up. These General Motors patent families are each linked via citations to at least twenty HFTO-funded fuel cell patent families, including families assigned to Emprise, the University of California, Plug Power and General Motors itself. Table 4-2 also includes patent families assigned to Ballard Power, Honda and Samsung SDI, each of which is linked via citations to at least fifteen HFTO-funded fuel cell patent families.

High-impact fuel cell patents owned by leading companies that have citation links back to HFTO-funded patents were also identified.[12] The idea is to highlight important technologies

[12] High-impact patents are identified using 1790's Citation Index metric. This metric is derived by first counting the number of times a patent is cited as prior art by subsequent patents. This number is then divided by the mean number of citations received by peer patents from the same issue year and technology (as defined by their first listed Cooperative Patent Classification). For example, the number of citations received by a 2010 patent in CPC Y02P 70/56 (Fuel Cell Manufacturing) is divided by the mean number of citations received by all patents in that CPC issued in 2010. The expected Citation Index for an individual patent is one. The extent to which a patent's Citation

owned by leading companies that are linked to earlier fuel cell research funded by HFTO. Table 4-3 lists leading company patents that are linked via citations to earlier HFTO-funded patents, and in turn have been cited as prior art by at least 100 subsequent patents, resulting in a Citation Index value above three (i.e., they have each been cited at least three times as many times as expected given their age and technology).

Table 4-3 - Highly Cited Leading Company Fuel Cell Patents Linked to Earlier HFTO-funded Fuel Cell Patents

US Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
5360679	1994	160	5.02	Ballard Power	Hydrocarbon fueled solid polymer fuel cell electric power generation system
6242120	2001	108	4.96	Ballard Power	System and method for optimizing fuel cell purge cycles
6165633	2000	141	4.57	Toyota	Method of and apparatus for reforming fuel and fuel cell system with fuel-reforming apparatus incorporated therein
5366821	1994	134	4.35	Ballard Power	Constant voltage fuel cell with improved reactant supply and control system
5641031	1997	111	4.17	Daimler	Arrangement of a drive unit in an electric vehicle
5677073	1997	116	4.04	Toyota	Fuel cell generator and method of the same
5252410	1993	120	4.00	Ballard Power	Lightweight fuel cell membrane electrode assembly with integral reactant flow passages
5503944	1996	119	3.98	Doosan Holding	Water management system for solid polymer electrolyte fuel cell power plants
6083637	2000	120	3.89	Daimler	Fuel cell energy generating system
6024848	2000	117	3.80	Doosan Holding	Electrochemical cell with a porous support plate

Ballard Power features prominently in Table 4-3, and is responsible for four of the seven patents at the head of the table. This includes the most highly-cited patent (US #5,360,679), which has been cited as prior art by 160 subsequent patents, more than five times as many citations as expected given its age and technology. This patent describes fuel cells for generating utility-grade electrical power. Ballard also has highly-cited patents in Table 4-3 for fuel cell optimization (US #6,242,120), voltage control (US #5,366,821) and membrane electrode assemblies (US #5,252,410). In addition to the Ballard patents, there are also highly-cited patents in Table 4-3 assigned to Toyota for a fuel cell with fuel-reforming capability (US #6,165,633) and Daimler for an electric vehicle drive train incorporating a fuel cell (US #5,641,031).

While the patent-level results focus on HFTO-funded fuel cell patent families, it is also interesting to note the Other DOE-funded fuel cell families linked to the largest number of

Index is greater or less than one reveals whether it has been cited more or less frequently than expected, and by how much. For example, a Citation Index of 1.5 shows that a patent has been cited 50% more frequently than expected. Meanwhile a Citation Index of 0.7 reveals that a patent has been cited 30% less frequently than expected. By extension, the expected Citation Index for a portfolio of patents is also one, with values above one showing that a portfolio has been cited more than expected, and values below one showing that a portfolio has not been cited as frequently as expected. Note that the Citation Index is calculated for U.S. patents only, since citation rates differ across patent systems.

subsequent patent families owned by leading companies in this technology. These Other DOE-funded families are listed in Table 4-4.

Table 4-4 - Other DOE-Funded Fuel Cell Patent Families Linked via Citations to Most Subsequent Leading Company Fuel Cell Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
26679927	4876115	1987	505	US Dept Energy (LANL)	Electrode assembly for use in a solid polymer electrolyte fuel cell
23805334	4973530	1989	398	US Dept Energy (LANL)	Fuel cell water transport
24989880	4670359	1985	358	Engelhard Corp	Fuel cell integrated with steam reformer
22325969	4804592	1987	331	US Dept Energy (LANL)	Composite electrode for use in electrochemical cells
27028607	4522894	1982	272	Engelhard Corp	Fuel cell electric power production
22222210	4781241	1987	271	Int'l Fuel Cells Corp	Heat exchanger for fuel cell power plant reformer
23822352	5045414	1989	241	Int'l Fuel Cells Corp	Reactant gas composition for fuel cell potential control
23451175	5554453	1995	237	Energy Research Corp	Carbonate fuel cell system with thermally integrated gasification
22506996	4324844	1980	220	Westinghouse Electric Corp	Variable area fuel cell cooling
24158653	4476198	1983	217	US Dept Energy (ANL)	Solid oxide fuel cell having monolithic core

The patent family at the head of Table 4-4 (representative patent US #4,876,115) is assigned to DOE (based on LANL research) and describes a fuel cell electrode assembly. It is linked to 505 patent families assigned to the leading companies, including multiple families from each company. The patent family in second place in Table 4-4 (representative patent US #4,973,530) is also assigned to DOE (LANL). It describes a method for gas regulation in fuel cells, and is linked via citations to 398 leading company patent families, again including multiple families from each company. Table 4-4 also includes patent families assigned to Engelhard describing fuel cells with steam reformers (representative patents US #4,670,359 and US #4,522,894) and families assigned to International Fuel Cells outlining heat exchangers for fuel cells (e.g., representative patent #4,781,241).

Overall, the backward tracing element of the analysis suggests that HFTO-funded and Other DOE-funded fuel cell patents have had a strong influence on subsequent innovations associated with the leading fuel cell companies. This influence can be seen both over time, and across these leading companies, with a number of DOE-funded patent families linked via citations to subsequent patents assigned to many of the leading companies.

Tracing Forwards from DOE-funded Fuel Cell Patents

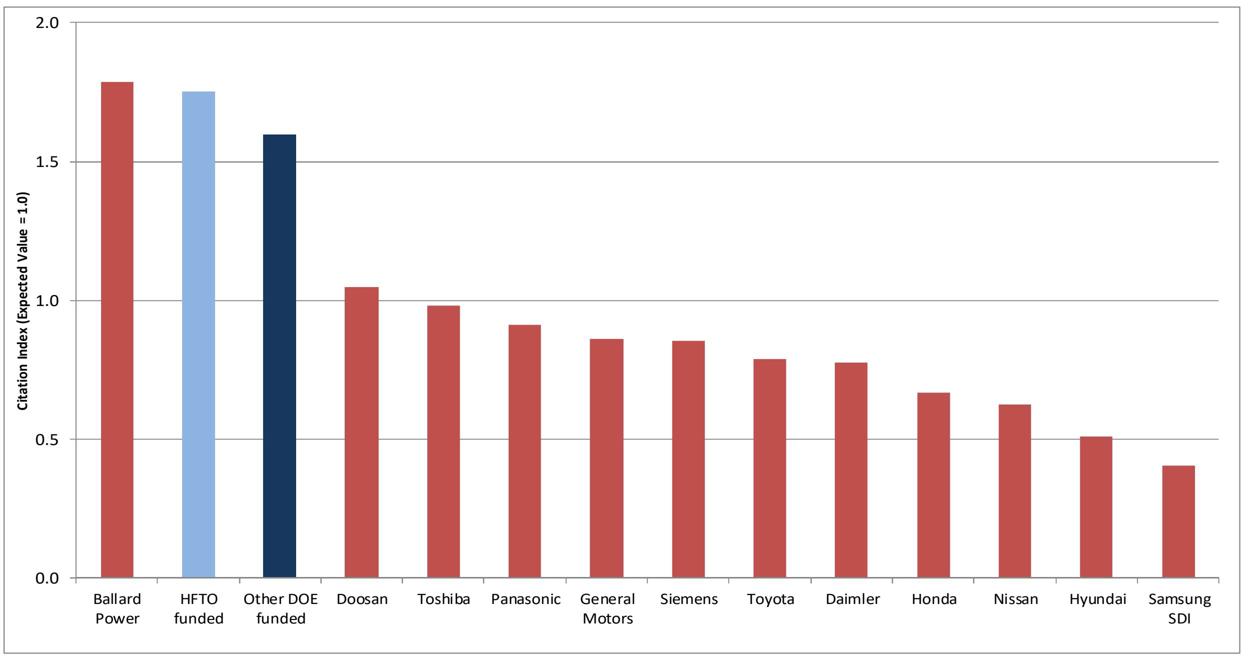
The previous section of the report examines the influence of DOE-funded fuel cell research upon technological developments associated with leading fuel cell companies. That analysis was based on tracing backwards in time from the patents of leading companies to previous generations of research. This section reports the results of an analysis tracing in the opposite direction – starting with HFTO-funded (and Other DOE-funded) fuel cell patents, and tracing forwards in time through two generations of citations. Hence, while the previous section of the report focuses on

DOE's influence upon a specific patent set (i.e., patents owned by leading fuel cell companies), this section of the report focuses on the broader influence of HFTO-funded (and Other DOE-funded) fuel cell research, both within and beyond the fuel cell industry. Also, in order to avoid repeating earlier results, the forward tracing concentrates primarily on patents that are linked to DOE-funded fuel cell research, but are not owned by leading fuel cell companies.

Organizational Level Results

As a starting point for the forward tracing analysis, Figure 4-16 shows Citation Index values for the portfolios of HFTO-funded and Other DOE-funded fuel cell patents, compared to the Citation Indexes of the twelve leading fuel cell companies. These Citation Indexes are based on citations from all subsequent patents (unlike the backward tracing, which only included citations from patents owned by the leading fuel cell companies).

Figure 4-16 - Citation Index for Leading Companies' Fuel Cell Patents, plus HFTO-funded and Other DOE-funded Fuel Cell Patents



This figure reveals that HFTO-funded fuel cell patents have an average Citation Index of 1.75, showing they have been cited 75% more frequently than expected by subsequent patents. This puts HFTO-funded patents in second place in Figure 4-16, behind only Ballard Power. The Citation Index for Other DOE-funded fuel cell patents is slightly lower at 1.60, but this still means that these patents have been cited 60% more frequently than expected. These are impressive results, especially given that, out of the twelve leading companies, only two (Ballard and Doosan Holdings) have a Citation Index above one.

The Citation Index metric measures the overall influence of the DOE-funded fuel cell patent portfolios, but does not necessarily address the breadth of this influence across technologies. The Cooperative Patent Classifications (CPCs) of the patent families linked via citations to earlier

HFTO-funded (and Other DOE-funded) fuel cell patent families were therefore identified.[13] These CPCs reflect the influence of DOE-funded research across technologies.

Figure 4-17 shows the CPCs with the largest number of patent families linked to HFTO-funded fuel cell patents. The CPCs in this figure are shown in two different colors – i.e., dark green for CPCs related to fuel cell technology and light green for CPCs beyond fuel cells. All but two of the CPCs in Figure 4-17 are in technologies related to fuel cells, with the most common CPCs being Y02P 70/56 (Fuel cell manufacturing) and H01M 2008/1095 (Polymer electrolytes). The two CPCs beyond fuel cell technology are B82Y 30/00 (Nanocomposites) and C01B 2203/066 (Synthesis gas production). These are examples of HFTO-funded fuel cell patents influencing developments in adjacent technologies.

Figure 4-17 - Number of Patent Families Linked via Citations to Earlier HFTO-Funded Fuel Cell Patents by CPC (Dark Green = Fuel Cell-related; Light Green = Other)

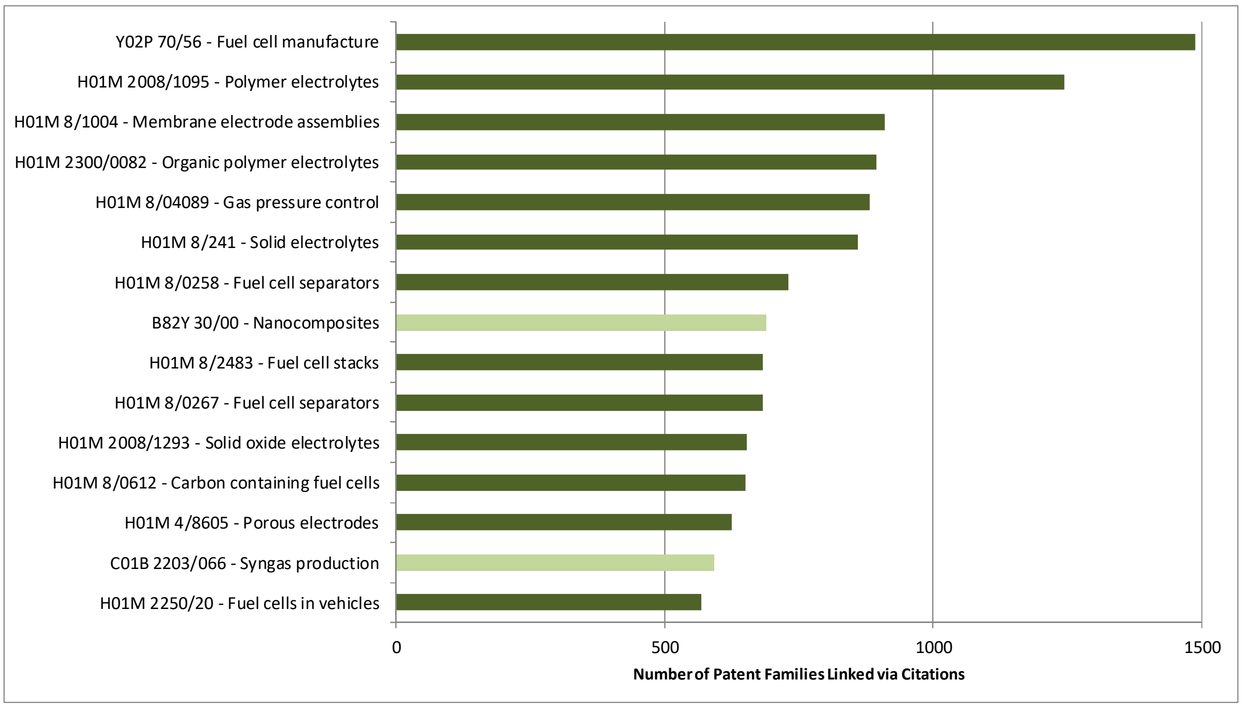


Figure 4-18 is similar to Figure 4-17, but is based on patent families linked to Other DOE-funded fuel cell patents. The CPCs in this figure again concentrate on technologies related to fuel cells, with similar CPCs at the head of the figure as those in Figure 4-17. There are four CPCs in Figure 4-18 from beyond fuel cell technology. These CPCs are H01M 10/0525 (Lithium-ion batteries), C01B 2203/0233 (Steam reforming), C01B 2203/066 (Synthesis gas production) and B82Y 30/00 (Nanocomposites). Again, these are examples of Other DOE-funded fuel cell research influencing developments in adjacent technologies.

[13] Patents typically have numerous CPCs attached to them, reflecting different aspects of the invention they describe. In this analysis, all CPCs attached to the patents linked to earlier DOE-funded patent families are included.

Figure 4-18 - Number of Patent Families Linked via Citations to Earlier Other DOE-Funded Fuel Cell Patents by CPC (Dark Green = Fuel Cell-related; Light Green = Other)

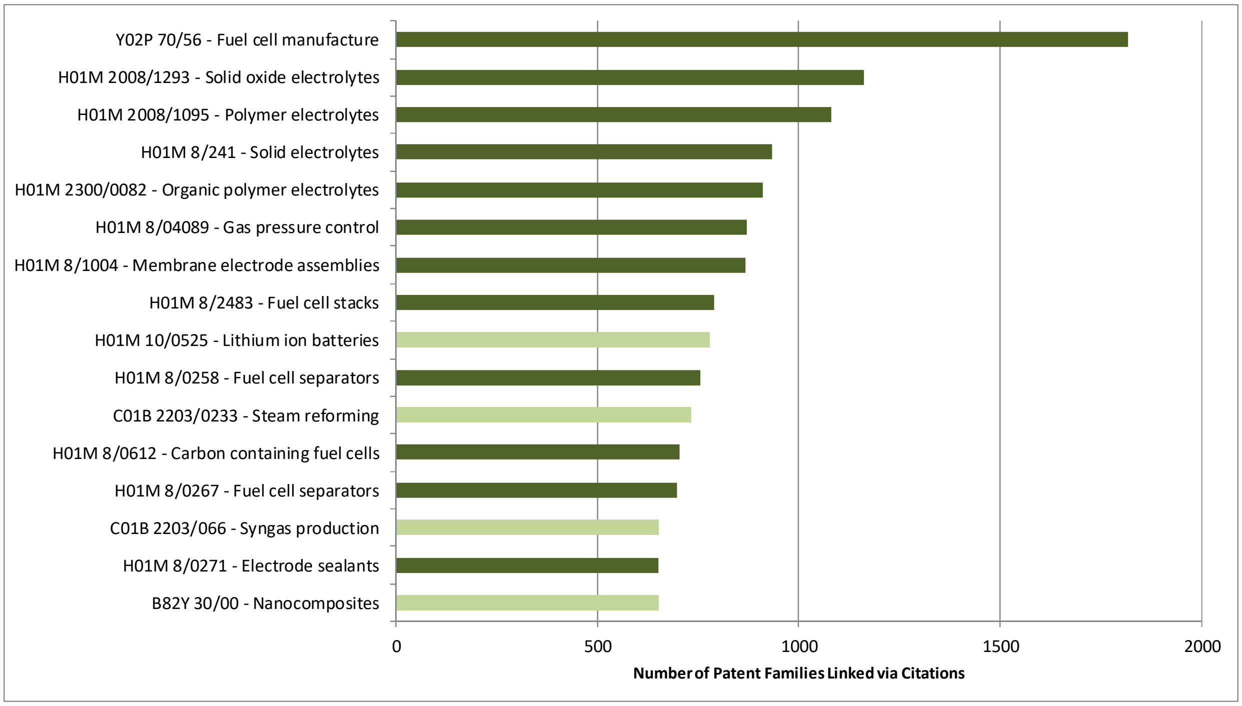
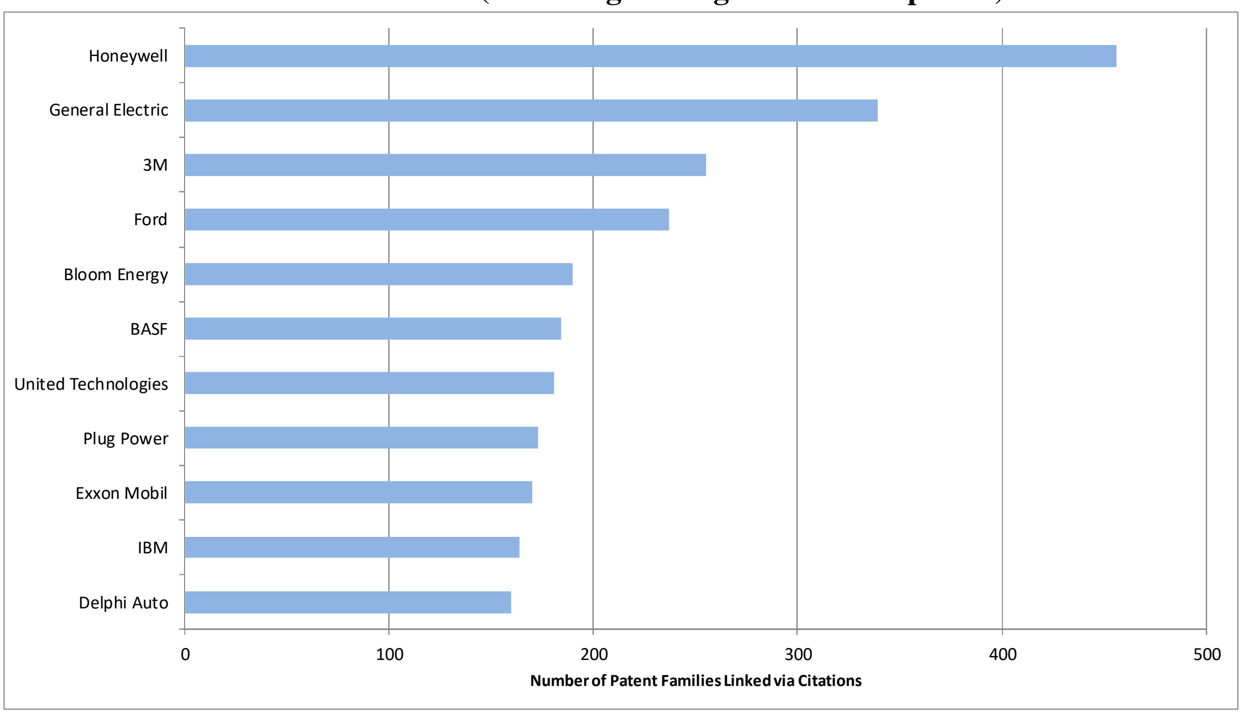


Figure 4-19 - Organizations with Largest Number of Patent Families Linked via Citations to HFTO-funded Fuel Cell Patents (excluding leading fuel cell companies)

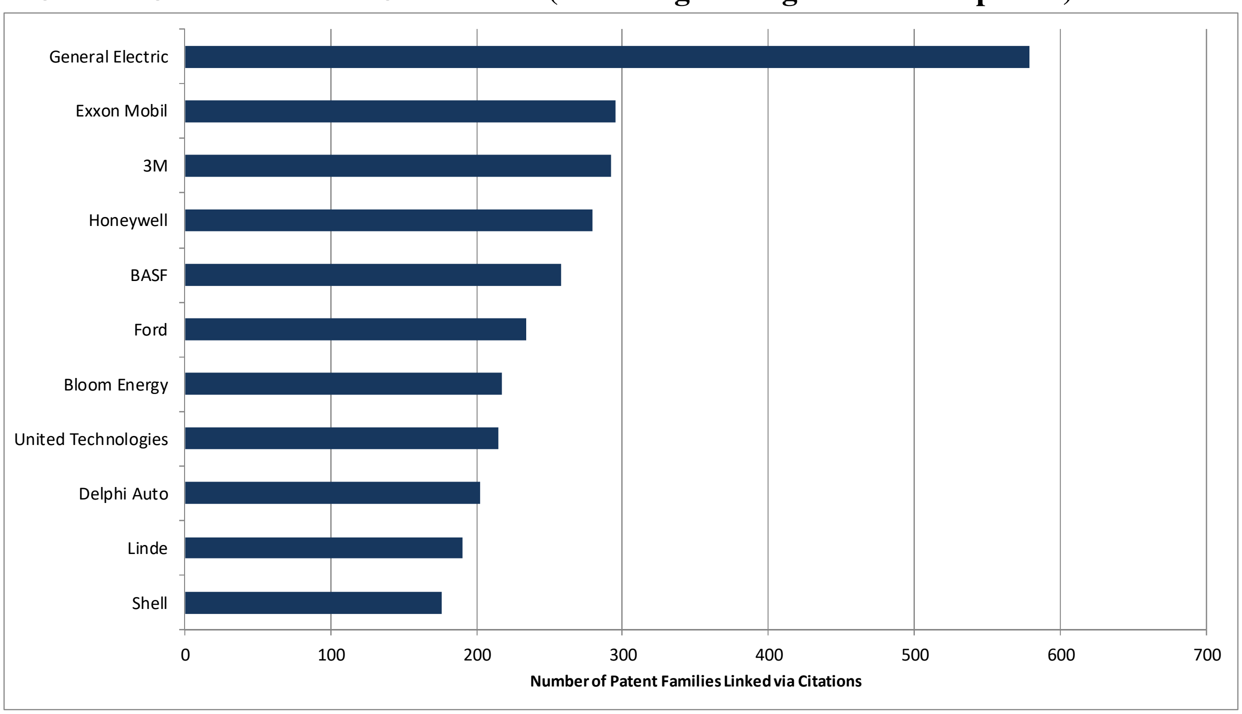


The organizations with the largest number of patent families linked via citations to earlier HFTO-funded fuel cell patents are shown in Figure 4-19. To avoid repeating the results from earlier, this figure excludes the twelve leading fuel cell companies used in the backward tracing element of the analysis. Also, note that Figure 4-19 includes all patent families assigned to each organization, not just their patent families describing fuel cell technology.

Figure 4-19 contains various very large companies with interests in many technologies. Honeywell is at the head of this figure, with 456 patent families linked via citations to earlier HFTO-funded fuel cell patents. These Honeywell patent families describe a range of technologies, including fuel cells, hydrogen production, and gas sensors. General Electric is in second place in Figure 4-19 with 339 patent families linked via citations to earlier HFTO-funded fuel cell patents. These General Electric patent families describe technologies such as fuel cells, engine control and catalyst manufacturing. The remaining companies in Figure 4-19 include specialist fuel cell companies (Bloom Energy, Plug Power), automotive companies (Ford, Delphi), and general technology companies (3M, BASF).

Figure 4-20 shows the organizations with the largest number of patent families linked via citations to earlier Other DOE-funded fuel cell patents. This figure contains a similar list of companies to those featured in Figure 4-19, which focused on patent families linked to earlier HFTO-funded fuel cell patents. These companies include General Electric, Exxon Mobil, 3M and Honeywell. Indeed, General Electric is at the head of Figure 4-20 by a wide margin, with 579 patent families linked via citations to earlier Other DOE-funded fuel cell patents. These General Electric patent families describe various technologies, including fuel cells, batteries, engine control and advanced materials.

Figure 4-20 - Organizations with Largest Number of Patent Families Linked via Citations to Other DOE-funded Fuel Cell Patents (excluding leading fuel cell companies)



Patent Level Results

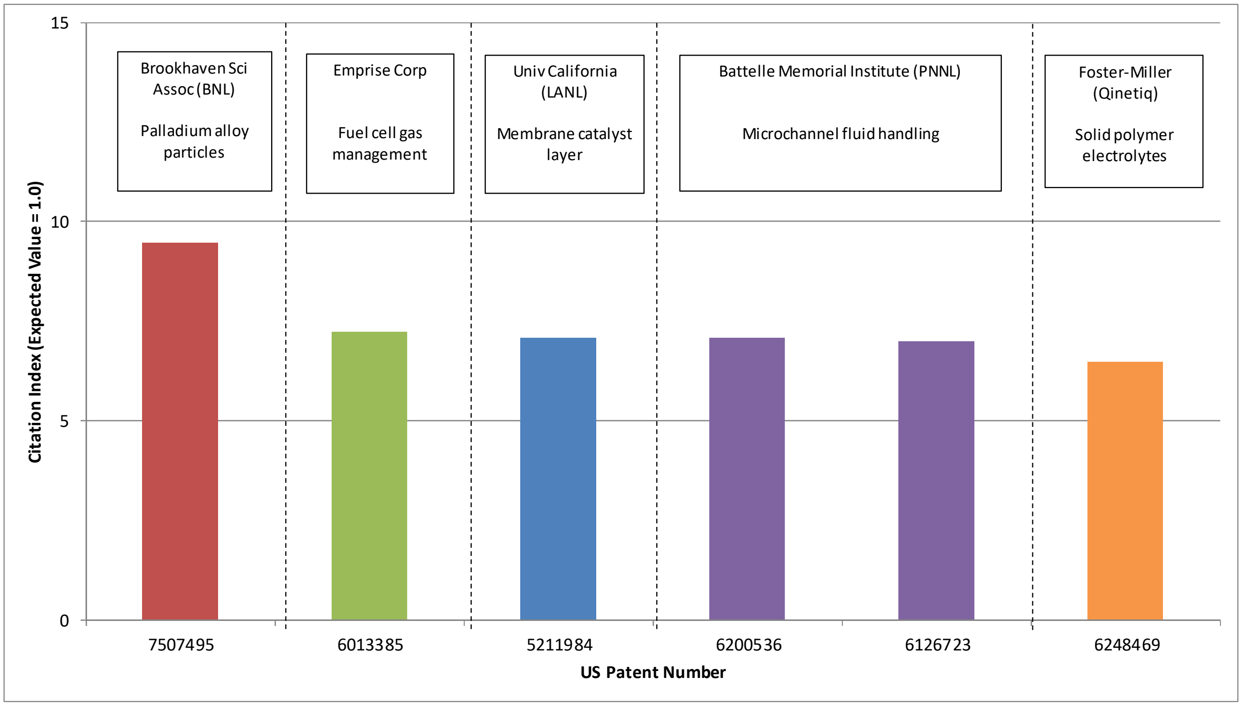
This section of the report drills down to identify individual DOE-funded (and particularly HFTO-funded) fuel cell patents whose influence on subsequent technological developments has been particularly strong. It also highlights patents that have extensive citation links to earlier HFTO-funded fuel cell research.

The simplest way of identifying high-impact HFTO-funded fuel cell patents is via overall Citation Indexes. The HFTO-funded patents with the highest Citation Index values are shown in Table 4-5, with selected patents also presented in Figure 4-21. The patent at the head of this table is assigned to Brookhaven Science Associates, through its management of Brookhaven National Laboratory. It describes palladium alloy particles that can be used as electrocatalysts in fuel cells. Since being granted in 2009, this patent has been cited as prior art by 50 subsequent patents, almost ten times as many citations as expected given its age and technology. The patent in second place in Table 4-5 is assigned to Emprise and describes controlling gas flow circuits in fuel cells. It has been cited by 223 subsequent patents, over seven times as many citations as expected. Also, note that the family containing this patent was highlighted earlier in the backward tracing element of the analysis, given its extensive citation links to patents assigned to the leading fuel cell companies. Table 4-5 also contains highly-cited patents from Los Alamos and Pacific Northwest National Laboratories, plus Foster-Miller (now owned by Qinetiq), General Motors and Honeywell.

Table 4-5 – List of Highly Cited HFTO-Funded Fuel Cell Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
7507495	2009	50	9.46	Brookhaven Sci Assoc (BNL)	Hydrogen absorption induced metal deposition on palladium and palladium-alloy particles
6013385	2000	223	7.23	Emprise Corp	Fuel cell gas management system
5211984	1993	145	7.08	Univ California (LANL)	Membrane catalyst layer for fuel cells
6200536	2001	161	7.07	Battelle Memorial Inst (PNNL)	Active microchannel heat exchanger
6126723	2000	166	6.99	Battelle Memorial Inst (PNNL)	Microcomponent assembly for efficient contacting of fluid
6248469	2001	146	6.46	Foster-Miller (Qinetiq)	Composite solid polymer electrolyte membranes
6077620	2000	164	6.33	General Motors	Fuel cell system with combustor-heated reformer
5763113	1998	165	5.28	General Motors	PEM fuel cell monitoring system
6607854	2003	78	5.22	Honeywell	Three-wheel air turbocompressor for PEM fuel cell systems

Figure 4-21 – Examples of Highly-Cited HFTO-funded Fuel Cell Patents



The Citation Indexes in Table 4-5 are based on a single generation of citations to HFTO-funded fuel cell patents. Tables 4-6 and 4-7 extend this by examining a second generation of citations – i.e., they show the HFTO-funded fuel cell patent families linked via citations to the largest number of subsequent patent families.[14] These subsequent families are divided into two groups, according to whether they are within or beyond fuel cell technology. This provides insights into which HFTO-funded patent families have been particularly influential within fuel cell technology, and which have had a broader impact beyond fuel cells.

Table 4-6 contains older HFTO-funded fuel cell patent families (i.e., with priority dates prior to 2000) linked via citations to the largest number of subsequent patent families. This table is headed by a patent family assigned to General Motors (representative patent US #5,316,871) describing membrane electrode assemblies. This patent family, which was highlighted earlier in the backward tracing element of the analysis, is linked to 2,578 subsequent patent families, 2,088 of which are related to fuel cells. It is one of a number of patent families in Table 4-6 that have extensive citation links to subsequent fuel cell patents. There are also patent families in the table that are linked primarily to non-fuel cell patents. These include a DOE patent family (representative patent US #5,208,154) describing a method for attaching biological particles to electrodes and a Battelle Memorial Institute (PNNL) patent family (representative patent US #6,129,973) outlining a mass exchanger. These patent families are each linked via citations to over 1,000 subsequent patent families, only a small percentage of which are related to fuel cells. This suggests that much of their influence has been beyond fuel cell technology.

[14] The HFTO-funded patent families are divided into two tables based on their age, since older patents tend to be connected to larger numbers of subsequent patents, simply because there has been more time for them to become linked to future generations of technology.

Table 4-6 – Pre-2000 HFTO-funded Fuel Cell Patent Families Linked via Citations to Largest Number of Subsequent Fuel Cell/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Fuel Cell Fams	Assignee	Title
25339073	1992	5316871	2578	2088	General Motors	Membrane-electrode assemblies for electrochemical cells
25169550	1991	5248566	2278	1248	US Dept Energy	Fuel cell system for transportation applications
27097172	1991	5234777	1995	1621	Univ California (LANL)	Membrane catalyst layer for fuel cells
24734680	1991	5208154	1765	29	US Dept Energy	Reversibly immobilized biological materials in monolayer films on electrodes
25413131	1997	6013385	1584	1129	Emprise Corp	Fuel cell gas management system
27417961	1991	5211984	1582	1324	Univ California (LANL)	Membrane catalyst layer for fuel cells
25527356	1997	6077620	1552	794	General Motors	Fuel cell system with combustor-heated reformer
24823046	1996	5763113	1500	1121	General Motors	PEM fuel cell monitoring system
25239061	1986	4650727	1217	981	US Dept Energy	Fuel processor for fuel cell power system
25471141	1997	6129973	1208	76	Battelle Memorial Inst (PNNL)	Microchannel laminated mass exchanger and method of making
23070037	1988	4910099	1190	935	US Dept Energy	Preventing CO poisoning in fuel cells

Table 4-7 contains newer HFTO-funded patent families, with priority dates from 2000 onwards. That said, most of these families are still relatively old, dating from the very start of this century. Two patent families stand out in this table in terms of their number of citation links to subsequent patent families. The first is a Honeywell patent family (representative patent US #6,607,854) describing a fuel cell system with a compressor to improve efficiency. This Honeywell patent family is linked via citations to 517 subsequent patent families, 115 of which are related to fuel cells. The second is a PNNL patent family (representative patent US #6,969,506) describing an integrated reactor for conducting exothermic and endothermic reactions simultaneously. It is linked to 511 subsequent patent families, only 46 of which are related to fuel cells, suggesting most of its influence has been in other technologies. Table 4-7 also contains patent families with more extensive citation links within fuel cell technology, notably General Motors patent families describing fuel cell combustors and shut-down operations.

Table 4-7 – Post-1999 HFTO-funded Fuel Cell Patent Families Linked via Citations to Largest Number of Subsequent Fuel Cell/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Fuel Cell Fams	Assignee	Title
24862893	2000	6607854	517	115	Honeywell	Three-wheel air turbocompressor for PEM fuel cell systems
26758565	2001	6969506	511	46	Battelle Memorial Inst (PNNL)	Methods of conducting simultaneous exothermic and endothermic reactions
24277344	2000	6572997	210	70	Hybrid Power Gen Systems	Nanocomposite for fuel cell bipolar plate
23982918	2000	6451465	205	124	General Motors	Method for operating a combustor in a fuel cell system
25208987	2001	6670301	132	72	Brookhaven Sci Assoc (BNL)	Carbon monoxide tolerant electrocatalyst with low platinum loading
46205187	2003	7351444	119	32	Intematix Corp	Low platinum fuel cell catalysts and method for preparing the same
26903130	2000	6921595	108	68	Nuvera Fuel Cells Inc	Joint-cycle high-efficiency fuel cell system with power generating turbine
23999777	2000	6376112	100	97	General Motors	Controlled shutdown of a fuel cell
36596779	2004	7691780	84	31	Brookhaven Sci Assoc (BNL)	Platinum- and platinum alloy-coated palladium and palladium alloy particles

The tables above identify HFTO-funded patent families linked particularly strongly to subsequent technological developments. Table 4-8 looks in the opposite direction, and identifies highly-cited patents linked to earlier HFTO-funded fuel cell patents.

Table 4-8 - Highly Cited Patents (not from leading Fuel Cell Companies) Linked via Citations to Earlier HFTO-funded Fuel Cell Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
5861137	1999	508	24.39	Idatech LLC	Steam reformer with internal hydrogen purification
7674536	2010	82	22.07	Nokia Corp	Fuel supply device and fuel supply system
7939218	2011	90	20.19	Nanosys Inc	Nanowire structures comprising carbon
8450012	2013	46	18.61	Amprius Inc	Interconnected hollow nanostructures containing high capacity active materials for use in rechargeable batteries
6863942	2005	235	18.08	State Univ New York	Free-standing and aligned carbon nanotubes and synthesis thereof
8722226	2014	34	16.43	24M Tech Inc	High energy density redox flow device
7368191	2008	92	16.05	Biosource Inc	Electrode array for use in electrochemical cells
8473250	2013	76	15.21	Solaredge Ltd	Monitoring of distributed power harvesting systems using DC power sources
7709414	2010	79	14.99	Nanostellar	Engine exhaust catalysts containing palladium-gold
8202649	2012	46	14.90	PolyPlus Battery Co	Active metal/aqueous electrochemical cells and systems

The patents in Table 4-8 are examples where HFTO-funded fuel cell research has formed part of the foundation for subsequent high-impact technologies. This table focuses on patent families not owned by the leading fuel cell companies, since those families were examined in the backward tracing element of the analysis. The patents in Table 4-8 are assigned to a variety of organizations, and describe many different technologies. The patent at the head of this table (US #5,861,137) is assigned to Idatech and has been cited as prior art by over 500 subsequent patents, almost 25 times as many citations as expected. This patent, which was granted in 1999, describes a steam reformer for hydrogen production. Table 4-8 also includes a number of more recent patents. These include a Nokia patent for a fuel supply system, a Nanosys patent describing carbon nanowires, and an Amprius patent outlining nanomaterials for use in rechargeable batteries. These are examples of HFTO-funded fuel cell patents influencing developments in other technologies.

As with the backward tracing element of the analysis, the patent-level results from the forward tracing focus on HFTO-funded fuel cell patents. However, within the forward tracing, it is also interesting to note the Other DOE-funded fuel cell patent families linked to the largest number of subsequent patent families within and beyond fuel cell technology. These Other DOE-funded fuel cell families are shown in Table 4-9.

Table 4-9 - Other DOE-funded Fuel Cell Patent Families Linked via Citations to Largest Number of Subsequent Fuel Cell/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Fuel Cell Fams	Assignee	Title
26679927	1987	4876115	2409	1773	US Dept Energy (LANL)	Electrode assembly for use in a solid polymer electrolyte fuel cell
27028607	1982	4522894	2190	1071	Engelhard Corp	Fuel cell electric power production
26913674	1980	4490444	1735	1331	Siemens (Westinghouse)	High temperature solid electrolyte fuel cell configurations and interconnections
22325969	1987	4804592	1644	1230	US Dept Energy (LANL)	Composite electrode for use in electrochemical cells
23451175	1995	5554453	1644	513	Energy Research Corp	Carbonate fuel cell system with thermally integrated gasification
23009973	1981	4424491	1487	287	US Dept Energy (LANL)	Automatic voltage imbalance detector
24158653	1983	4476198	1461	1265	US Dept Energy (ANL)	Solid oxide fuel cell having monolithic core
26913653	1980	4395468	1303	1022	Siemens (Westinghouse)	Fuel cell generator
23805334	1989	4973530	1295	1082	US Dept Energy (LANL)	Fuel cell water transport
24989880	1985	4670359	1256	846	Engelhard Corp	Fuel cell integrated with steam reformer

The patent family at the head of Table 4-9 (representative patent US #4,876,115) is assigned to DOE and describes a fuel cell electrode assembly. It is linked via citations to 2,409 subsequent patent families, 1,773 of which are related to fuel cells. This patent family was also highlighted in the backward tracing element of the analysis due to its extensive citation links to patents assigned to the leading fuel cell companies. It is one of a number of patent families in Table 4-9 assigned to DOE (and resulting from research carried out at LANL), most of which have extensive citation links within fuel cell technology. The same is true for patent families assigned to other organizations in Table 4-9, including Engelhard and Siemens (Westinghouse).

The forward tracing element of the analysis shows that HFTO-funded and Other DOE-funded fuel cell patents are linked via citations to subsequent fuel cell patents assigned to a number of very large companies. The influence of HFTO-funded and Other DOE-funded fuel cell research can also be seen across a range of technologies, including hydrogen production, advanced batteries and nanomaterials.

Overall, the results from the fuel cell analysis suggest that DOE-funded patenting in this technology has increased over time, with HFTO-funded patents representing a growing percentage of the total. The portfolios of HFTO-funded and Other DOE-funded fuel cell patents have had a strong influence on subsequent innovations associated with the leading companies in fuel cell technology. Their influence also extends beyond fuel cells into other technologies, including adjacent technologies such as hydrogen production, and other technologies including advanced batteries and nanomaterials.

5. Results – Hydrogen Production

This section of the report outlines the results of an analysis tracing the influence of HFTO-funded and Other DOE-funded hydrogen production research on subsequent developments both within and beyond hydrogen production technology. The results are divided into three main sections. The first section examines trends in patenting over time in hydrogen production, and assesses the distribution of HFTO-funded and Other DOE-funded patents across hydrogen production technologies. The second section then reports the results of an analysis tracing backwards from hydrogen production patents owned by the leading companies in this technology. The purpose of this analysis is to determine the extent to which hydrogen production innovations developed by leading companies build upon earlier hydrogen production research funded by HFTO (plus hydrogen production research funded by the remainder of DOE). The third section reports the results of an analysis tracing forwards from HFTO-funded (and Other DOE-funded) hydrogen production patents. The purpose of this analysis is to assess the broader influence of DOE-funded research upon subsequent developments within and beyond hydrogen production technology.

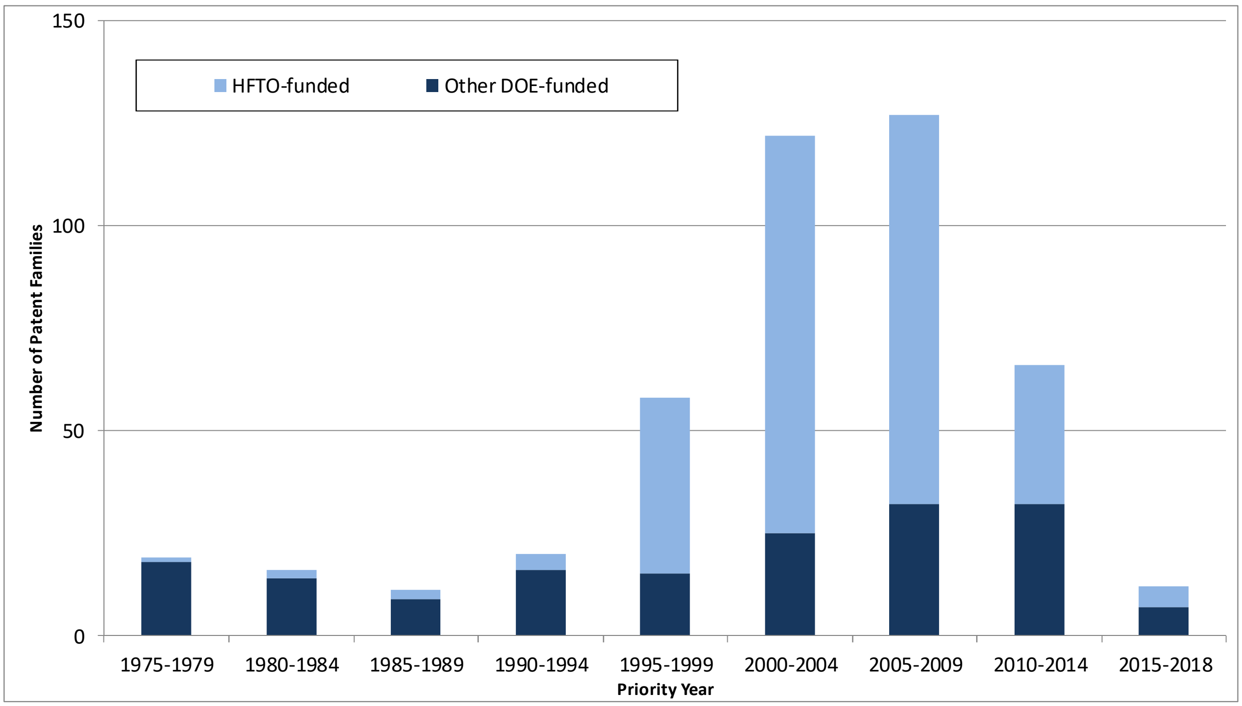
Overall Trends in Hydrogen Production Patenting

Trends in Hydrogen Production Patenting over Time

Figure 5-1 shows the number of HFTO-funded and Other DOE-funded hydrogen production patent families by priority year – i.e., the year of the first application in each patent family. This figure reveals that DOE-funded hydrogen production patenting was relatively sparse in the earliest time periods in the analysis. In 1975-1979, there were a total of 19 DOE-funded patent families filed, followed by 16 in 1980-1984, 11 in 1985-1989 and 20 in 1990-1994. Out of these 66 patent families filed between 1975 and 1994, only nine are defined as HFTO-funded.

After 1994, DOE-funded hydrogen production patenting started to increase, with 58 patent families filed in 1995-1999, 43 of which were HFTO-funded. The upward trend continued in the following time periods, with 122 DOE-funded patent families filed in 2000-2004 (97 funded by HFTO) and 127 filed in 2005-2009 (95 funded by HFTO). DOE-funded hydrogen production patenting then declined markedly in 2010-2014, with 66 patent families filed in this time period, 34 of which were funded by HFTO. The decline continued in 2015-2018, although these data are incomplete, since they only include patents issued through the end of the 2018 study period.

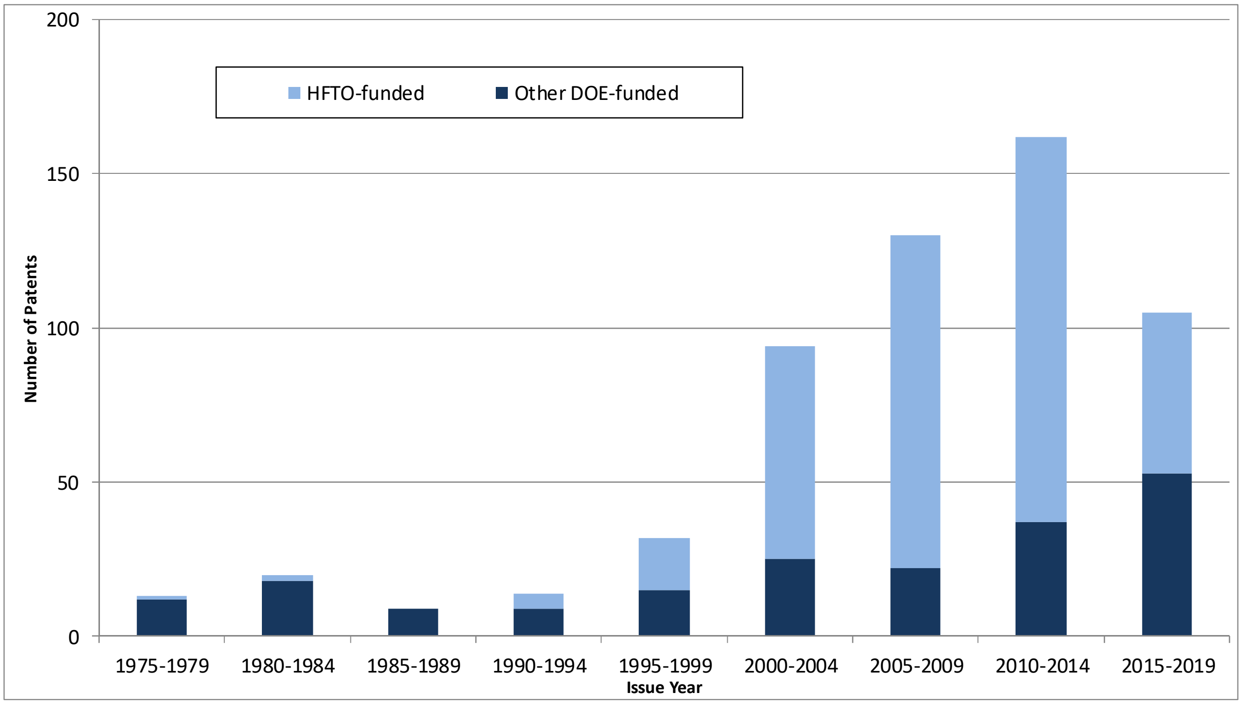
Figure 5-1 - Number of Hydrogen Production Patent Families funded by HFTO and Other DOE Sources by Priority Year (5-Year Totals)



Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 5-2 shows the number of HFTO-funded and Other DOE-funded hydrogen production granted U.S. patents. This figure follows a similar pattern to Figure 5-1. There is relatively little patent activity in the earlier time periods, with many of the patents defined as Other DOE-funded. Patenting then started to increase, particularly from 2000 onwards, with HFTO-funded patents representing an increasing percentage of the overall number. In 2000-2004, 94 DOE-funded U.S. hydrogen production patents were granted, 69 of which were funded by HFTO. These numbers increased to 130 DOE-funded U.S. patents in 2005-2009 (108 funded by HFTO) and 162 DOE-funded U.S. patents in 2010-2014 (125 funded by HFTO). DOE-funded hydrogen patenting declined in the most recent time period, with 105 DOE-funded patents granted in 2015-2019 (52 funded by HFTO), although data from this period are incomplete (see note below Figure 5-2).

Figure 5-2 - Number of DOE-Funded Hydrogen Production Granted U.S. Patents by Issue Year (5-Year Totals)

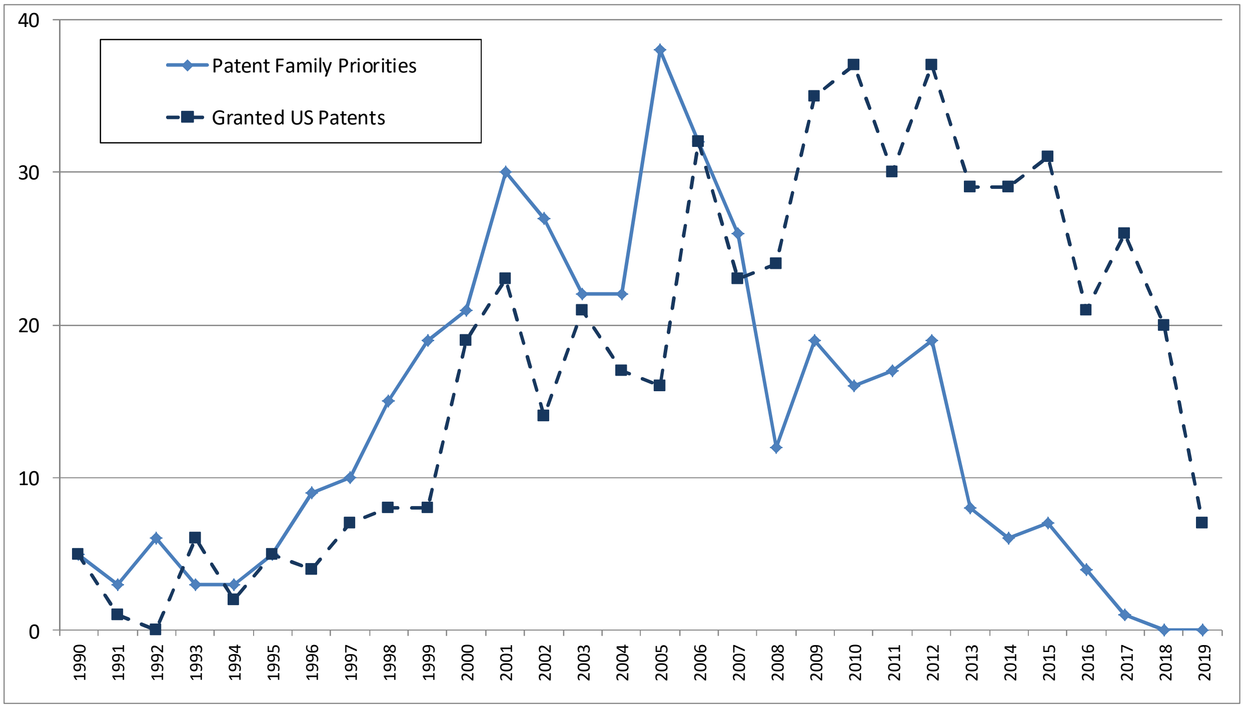


Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

Comparing Figures 5-1 and 5-2 shows the effect of time lags in the patenting process, with many of the patent families with priority dates in 2000-2004 and 2005-2009 (Figure 5-1) resulting in granted U.S. patents in 2005-2009 and 2010-2014 (Figure 5-2). These time lags can also be seen in Figure 5-3, which shows hydrogen production patent family priority years and issue years for granted U.S. hydrogen production patents (in this figure, HFTO and Other DOE are combined, in order to simplify the presentation). Figure 5-3 reveals that the peaks in patent family priorities occurred in 2001 and 2005, with subsequent peaks in granted U.S. patents in 2006 and 2009-2012. This figure also shows that the number of DOE-funded patent families declined sharply after 2012, resulting in a subsequent decrease in granted U.S. patents after 2015 (note that, due to the primary data collection for this analysis ending in 2018, the number granted U.S. patents declines further in 2019, and the number of patent families is zero).

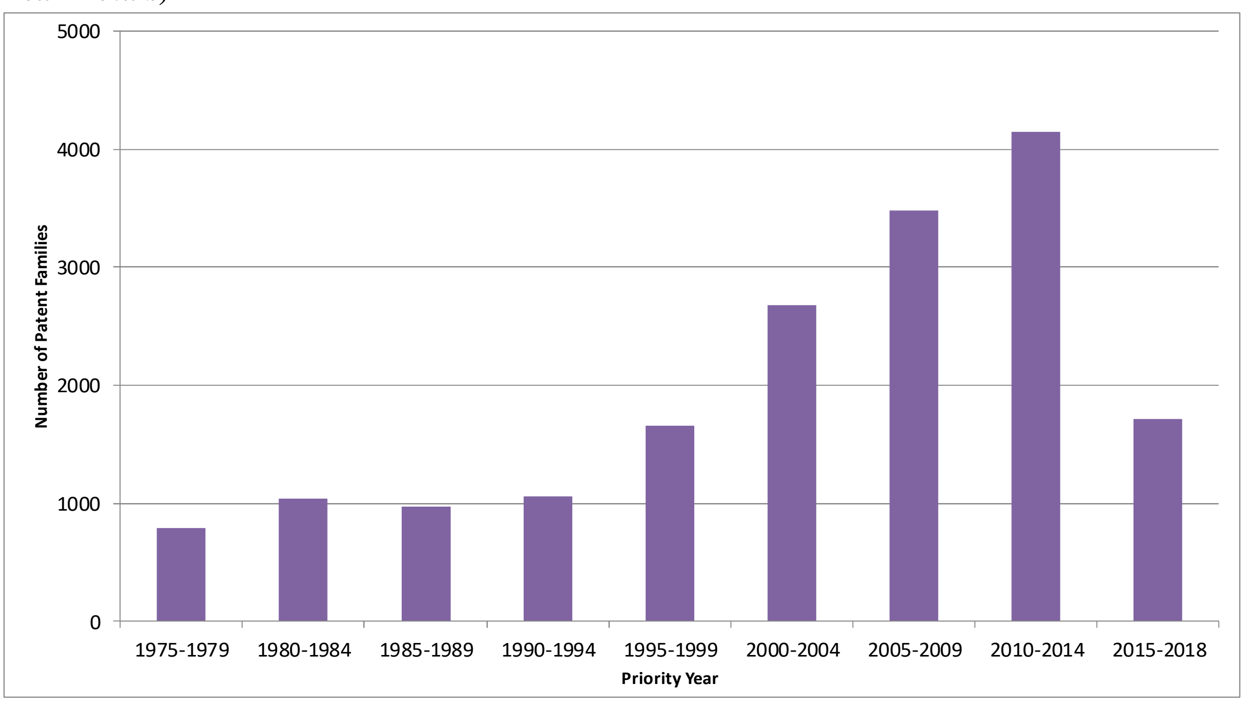
Figures 5-1 – 5-3 focus on DOE-funded hydrogen production patent families. Figure 5-4 broadens the scope, and shows the overall number of hydrogen production patent families by priority year (based on USPTO, EPO, and WIPO filings). This figure follows a relatively similar pattern to Figure 5-1, which focused on DOE-funded patents, albeit with one notable difference. Specifically, overall patenting in hydrogen production started to increase markedly in the second half of the 1990s, as did DOE-funded patenting. It continued to increase until 2010-2014, peaking at 4,145 patent families filed in that time period, before declining sharply in 2015-2018 (although data for the latter period are incomplete). As such, the peak in overall hydrogen patenting occurred after the peak in DOE-funded hydrogen production patenting, which started to decline after 2005-2009.

Figure 5-3 - Number DOE-funded Hydrogen Production Patent Families (by Priority Year) and Granted U.S. Patents (by Issue Year)



Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

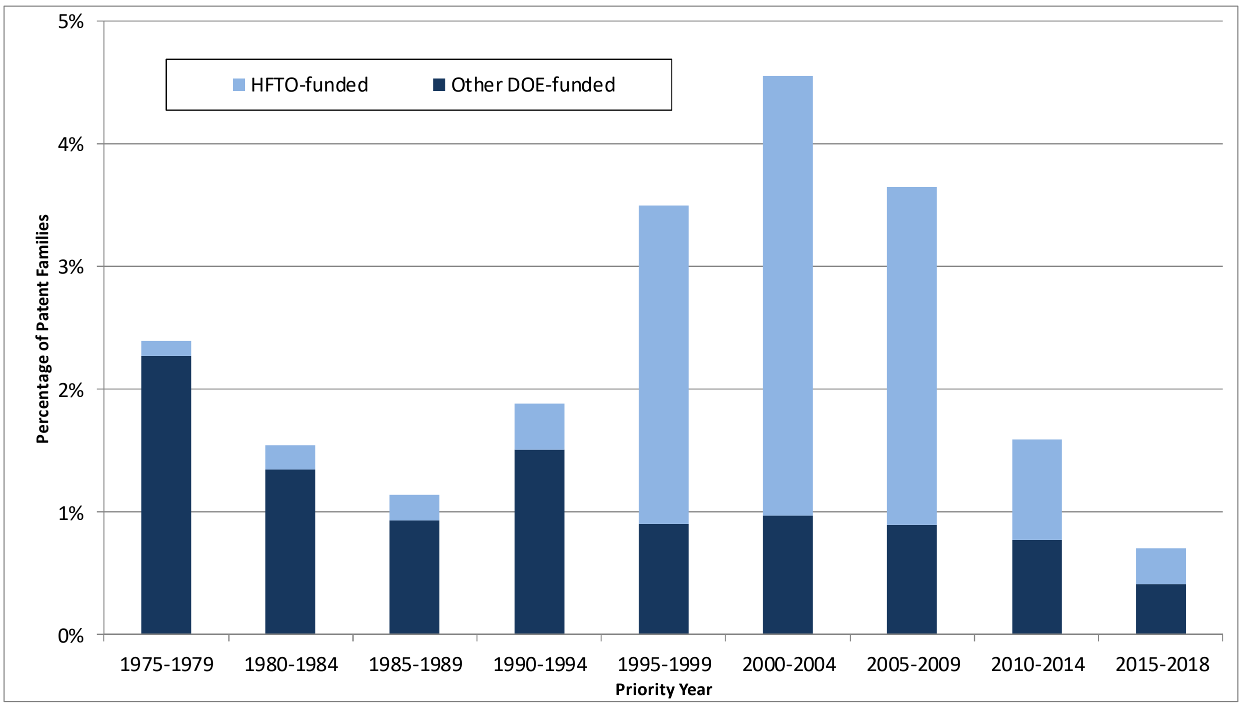
Figure 5-4 - Total Number of Hydrogen Production Patent Families by Priority Year (5-Year Totals)



Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 5-5 shows the percentage of hydrogen production patent families in each time period that were funded by DOE (HFTO plus Other DOE). This figure reveals that, in the earliest time periods covered by the analysis, 1-2% of hydrogen production patent families were funded by DOE, with only a fraction of these confirmed as being funded by HFTO. Between 1995 and 2009, more than 3% of hydrogen production patent families were funded by DOE, peaking at 4.5% in 2000-2004 (with 3.6% funded by HFTO). The percentage declined after 2009, as overall hydrogen production patenting continued to increase while DOE-funded patenting decreased (see Figures 5-1 and 5-4). Overall, 2.5% of hydrogen production patent families in the period 1976-2018 were funded by DOE.

Figure 5-5 - Percentage of Hydrogen Production Patent Families Funded by DOE by Priority Year



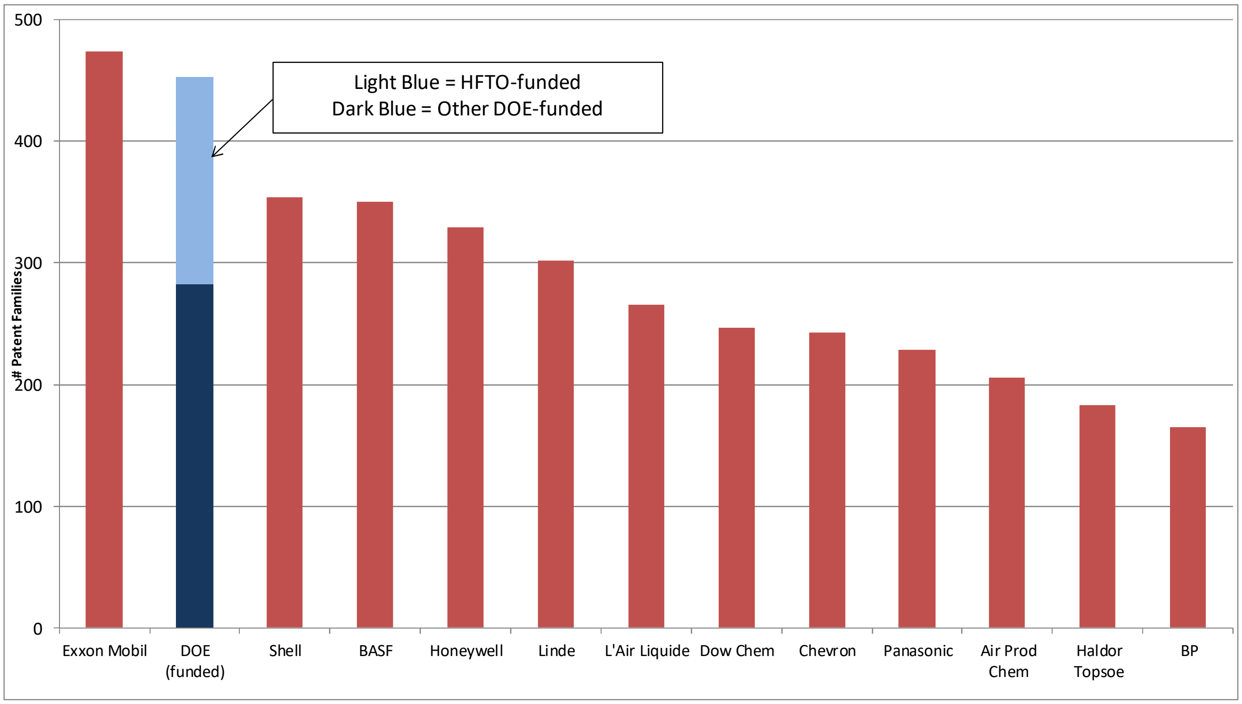
Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Leading Hydrogen Production Patenting Companies

The twelve leading patenting companies overall in hydrogen production technology are listed above in Table 3-4, along with their number of hydrogen production patent families. Figure 5-6 shows the same information in graphical form, while also including DOE-funded patent families. This figure reveals that, among the leading companies, ExxonMobil has the largest hydrogen production patent portfolio, containing 474 patent families. It is followed by Shell (354 families), BASF (350) and Honeywell (329). One notable feature of Figure 5-6 is the geographical distribution of the leading companies, with six from Europe, five from North America, and one from Asia. The DOE-funded hydrogen production portfolio of 453 patent families (284 HFTO-funded; 169 Other-DOE funded) is the second largest in Figure 5-6, after only ExxonMobil.

It should be noted that there is a small amount of double-counting of patent families in Figure 5-6. Specifically, out of the 3,348 hydrogen production patent families assigned to the leading companies, 27 acknowledge funding from DOE. Most of these are HFTO-funded Air Products & Chemicals families and Other DOE-funded Linde families (via its merger with Praxair). They are counted in both the associated segments of the DOE-funded column and in the respective company columns. This double-counting is appropriate, since these families are both funded by DOE and assigned to a leading company.

Figure 5-6 – Leading Hydrogen Production Companies (based on no. of patent families)



Assignees of HFTO/Other DOE Hydrogen Production Patents

The DOE-funded hydrogen production patent portfolios are constructed somewhat differently from the portfolios of the top twelve companies listed in Figure 5-6. Specifically, DOE's 453 patent families are those funded by DOE, but they are not necessarily assigned to the agency. For example, HFTO (or another DOE office) may have partially or fully funded research projects at DOE labs or companies. In such cases, the assignees of any resulting patents may be the DOE lab managers or companies (as with the 27 leading company families referred to above).

Figure 5-7 shows the leading assignees on HFTO-funded hydrogen production patent families. This figure is headed by Air Products & Chemicals with 42 HFTO-funded patent families. This is more than twice as many patent families as the organization in second place in Figure 5-7 – MRIGlobal (formerly Midwest Research Institute), with 17 patent families resulting from its management of the National Renewable Energy Laboratory (NREL). The remaining organizations in Figure 5-7 include companies (Nuvera Fuel Cells and General Electric), universities (Central Florida), and DOE lab managers (Battelle Memorial Institute and the Alliance for Sustainable Energy).

Figure 5-7 - Assignees with Largest Number of HFTO-Funded Hydrogen Production Patent Families

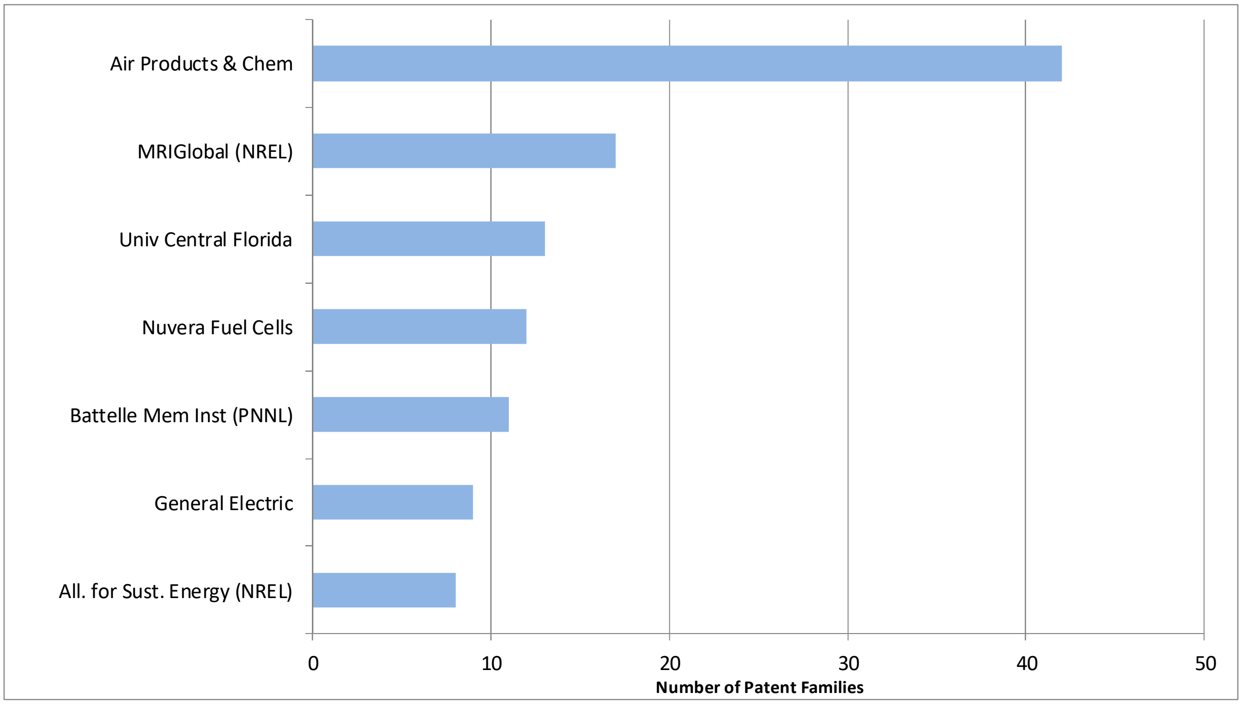


Figure 5-8 - Assignees with Largest Number of Other DOE-funded Hydrogen Production Patent Families

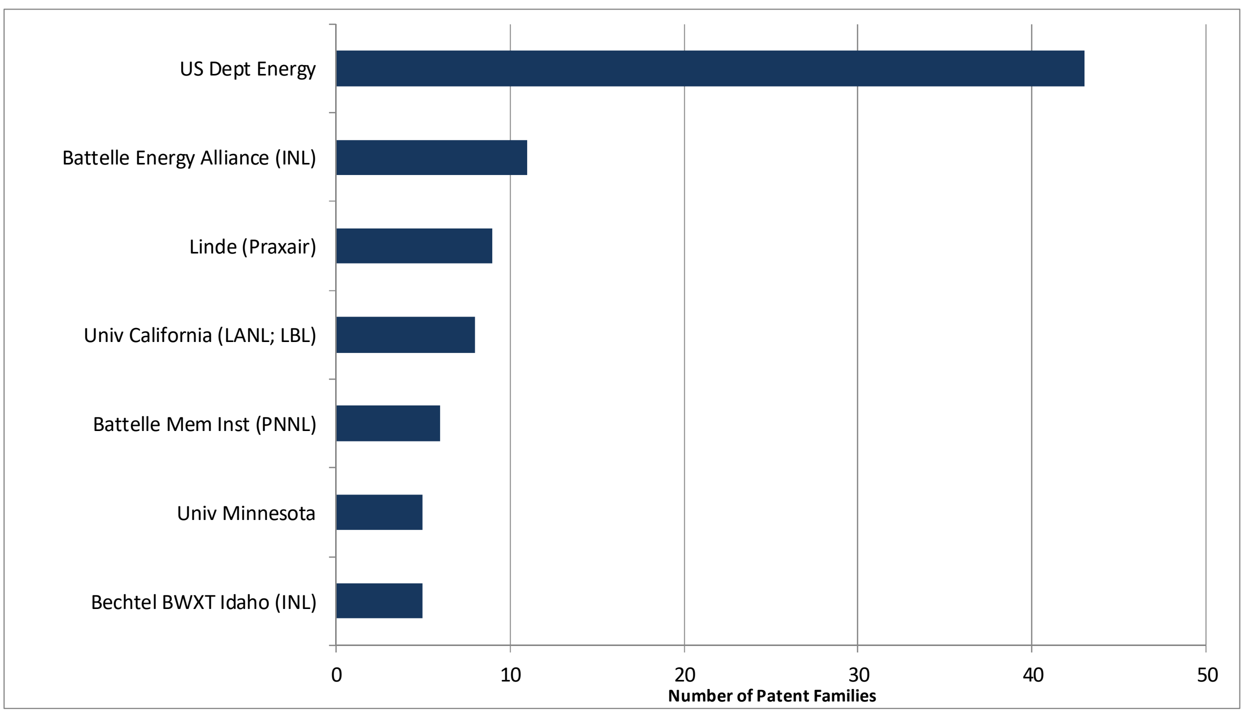


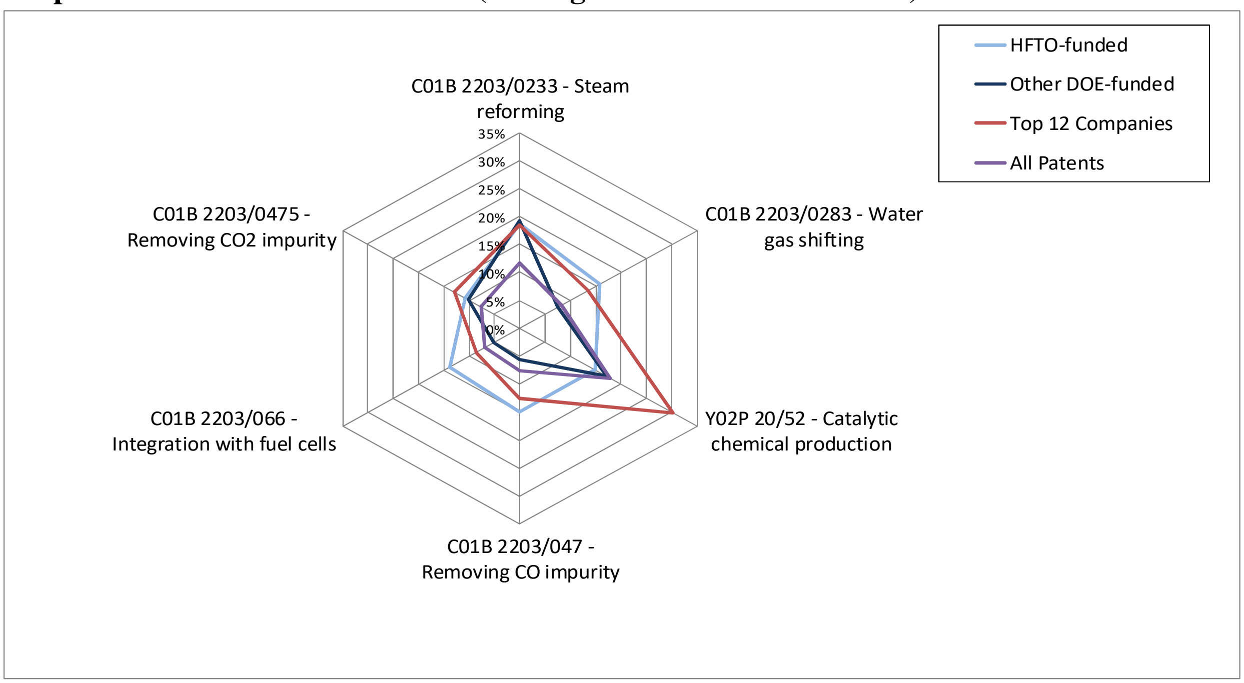
Figure 5-8 shows the leading assignees on Other DOE-funded hydrogen production patent families. This figure is headed by DOE, with 43 patent families assigned to the agency itself.

Such an assignment may occur for various reasons, including where the inventors are federal employees; where the funding recipient elects not to pursue patent protection for, or take title to, the invention; or where the funding recipient does not have the right to take title to the invention. Figure 5-8 also includes a number of DOE lab managers – Battelle Energy Alliance and Bechtel BWXT Idaho (both Idaho National Laboratory), University of California (Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory), and Battelle Memorial Institute (Pacific Northwest National Laboratory) – plus Linde Plc (through its merger with Praxair) and the University of Minnesota.

Distribution of Hydrogen Production Patents across Patent Classifications

This section analyzes the distribution of HFTO-funded hydrogen production U.S. patents across Cooperative Patent Classifications (CPCs).[15] The distribution is then compared to those associated with Other DOE-funded hydrogen production patents; hydrogen production patents assigned to the twelve leading companies; and the universe of all hydrogen production patents. This analysis provides insights into the technological focus of HFTO funding in hydrogen production, versus the focus of the remainder of DOE, leading hydrogen production companies, and hydrogen production technology in general. The results from this CPC analysis are shown in two separate charts, each from a different perspective. The first chart (Figure 5-9) is based on the six CPCs that are most prevalent among HFTO-funded hydrogen production patents.

Figure 5-9 - Percentage of Hydrogen Production U.S. Patents in Most Common Cooperative Patent Classifications (Among HFTO-Funded Patents)



[15] The CPC is a patent classification system. Patent offices attach numerous CPC classifications to a patent, covering the different aspects of the subject matter in the claimed invention. In generating these charts, all CPCs associated with each patent are included.

The purpose of this chart is thus to show the main focus areas of HFTO-funded hydrogen production research, and the extent to which these areas translate to other portfolios (Other DOE-funded; leading hydrogen production companies; all hydrogen production). This figure shows that HFTO-funded research includes relatively balanced coverage across the six CPCs (which is not particularly surprising, since the HFTO-funded patent portfolio forms the basis for the CPCs included in the chart). The most common CPCs among HFTO-funded hydrogen production patents are C01B 2203/0233 (Steam reforming), C01B 2203/0283 (Water gas shifting) and Y02P 20/52 (Catalytic chemical production). The latter CPC is also a particular focus for patents owned by the leading companies. Meanwhile, the integration of hydrogen production with fuel cells (CPC C01B 2203/066) is an area where HFTO-funded patents have a much greater concentration than the other portfolios.

Figure 5-10 is similar to Figure 5-9, except that it is from the perspective of the most common CPCs among all hydrogen production patents. Hence, the purpose of this chart is to show the main research areas within hydrogen production as a whole, and how these areas are represented in selected hydrogen production portfolios (HFTO-funded; Other DOE-funded; leading hydrogen production companies). Four of the six CPCs in this figure were also featured in Figure 5-9. The new CPCs in Figure 5-10 are C01B 2203/1241 (Production of syngas from methane or natural gas) and Y02E 60/366 (Water electrolysis). All the portfolios have a significant presence in the former CPC, while only a small percentage of HFTO-funded and leading company patents have the latter CPC attached to them.

Figure 5-10 - Percentage of Hydrogen Production U.S. Patents in Most Common Cooperative Patent Classifications (Among All Hydrogen Production Patents)

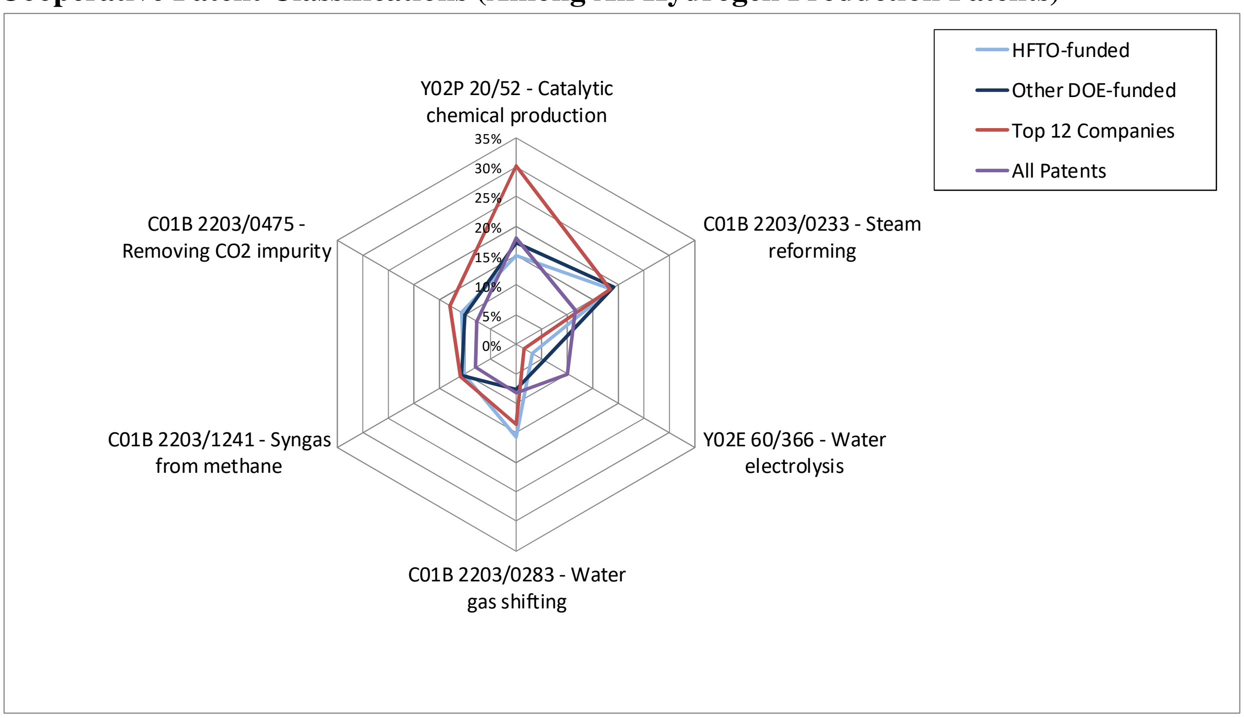
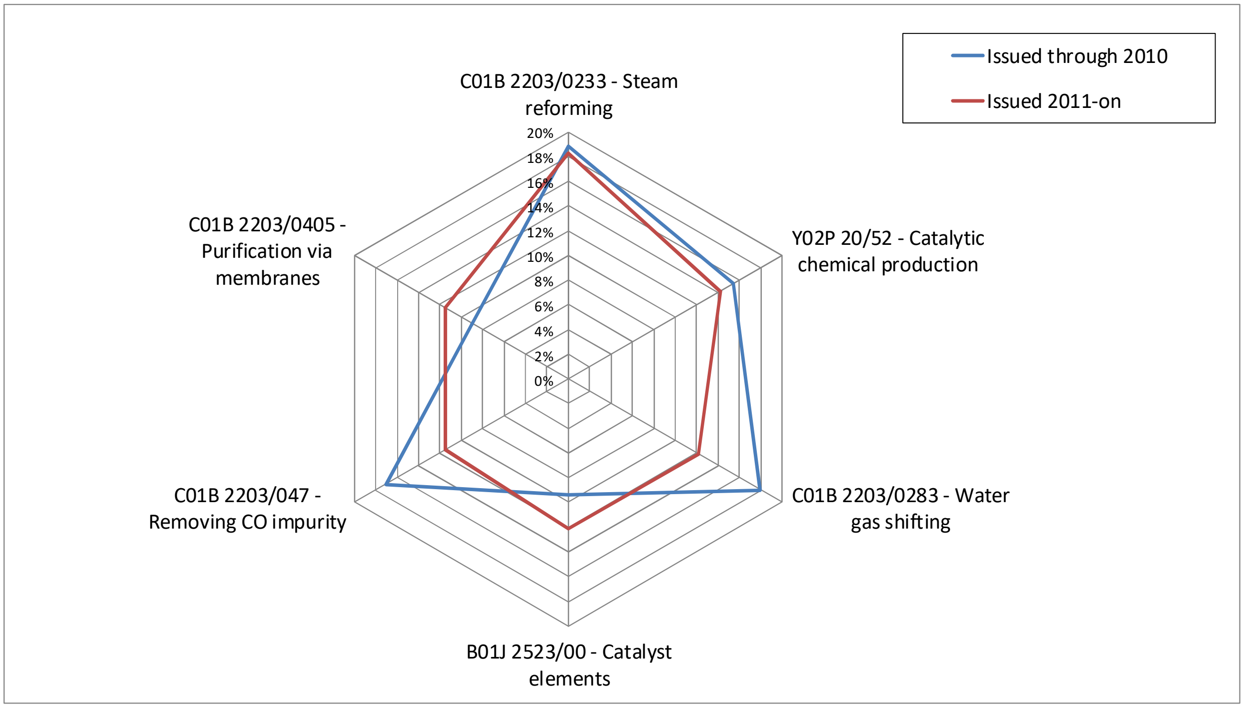


Figure 5-11 compares the CPC distribution of HFTO-funded hydrogen production U.S. patents across two time periods – patents issued through 2010, and those issued from 2011 onwards.

This figure reveals a high level of consistency in the technological focus of HFTO-funded patents over time, with similar percentages of patents in each CPC in both time periods. There is some growth in CPC B01J 2523/00 (Catalyst elements) and CPC C01B 2203/0405 (Purification via membranes) in the more recent time period. At the same time, the percentage of patents in C01B 2203/0283 declined. However, none of these changes are dramatic.

Figure 5-11 - Percentage of HFTO-funded Hydrogen Production U.S. Patents in Most Common Cooperative Patent Classifications across Two Time Periods



Tracing Backwards from Hydrogen Production Patents Owned by Leading Companies

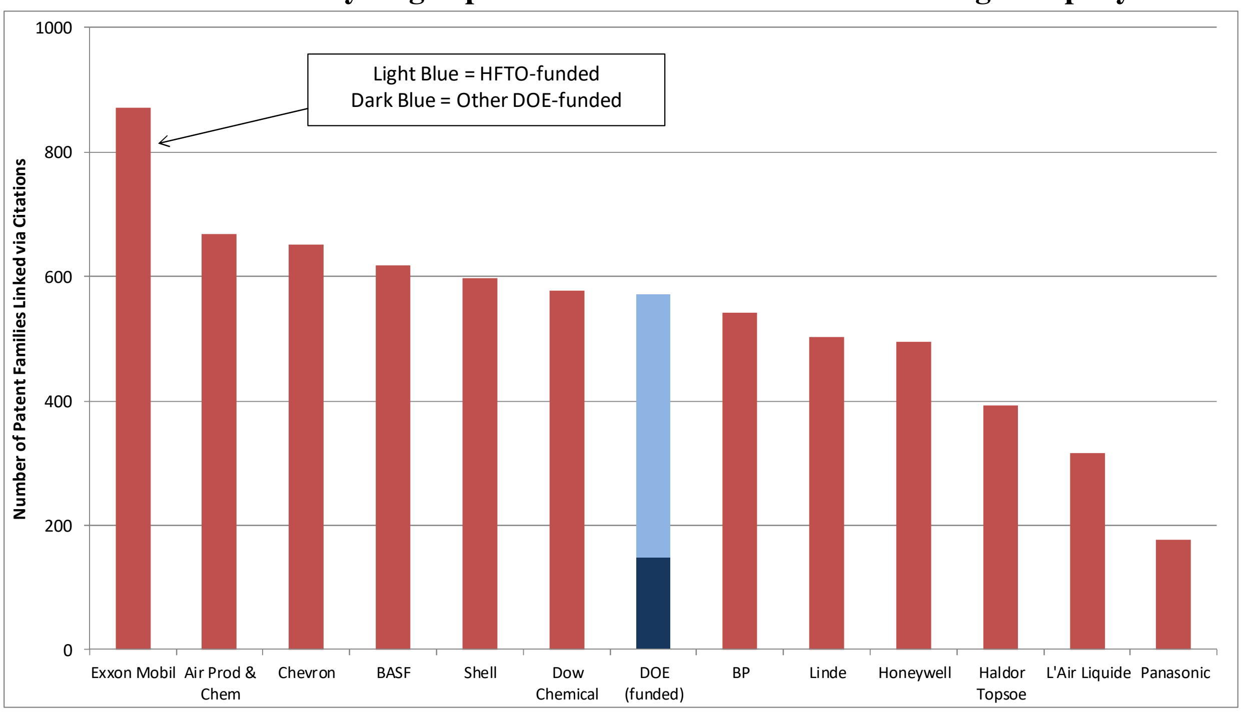
This section reports the results of an analysis tracing backwards in time from hydrogen production patents owned by leading companies in this technology to earlier research, including that funded by HFTO (and by DOE in general). The results in this section are presented at two levels. First, results are reported at the organizational level. These results reveal the extent to which HFTO-funded (and Other DOE-funded) research forms a foundation for subsequent innovations associated with leading hydrogen production companies. Second, there is a drill-down to the level of individual patents, with a particular focus on HFTO-funded hydrogen production patents. These patent-level results highlight specific HFTO-funded patents that are linked extensively via citations to subsequent patents owned by leading companies. They also highlight which hydrogen production patents owned by these leading companies are linked most extensively via citations to earlier HFTO-funded research.

Organizational Level Results

In the organizational level results, the influence of HFTO-funded and Other DOE-funded hydrogen production research is compared against the influence of leading companies in this technology. The leading companies that build most extensively on DOE-funded hydrogen production research are then identified.

Figure 5-12 compares the influence of HFTO-funded and Other DOE-funded hydrogen production research to the influence of research carried out by the top twelve hydrogen production companies. Specifically, this figure shows the number of hydrogen production patent families assigned to the leading companies that are linked via citations to earlier hydrogen production patent families assigned to each of these leading companies (plus patent families funded by DOE). This figure thus shows the companies whose patents have had the strongest influence upon subsequent developments made by leading companies in hydrogen production.[16]

Figure 5-12 - Number of Leading Company Hydrogen Production Patent Families Linked via Citations to Earlier Hydrogen production Patents from each Leading Company



[16] This figure compares the influence of patents *funded* by HFTO/Other DOE against patents *owned* by (i.e. assigned to) organizations. Such a comparison is reasonable, since patents funded by organizations through their R&D budgets will be assigned to those organizations. Also, organizations cannot choose to reference the patents of a non-competitor (such as DOE) rather than the patents of a competitor in order to reduce the "credit" given to that competitor. Such an omission could lead to the invalidation of their patents. Note that, as in Figure 5-6, there is a small amount of double-counting in Figure 5-12, as some patent families assigned to leading companies were funded by DOE. Also, in Figures 5-12 – 5-15, leading company patent families linked to both HFTO-funded and Other DOE-funded patents are allocated to the HFTO-funded segment of the DOE column, in order to avoid double-counting these families.

In total, 571 leading company hydrogen production patent families (i.e., 17.2% of their 3,319 families) are linked via citations to earlier DOE-funded hydrogen production patents. Out of these 571 families, 423 (i.e., 12.7% of leading company families) are linked to HFTO-funded patents. This finding puts DOE-funded patents in the center of the distribution in Figure 5-12. ExxonMobil is at the head of the figure, with 871 leading company patent families linked to its patents, followed by Air Products & Chemicals (669 families), Chevron (652) and BASF (618). Overall, most of the organizations in Figure 5-12 (including DOE) have similar numbers of patent families linked to them via citations, suggesting this is a highly-connected technology without a single dominant patent portfolio.

Figure 5-13 shows the number of hydrogen production patent families assigned to each leading company that are linked via citations to earlier HFTO-funded and Other DOE-funded patents. Linde is at the head of this figure, with 100 hydrogen production patent families linked via citations to DOE-funded patents, 78 of which are linked to HFTO-funded patents. Air Products & Chemicals is in second place, with 75 patent families linked to DOE-funded patents (54 to HFTO-funded patents), followed by Shell (72 families linked to DOE; 45 to HFTO) and Chevron (59 families linked to DOE; 45 to HFTO). In general, Figure 5-13 shows that, with the exception of companies at the right-hand end of the distribution, leading companies are linked more extensively via citations to HFTO-funded patents than to Other DOE-funded patents.

Figure 5-13 - Number of Patent Families Assigned to Leading Hydrogen Production Companies Linked via Citations to Earlier HFTO/Other DOE-funded Hydrogen Production Patents

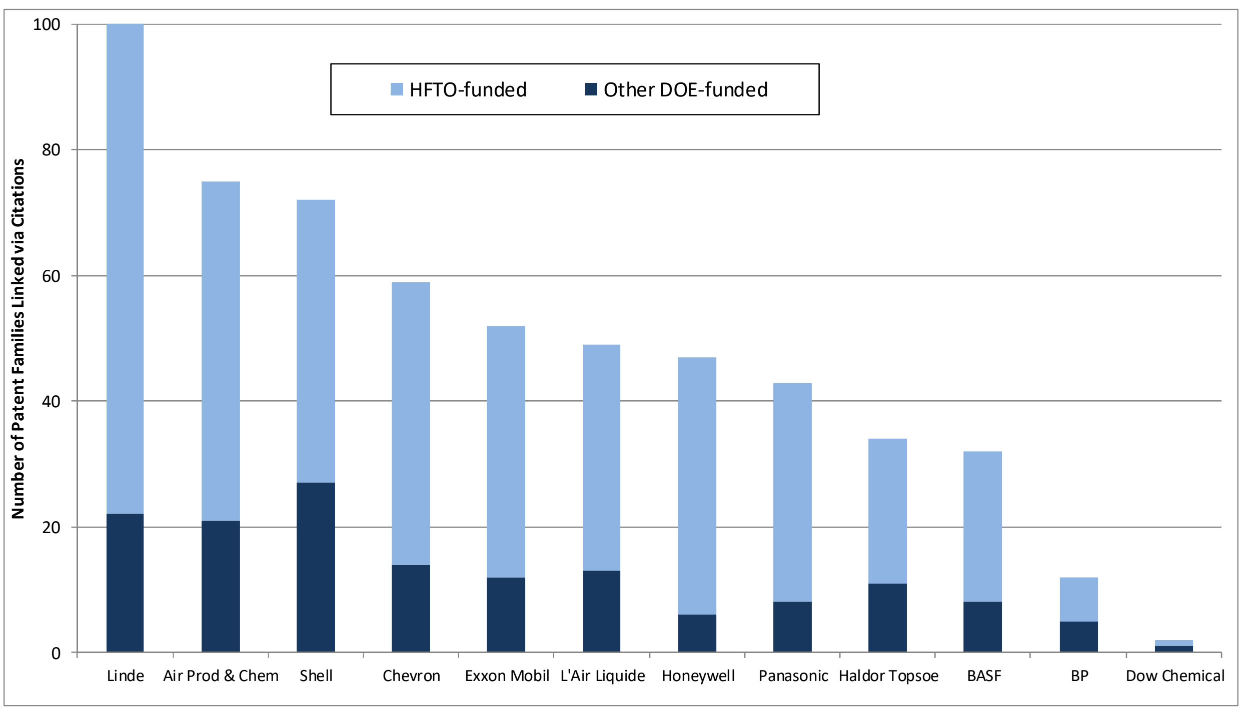
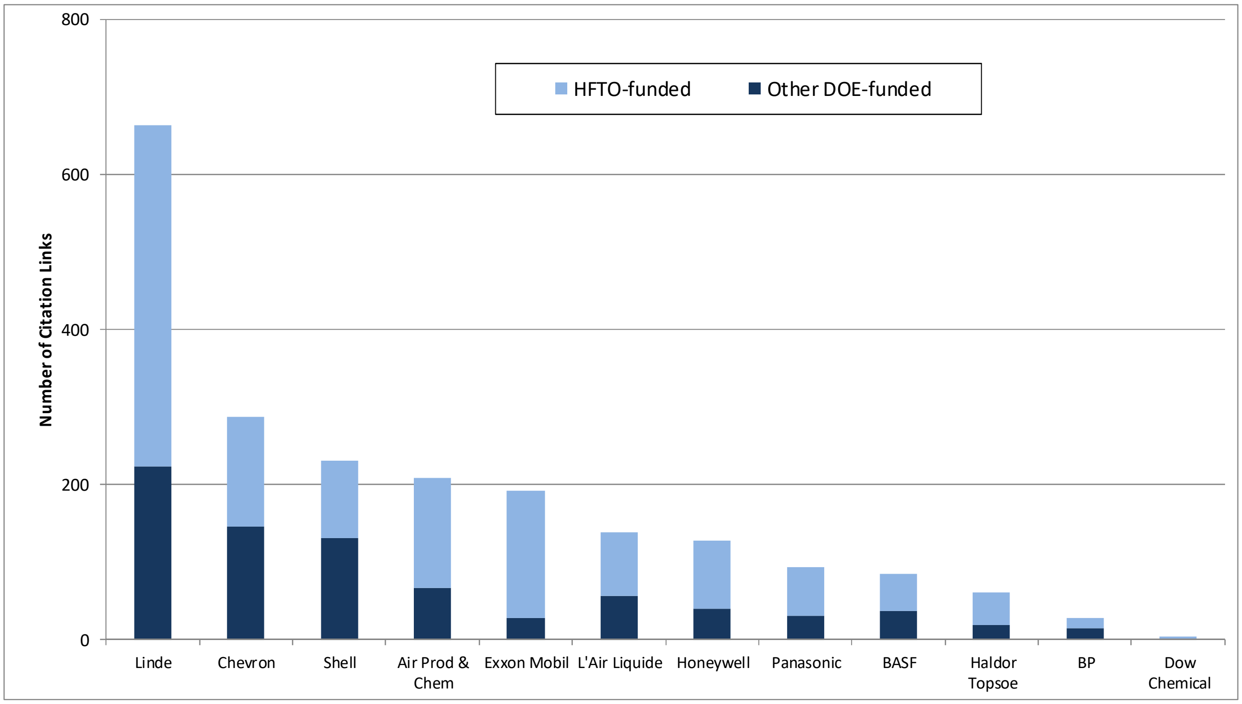


Figure 5-14 counts the total number of citation links from leading companies to earlier DOE-funded patents. This differs slightly from the count of linked families in Figure 5-13, since a single patent family may be linked to multiple earlier DOE-funded patents. Linde is again at the head of Figure 5-14, with a total of 663 citation links to earlier DOE-funded hydrogen production patents, 440 of which are links to HFTO-funded patents. Chevron, Shell and Air Products & Chemicals are again prominent in Figure 5-14, although the gap to them from Linde is greater than it was in Figure 5-13.

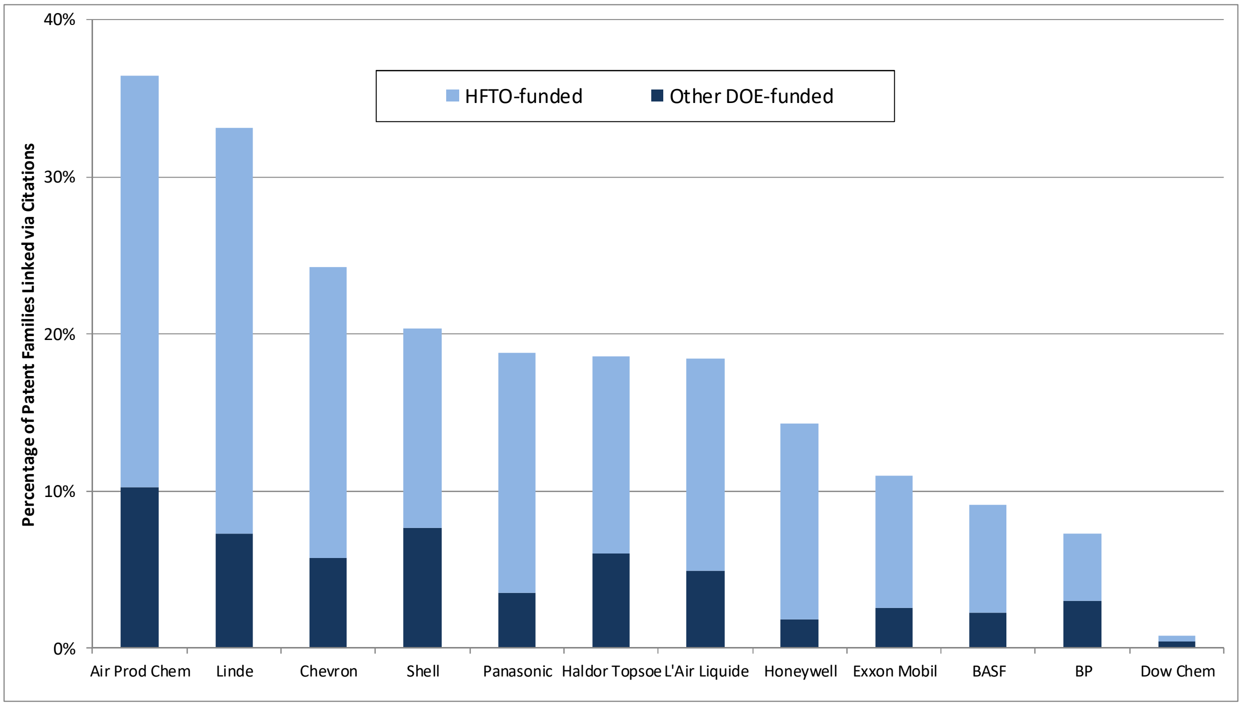
Figure 5-14 - Total No. of Citation Links from Leading Hydrogen Production Company Patent Families to Earlier HFTO/Other DOE-funded Hydrogen Production Patents



There is an element of portfolio size bias in the patent family counts in Figures 5-13 and 5-14. Companies with larger hydrogen production patent portfolios are likely to have more patent families linked to DOE, simply because they have more families overall. Figure 5-15 accounts for this portfolio size bias by calculating the percentage of each leading company's hydrogen production patent families that are linked via citations to earlier DOE-funded hydrogen production patents, rather than their absolute number. This is a measure of how extensively each company builds on DOE-funded research, relative to their overall patent output.

Figure 5-15 reveals that two leading companies have more than 30% of their hydrogen production patent families linked via citations to earlier DOE-funded hydrogen production patents. Air Products & Chemical has 36.4% of its patent families linked via citations to DOE-funded patents (22.4% are linked to HFTO-funded patents), while Linde has 33.1% of its patent families linked to DOE (25.8% linked to HFTO). Chevron and Shell are again prominent in Figure 5-15, with more than 20% of their patent families linked via citations to DOE-funded patents. This suggests that DOE-funded (and especially HFTO-funded) hydrogen production patents have had a particularly strong influence on innovations developed by these four companies.

Figure 5-15 - Percentage of Leading Hydrogen Production Company Patent Families Linked via Citations to Earlier HFTO/Other DOE-funded Hydrogen Production Patents



Patent Level Results

The previous section of the report examined results at the level of entire patent portfolios. The purpose of this section is to drill down to identify individual DOE-funded hydrogen production patent families (in particular HFTO-funded families) that are linked via citations to subsequent hydrogen production patents owned by leading companies in this technology. Looking in the opposite direction, it also identifies individual hydrogen production patents owned by leading companies that have extensive citation links to earlier HFTO-funded research.

Table 5-1 shows the HFTO-funded hydrogen patent families linked via citations to the largest number of subsequent patent families owned by leading companies in this technology. The patent at the top of Table 5-1 is assigned to Nuvera Fuel Cells (it was originally assigned to Arthur D. Little, whose fuel cells business merged with De Nora Fuel Cells in 2000 to form Nuvera). This patent family describes a method for producing hydrogen and carbon dioxide from hydrocarbon fuels. It is linked to 81 patent families owned by the leading companies, describing various aspects of hydrogen processing, including catalysts and steam reforming. This includes at least one family from each of the twelve leading companies. Air Products & Chemicals has a number of patent families in Table 5-1. These include the patent family in second place in the table (representative patent US #5,681,373), which is linked via citations to 80 subsequent families assigned to the leading companies. This includes families from ten of these twelve companies (the exceptions being Dow and Honeywell).

Table 5-2 looks in the opposite direction to Table 5-1, and lists the hydrogen production patent families owned by leading companies that are linked via citations to the largest number of earlier patent families funded by HFTO.

Table 5-1 – HFTO-Funded Hydrogen Production Patent Families Linked via Citations to Most Subsequent Leading Company Hydrogen Production Patent Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
24825221	6083425	1996	81	Nuvera Fuel Cells	Method for converting hydrocarbon fuel into hydrogen gas and carbon dioxide
23592959	5681373	1995	80	Air Products & Chemicals	Planar solid-state membrane module
25544231	6048472	1997	67	Air Products & Chemicals	Production of synthesis gas by mixed conducting membranes
27111356	5271916	1991	64	General Motors	Device for staged carbon monoxide oxidation
23925657	5738708	1995	61	Univ California (LANL)	Composite metal membrane
23799772	4473622	1982	60	General Electric	Rapid starting methanol reactor system
25354618	6077323	1997	54	Air Products & Chemicals	Synthesis gas production by ion transport membranes
22564951	6114400	1998	52	Air Products & Chemicals	Synthesis gas production by mixed conducting membranes with integrated conversion into liquid products
25464666	6783750	2001	40	Linde (Praxair)	Hydrogen production method
22846308	6103143	1999	34	Air Products & Chemicals	Process and apparatus for the production of hydrogen by steam reforming of hydrocarbon

Table 5-2 - Leading Company Hydrogen Production Patent Families Linked via Citations to Largest Number of HFTO Funded Hydrogen Production Patent Families

Patent Family #	Representative Patent #	Priority Year	# HFTO Fams	Assignee	Title
51789751	10005664	2015	23	Linde Plc (Praxair)	Method and system for producing a synthesis gas using an oxygen transport membrane based reforming system
59018909	10118823	2015	22	Linde Plc (Praxair)	Method of thermally-stabilizing an oxygen transport membrane-based system
51789750	9839899	2016	22	Linde Plc (Praxair)	Method and system for producing methanol using an integrated oxygen transport membrane based system
56924491	9938145	2016	22	Linde Plc (Praxair)	Method and system for adjusting synthesis gas module in an oxygen transport membrane based reforming system
51794967	9452401	2014	21	Linde Plc (Praxair)	Ceramic oxygen transport membrane array reactor and reforming method
53774528	9562472	2015	21	Linde Plc (Praxair)	Oxygen transport membrane reactor based method and system for generating power
53038189	9028720	2014	15	Air Prod & Chem	Ion transport membrane reactor systems and methods for producing synthesis gas
45525007	8435328	2011	11	Linde Plc	Ten bed pressure swing adsorption process operating in normal and turndown modes
49881089	8722010	2012	11	L'Air Liquide	Coproduction of oxygen, hydrogen, and nitrogen using ion transport membranes
43925797	8632922	2010	10	Royal Dutch Shell	Systems and processes for operating fuel cell systems

Table 5-2 is dominated by patent families assigned to Linde Plc, following its merger with Praxair, which is responsible for the first six families in the table. The Linde patent at the head of this table (representative patent US #10,005,664) describes a method for producing syngas. It is linked via citations to 23 earlier HFTO-funded patent families, notably families assigned to Air Products & Chemicals describing membrane-based systems and syngas production. These same HFTO-funded Air Products & Chemicals patent families are also linked via citations to a number of the other Linde patent families at the head of Table 5-2.

High-impact hydrogen production patents owned by leading companies that have citation links back to HFTO-funded patents were also identified.[17] The idea is to highlight important technologies owned by leading companies that are linked to earlier hydrogen production research funded by HFTO. Table 5-3 lists leading company patents that are linked via citations to HFTO-funded patents, and in turn have been cited as prior art by at least 30 subsequent patents, resulting in a Citation Index value above four (i.e., they have each been cited at least four times as many times as expected given their age and technology).

Table 5-3 - Highly Cited Leading Company Hydrogen Production Patents Linked via Citations to Earlier HFTO-funded Hydrogen Production Patents

Patent	Issue Year	# Cites Received	Citation Index	Assignee	Title
7491250	2009	114	10.94	Exxon Mobil	Pressure swing reforming
6821501	2004	176	10.67	Royal Dutch Shell	Integrated flameless distributed combustion/steam reforming membrane reactor for hydrogen production
7815892	2010	63	10.65	Exxon Mobil	Integration of hydrogen and power generation using pressure swing reforming
7265076	2007	60	7.77	Panasonic	CO removal catalyst, method of producing CO removal catalyst, hydrogen purifying device and fuel cell
7503948	2009	73	7.00	Exxon Mobil	Solid oxide fuel cell systems having temperature swing reforming
7354562	2008	41	5.92	Air Products & Chem	Simultaneous shift-reactive and adsorptive process to produce hydrogen
7427368	2008	34	5.33	Linde Plc	Synthesis gas and carbon dioxide generation method
6732796	2004	265	5.18	Royal Dutch Shell	In situ production of synthesis gas from a hydrocarbon containing formation
6695983	2004	52	4.79	BP/Linde Plc	Syngas production method utilizing an oxygen transport membrane
6190623	2001	114	4.60	Honeywell	Apparatus for providing a pure hydrogen stream for use with fuel cells

[17] High-impact patents are identified using 1790's Citation Index metric. This metric is derived by first counting the number of times a patent is cited as prior art by subsequent patents. This number is then divided by the mean number of citations received by peer patents from the same issue year and technology (as defined by their first listed Cooperative Patent Classification). For example, the number of citations received by a 2010 patent in CPC C01B 2203/0233 (Steam Reforming) is divided by the mean number of citations received by all patents in that CPC issued in 2010. The expected Citation Index for an individual patent is one. The extent to which a patent's Citation Index is greater or less than one reveals whether it has been cited more or less frequently than expected. For example, a Citation Index of 1.5 shows that a patent has been cited 50% more frequently than expected. Meanwhile a Citation Index of 0.7 reveals that a patent has been cited 30% less frequently than expected. By extension, the expected Citation Index for a portfolio of patents is also one, with values above one showing that a portfolio has been cited more than expected, and values below one showing that a portfolio has not been cited as frequently as expected. Note that the Citation Index is calculated for U.S. patents only, since citation rates differ across patent systems.

Table 5-3 is headed by an ExxonMobil patent (US #7,491,250) describing syngas production using pressure swing reforming. This patent has been cited as prior art by 114 subsequent patents, almost eleven times as many citations as expected, given its age and technology. In turn, this ExxonMobil is linked via citations to an earlier HFTO-funded Air Products & Chemicals patent family related to steam reforming. The patent in second place in Table 5-3 (US #6,821,501) is assigned to Shell, and describes a hydrogen production reactor for use in a hybrid power system. It has been cited by 176 subsequent patents, more than ten times as many citations as expected. In turn, this Shell patent is linked via citations to an earlier Los Alamos National Laboratory patent for a hydrogen-permeable membrane. ExxonMobil and Shell also have other highly cited patents linked via citations to HFTO-funded patents in Table 5-3, as do Panasonic, Air Products & Chemicals and Linde.

While the patent-level results focus on HFTO-funded hydrogen production patent families, it is also interesting to note the Other DOE-funded fuel cell families linked to the largest number of subsequent patent families owned by leading companies in this technology. These Other DOE-funded families are listed in Table 5-4. They are assigned to a variety of organizations, including companies (Bend Research, Engelhard, Air Products & Chemicals, Linde), DOE lab managers (University of California, Battelle Memorial Institute) and DOE itself. The patent family at the head of the table (representative patent US #5,498,278) is assigned to Bend Research and describes composite metal membranes for use in hydrogen separation. It is linked to 68 patent families owned by the leading companies, notably Shell families describing syngas production and Chevron families related to hydrogen production. The second-place patent family is assigned to the University of California, through its management of Los Alamos National Laboratory. This family is linked via citations to 58 patent families owned by the leading companies, including families from ten of these twelve companies (all except Dow and Honeywell).

Table 5-4 - Other DOE-Funded Hydrogen Production Patent Families Linked via Citations to Subsequent Leading Company Hydrogen Production Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
23415823	5498278	1990	68	Bend Research Inc	Composite hydrogen separation element and module
23256817	5525322	1994	58	Univ California (LANL)	Method for simultaneous recovery of hydrogen from water and from hydrocarbons
22056489	5451386	1993	53	Univ Oregon	Hydrogen-selective membrane
25129823	4696680	1985	50	US Dept Energy	Method and apparatus for the selective separation of gaseous coal gasification products by pressure swing adsorption
26982829	4504447	1981	48	US Dept Energy	Slab reformer
26887329	4946667	1985	39	Engelhard Corp	Method of steam reforming methanol to hydrogen
25104089	5814112	1996	23	Battelle Mem Inst (PNNL)	Nickel/ruthenium catalyst and method for aqueous phase reactions
21759879	6056807	1998	21	Air Products & Chem	Fluid separation devices capable of operating under high carbon dioxide partial pressures
46516866	8349214	2011	21	Linde Plc (Praxair)	Synthesis gas method and apparatus

Overall, the backward tracing element of the analysis suggests that HFTO-funded and Other DOE-funded hydrogen production patents have had a relatively strong influence on subsequent innovations associated with leading companies in this technology. This influence can be seen across a number of the companies, covering various technologies related to hydrogen production.

Tracing Forwards from DOE-funded Hydrogen Production Patents

The previous section of the report examines the influence of DOE-funded hydrogen production research upon innovations associated with leading hydrogen production companies. That analysis was based on tracing backwards in time from the patents of leading companies to previous generations of research. This section reports the results of an analysis tracing in the opposite direction – starting with HFTO-funded (and Other DOE-funded) hydrogen production patents, and tracing forwards in time through two generations of citations. Hence, while the previous section of the report focuses on DOE's influence upon a specific patent set (i.e., patents owned by leading hydrogen production companies), this section of the report focuses on the broader influence of HFTO-funded (and Other DOE-funded) hydrogen production research, both within and beyond the hydrogen production industry. Also, in order to avoid repeating earlier results, the forward tracing concentrates primarily on patents that are linked to DOE-funded hydrogen production research, but are not owned by leading hydrogen production companies.

Organizational Level Results

As a starting point for the forward tracing analysis, Figure 5-16 shows Citation Index values for the portfolios of HFTO-funded and Other DOE-funded hydrogen production patents, compared to the Citation Indexes of the twelve leading hydrogen production companies. These Citation Indexes are based on citations from all subsequent patents (unlike the backward tracing, which only included citations from patents owned by the leading hydrogen production companies).

Figure 5-16 - Citation Index for Leading Companies' Hydrogen Production Patents, plus HFTO-funded and Other DOE-funded Hydrogen Production Patents

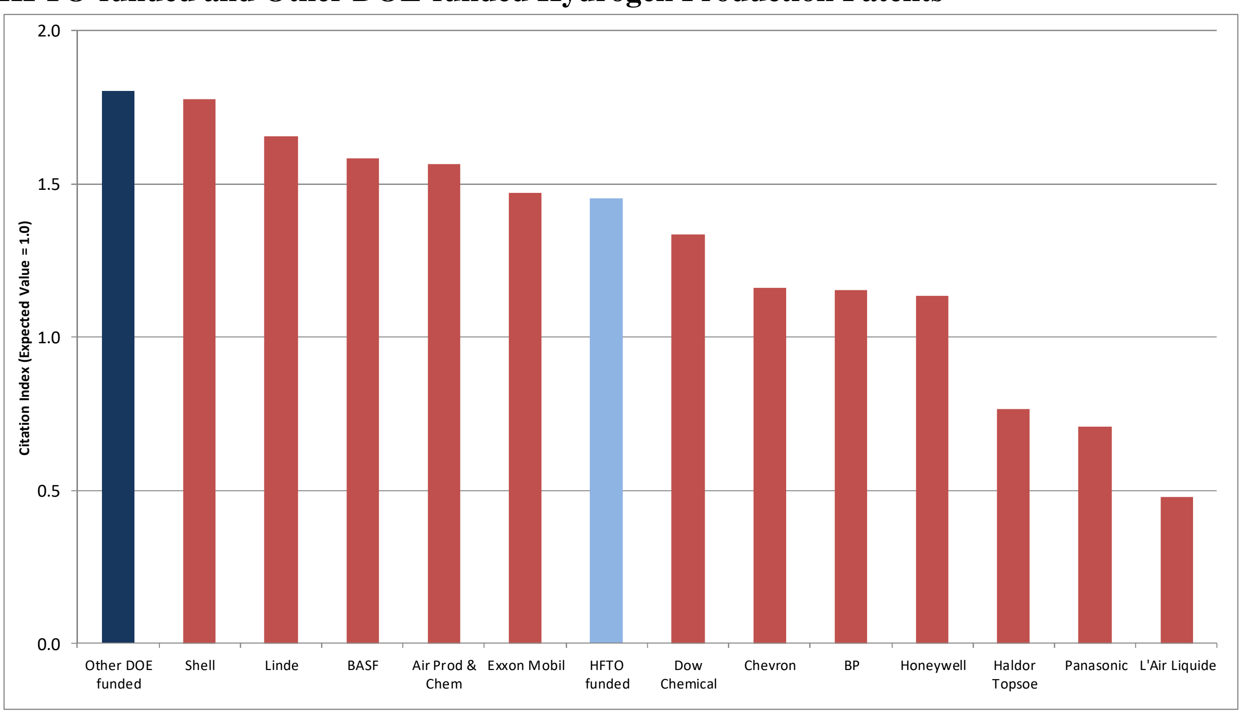


Figure 5-16 reveals that Other DOE-funded hydrogen production patents have a higher average Citation Index than all twelve leading companies in this industry. Their Citation Index of 1.80 shows that they have been cited 80% more frequently than expected, given their age and technology distribution. HFTO-funded hydrogen production patents have a lower average Citation Index of 1.45, but this still means they have been cited 45% more frequently than expected. This Citation Index puts HFTO-funded patents at the center of the distribution among the leading companies.

The Citation Index metric measures the overall influence of DOE-funded hydrogen production patents, but does not necessarily address the breadth of this influence across technologies. The Cooperative Patent Classifications (CPCs) of the patent families linked via citations to earlier HFTO-funded (and Other DOE-funded) hydrogen production patent families were therefore identified.[18] These CPCs reflect the influence of DOE-funded research across technologies.

Figure 5-17 - Number of Patent Families Linked via Citations to Earlier HFTO-Funded Hydrogen Production Patents by CPC (Dark Green = Hydrogen Production; Light Green = Other)

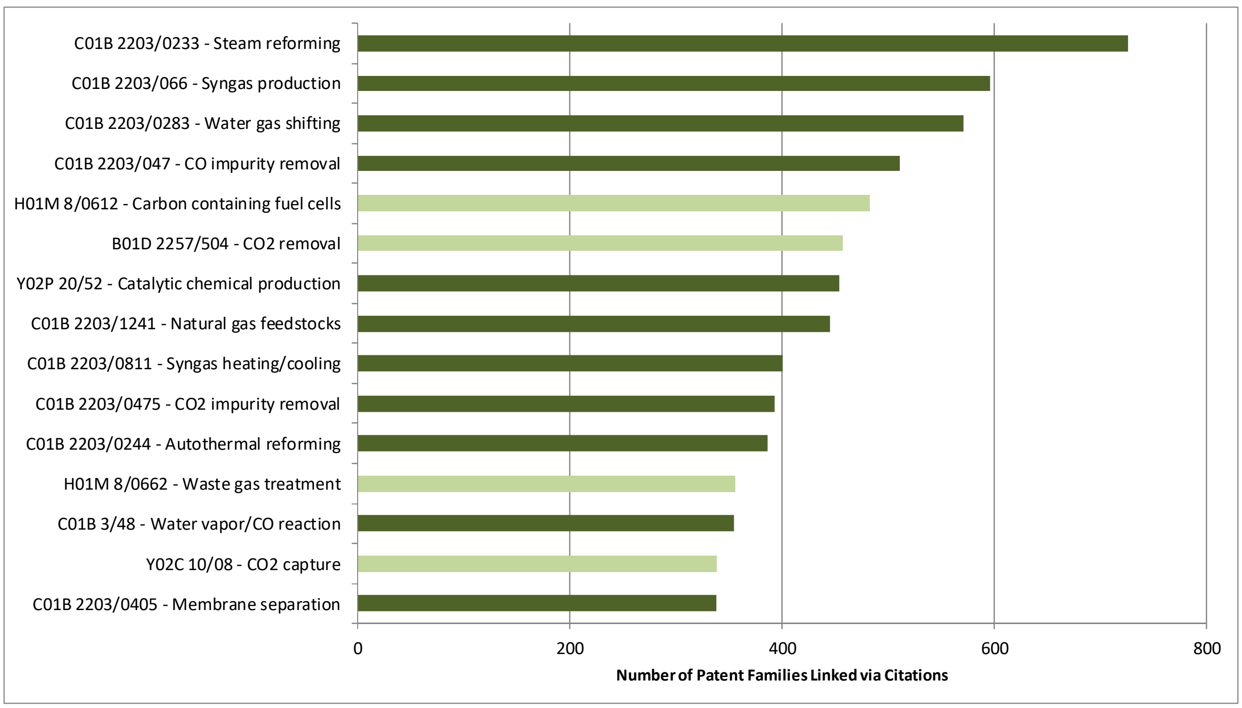


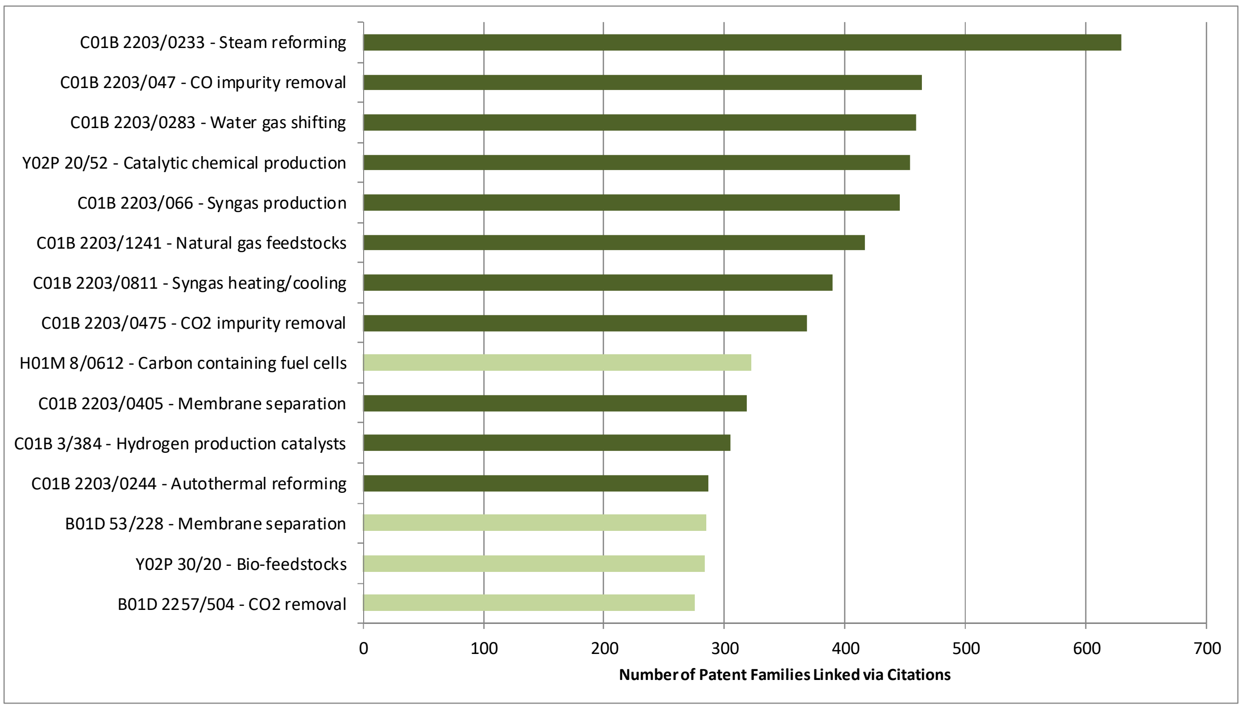
Figure 5-17 shows the CPCs with the largest number of patent families linked via citations to HFTO-funded hydrogen production patents. The CPCs in this figure are shown in two different colors – i.e., dark green for CPCs related to hydrogen production and light green for CPCs beyond hydrogen production. Out of the fifteen CPCs in Figure 5-17, eleven are related to hydrogen production. The most prevalent of these CPCs are C01B 2203/0233 (Steam reforming),

[18] Patents typically have numerous CPCs attached to them, reflecting different aspects of the invention they describe. In this analysis, all CPCs attached to the patents linked to earlier DOE-funded hydrogen production patent families are included.

C01B 2203/066 (Syngas production), C01B 2203/0283 (Water gas shifting) and C01B 2203/047 (Carbon monoxide impurity removal). Meanwhile, the CPCs beyond hydrogen production are H01M 8/0612 (Carbon-containing fuel cells), B01D 2257/504 and Y02C 10/08 (Carbon dioxide removal/capture), and H01M 8/0662 (Waste gas treatment). The latter are examples of the influence of HFTO-funded hydrogen production research extending into adjacent technologies.

Figure 5-18 is similar to Figure 5-17, but is based on patent families linked via citations to Other DOE-funded hydrogen production patents. Again, CPCs related to hydrogen production are shown in dark green, while CPCs related to other technologies are in light green. This figure is again dominated by CPCs related to hydrogen production, with a particular focus on steam reforming, carbon monoxide impurity removal and water gas shifting. The non-hydrogen production CPCs in Figure 5-18 are again similar to those in Figure 5-17, with the addition of Y02P 30/20 (Bio-feedstocks).

Figure 5-18 - Number of Patent Families Linked via Citations to Earlier Other DOE-Funded Hydrogen production Patents by CPC



The organizations with the largest number of patent families linked via citations to earlier HFTO-funded hydrogen production patents are shown in Figure 5-19. To avoid repeating the results from earlier, this figure excludes the twelve leading hydrogen production companies used in the backward tracing element of the analysis. Also, note that Figure 5-19 includes all patent families assigned to each organization, not just their patent families describing hydrogen production technology. This figure is dominated by very large companies. Automotive companies are particularly prominent, notably General Motors, Toyota, Ford and Honda, showing how HFTO-funded hydrogen production research has influenced subsequent developments in the automotive industry. Figure 5-19 also includes a number of specialist fuel cell companies, such as Ballard Power and Bloom Energy, reflecting the influence of HFTO-funded hydrogen production research in the fuel cells industry.

Figure 5-19 - Organizations with Most Patent Families Linked via Citations to HFTO-funded Hydrogen Production Patents (excluding leading hydrogen production companies)

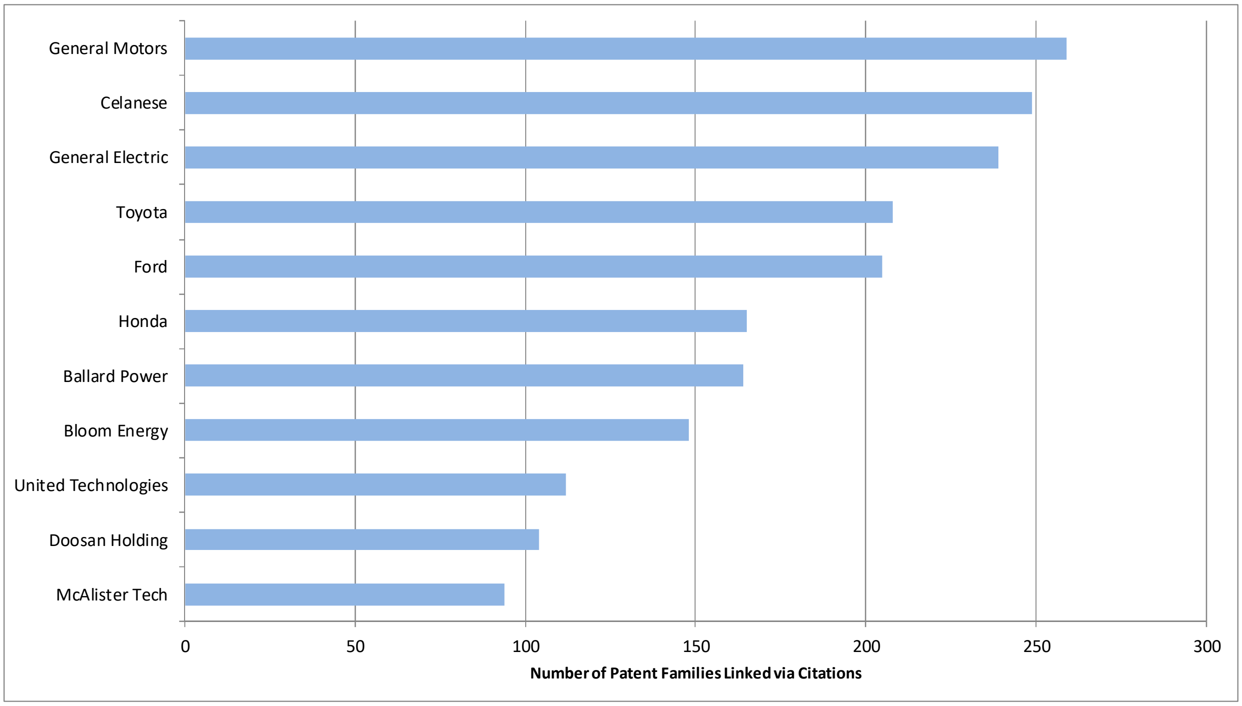


Figure 5-20 - Organizations Most Patent Families Linked via Citations to Other DOE-funded Hydrogen Production Patents (excluding leading hydrogen production companies)

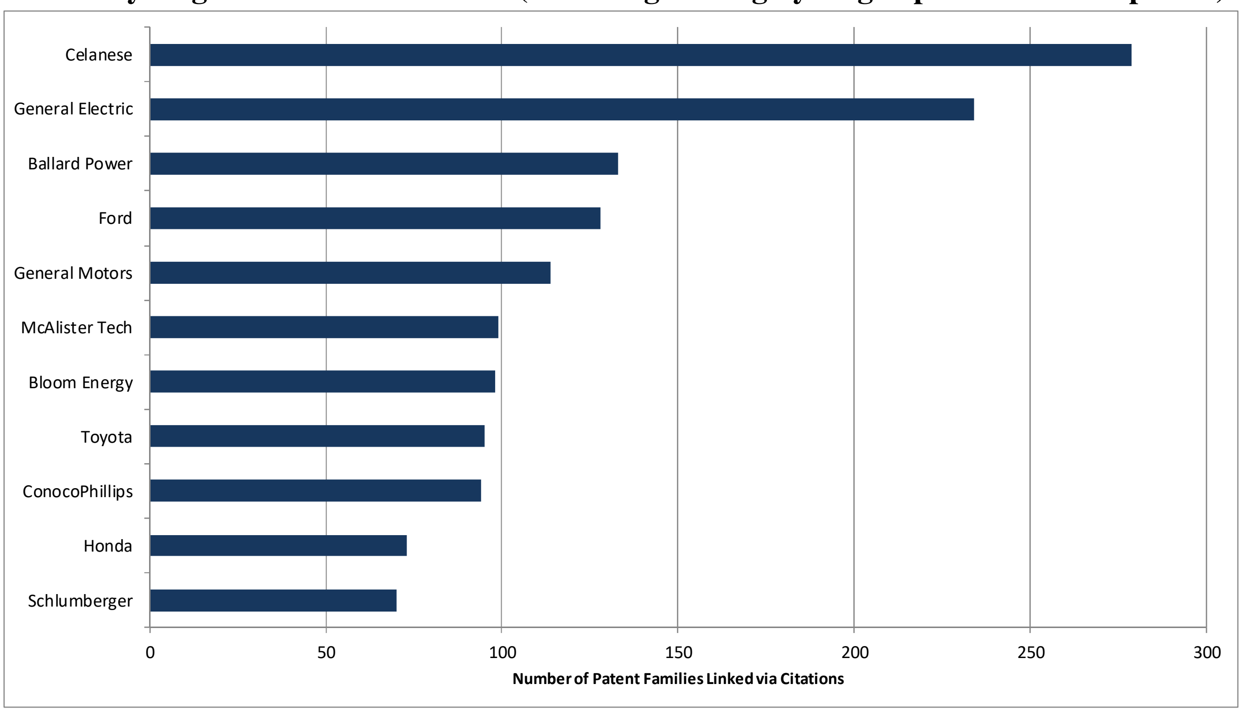


Figure 5-20 shows the organizations with the largest number of patent families linked via citations to earlier Other DOE-funded hydrogen production patents. This figure is dominated by two companies. Celanese is at the head of the figure, with 279 patent families linked via citations to earlier Other DOE-funded hydrogen production patents. These Celanese patent families focus on various technologies, with a particular concentration on ethanol production. General Electric is in second place in Figure 5-20 with 234 patent families linked via citations to Other DOE-funded hydrogen production patents. These General Electric patent families outline numerous technologies, notably turbine engines and waste gas treatment. Beyond Celanese and General Electric, Figure 5-20 again features a number of automotive and fuel cell companies, showing the influence of DOE-funded hydrogen production research in those technologies.

Patent Level Results

This section of the report drills down to identify individual DOE-funded (and particularly HFTO-funded) hydrogen production patents whose influence on subsequent technological developments has been particularly strong. It also highlights patents that have extensive citation links to earlier HFTO-funded hydrogen production research.

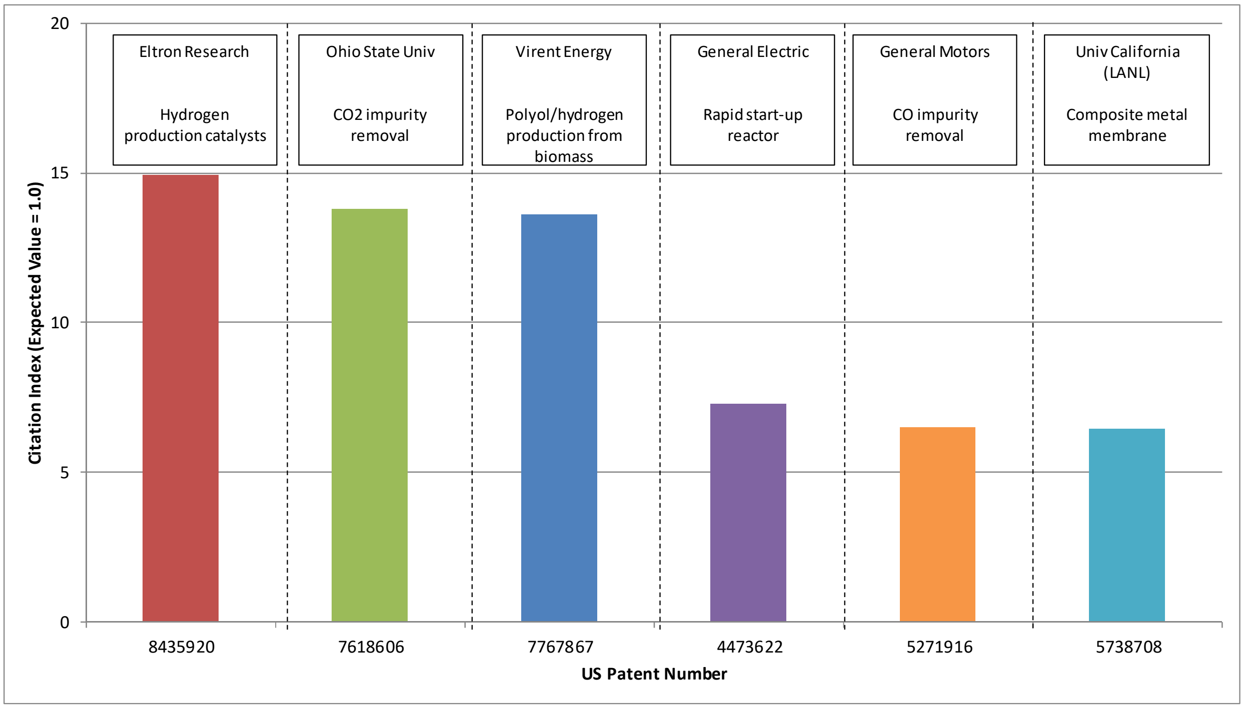
The simplest way of identifying high-impact HFTO-funded hydrogen production patents is via overall Citation Indexes. The HFTO-funded patents with the highest Citation Index values are shown in Table 5-5, with selected patents also presented in Figure 5-21. The patents in this table include older patents that have received large numbers of citations from subsequent generations of patents, and more recent patents that have attracted more citations than expected. One advantage of using Citation Indexes is that these two groups of patents can be compared directly, since each is benchmarked against peer patents of the same age and technology.

Table 5-5 – List of Highly Cited HFTO-Funded Hydrogen Production Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
8435920	2013	43	14.94	Eltron Research	Cyclic catalytic upgrading of chemical species using metal oxide materials
7618606	2009	98	13.79	Ohio State Univ	Separation of carbon dioxide (CO2) from gas mixtures by calcium based reaction separation (CaRS-CO2) process
7767867	2010	53	13.62	Virent Energy	Methods and systems for generating polyols
4473622	1984	136	7.27	UTRC (Raytheon)	Rapid starting methanol reactor system
5271916	1993	90	6.50	General Motors	Device for staged carbon monoxide oxidation
5738708	1998	153	6.44	Univ California (LANL)	Composite metal membrane
6641625	2003	131	6.16	Nuvera Fuel Cells	Integrated hydrocarbon reforming system and controls
7033570	2006	66	5.93	Univ Colorado / MRIGlobal	Solar-thermal fluid-wall reaction processing
5917136	1999	109	5.31	Air Products & Chem	Carbon dioxide pressure swing adsorption process using modified alumina adsorbents
6114400	2000	116	4.38	Air Products & Chem	Synthesis gas production by mixed conducting membranes with integrated conversion into liquid products

The patent at the head of Table 5-5 is assigned to Eltron Research, and was issued in 2013. It describes catalysts that can be used in hydrogen production, among other applications. This patent has been cited as prior art by 43 subsequent patents, which is almost fifteen times as many citations as expected for a patent of its age and technology. The patent in second place is a 2009 Ohio State University patent describing a method for separating carbon dioxide in hydrogen production. This patent has been cited by 98 subsequent patents, almost fourteen times as many citations as expected. Table 5-5 also contains a number of older HFTO-funded patents that have been highly cited by subsequent patents. These include a General Electric patent related to hydrogen production for fuel cells (US #4,473,622), a University of California (Los Alamos National Laboratory) patent describing a hydrogen-permeable membrane (US #5,738,708) and a Nuvera Fuel Cells patent related to a fuel reforming systems (US #6,641,625).

Figure 5-21 – Examples of Highly-Cited HFTO-funded Hydrogen Production Patents



The Citation Indexes in Table 5-5 are based on a single generation of citations to HFTO-funded hydrogen production patents. Tables 5-6 and 5-7 extend this by examining a second generation of citations – i.e., they show the HFTO-funded hydrogen production patents linked via citations to the largest number of subsequent patent families.[19] These subsequent families are divided into two groups, according to whether they are within or beyond hydrogen production technology (i.e., whether they are in the hydrogen production patent universe constructed in the initial step of this project). This provides insights into which HFTO-funded patent families have been particularly influential within hydrogen production technology, and which have had a broader impact beyond hydrogen production.

[19] The HFTO-funded patent families are divided into two tables based on their age, since older patents tend to be connected to larger numbers of subsequent patents, simply because there has been more time for them to become linked to future generations of technology.

Table 5-6 contains older patent families, with priority dates prior to 2000. This table is headed by a General Electric patent family describing hydrogen production for fuel cells. This family contains the US patent (US #4,473,622) highlighted earlier among the highly-cited patents in Table 5-5. It is linked via citations to 1,253 subsequent patent families, 329 of which are within hydrogen production. The second patent family in Table 5-6 (representative patent US #5,271,916) is assigned to General Motors, and describes a method for reducing carbon dioxide in a hydrogen-rich gas stream. It is linked via citations to 1,226 subsequent patent families, 347 of which are related to hydrogen production. In general, the patent families in Table 5-6 have extensive citation links both within and beyond hydrogen production. That said, there are exceptions where patent families are linked primarily to subsequent patents outside hydrogen production. For example, Table 5-6 includes an MIT patent family (representative patent US #6,560,958) for an emissions abatement system using hydrogen as a reducing gas. This patent family is linked via citations to 748 subsequent patent families, only 46 of which are related to hydrogen production, with many of the others describing emissions control.

Table 5-6 – Pre-2000 HFTO-funded Hydrogen Production Patent Families Linked via Citations to Largest Number of Subsequent Hydrogen Production/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Hyd Prodn Fams	Assignee	Title
23799772	1982	4473622	1253	329	General Electric	Rapid starting methanol reactor system
27111356	1991	5271916	1226	347	General Motors	Device for staged carbon monoxide oxidation
24825221	1996	6083425	1193	468	Arthur D. Little Inc	Method for converting hydrocarbon fuel into hydrogen gas and carbon dioxide
23592959	1995	5681373	886	240	Air Products & Chem	Planar solid-state membrane module
24148800	1995	5656064	886	89	Air Products & Chem	Base treated alumina in pressure swing adsorption
23495413	1999	6560958	748	46	MIT	Emission abatement system
23925657	1995	5738708	695	296	Univ California (LANL)	Composite metal membrane
24837049	1996	5637415	690	211	General Motors	Controlled CO preferential oxidation
23576014	1989	4919813	659	48	US Dept Energy	Photoenhanced anaerobic digestion of organic acids
25499438	1992	5367283	529	25	Lockheed Martin (ORNL)	Thin film hydrogen sensor

Table 5-7 contains newer HFTO-funded patent families, with priority dates from 2000 onwards. That said, most of these families are still relatively old, dating from the very start of this century. Four of the first five patent families in this table are assigned to Battelle Memorial Institute, through its management of Pacific Northwest National Laboratory. These Battelle patent families (for example, representative patent US #7,125,540) are related to microchannel devices, which can be used to produce hydrogen from hydrocarbon fuels, among other applications. They are each linked via citations to over 250 subsequent patent families, with many of these subsequent families being from beyond hydrogen production. This reflects the many potential applications of microchannel technology. Also prominent in Table 5-7 are a University of Central Florida patent family (representative patent US #6,653,005) for a compact hydrogen generator and an Ohio State University patent family (representative patent US #7,067,456) describing carbon dioxide separation in hydrogen-rich gas streams.

Table 5-7 – Post-1999 HFTO-funded Hydrogen Production Patent Families Linked via Citations to Largest Number of Subsequent Hydrogen Production/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Hyd Prodn Fams	Assignee	Title
24356190	2000	7125540	371	58	Battelle Memorial Inst (PNNL)	Microsystem process networks
29586387	2000	6653005	367	75	Univ Central Florida	Portable hydrogen generator-fuel cell apparatus
25296065	2001	6508862	313	23	Battelle Memorial Inst (PNNL)	Apparatus and methods for separation/purification utilizing rapidly cycled thermal swing sorption
24355649	2000	6666909	284	17	Battelle Memorial Inst (PNNL)	Microsystem capillary separations
28045294	2002	7297324	267	41	Battelle Memorial Inst (PNNL)	Microchannel reactors with temperature control
35909823	2003	7067456	254	36	Ohio State Univ	Sorbent for separation of carbon dioxide (CO2) from gas mixtures
25221328	2001	6713040	219	36	Argonne National Lab	Method for generating hydrogen for fuel cells
23091137	2001	6682838	217	46	Texaco	Integrated fuel processor, fuel cell stack, and tail gas oxidizer with carbon dioxide removal
39492770	2006	7767867	204	25	Virent Energy Systems	Methods and systems for generating polyols

The tables above identify HFTO-funded patent families linked particularly strongly to subsequent technological developments. Table 5-8 looks in the opposite direction, and identifies highly-cited patents linked to earlier HFTO-funded hydrogen production patents. As such, these are examples where HFTO-funded hydrogen production research has formed part of the foundation for subsequent high-impact innovations. This table focuses on patent families not owned by the leading hydrogen production companies, since those families were examined in the backward tracing element of the analysis.

The patent at the head of Table 5-8 (US #6,152,987) is assigned to Worcester Polytechnic Institute, and describes a hydrogen separation module. This patent has been cited as prior art by 337subsequent patents, which is almost fourteen times as many citations as expected for a patent of its age and technology. Many of these subsequent citing patents are assigned to Shell, and describe extraction and conversion of hydrocarbons and hydrogen. The second patent in Table 5-8 (US #7,767,867) is a 2010 Marathon Petroleum patent describing a method for generating oxygenated hydrocarbon products from biomass, using hydrogen produced from a portion of the biomass. This patent has been cited by 53 subsequent patents, more than thirteen times as many citations as expected. The remaining patents in Table 5-8 are assigned to a number of different organizations, cover a variety of technologies (including fuel cells, batteries and power generation), and have a range of issue dates. This reflects the influence of HFTO-funded hydrogen production patents over time across a range of applications.

Table 5-8 - Highly Cited Patents (not from leading hydrogen production companies) Linked via Citations to Earlier HFTO-funded Hydrogen Production Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
6152987	2000	337	13.95	Worcester Polytech Inst	Hydrogen gas-extraction module and method of fabrication
7767867	2010	53	13.62	Marathon Petroleum Corp	Methods and systems for generating polyols
7097925	2006	120	13.58	Xebec Adsorption Inc	High temperature fuel cell power plant
8147599	2012	58	13.48	McAlister Technologies	Apparatuses and methods for storing and/or filtering a substance
7169489	2007	99	11.77	FuelSell Technologies Inc	Hydrogen storage, distribution, and recovery system
7641992	2010	37	9.79	Medtronic Inc	Medical device having lithium-ion battery
7067208	2006	53	9.66	Bloom Energy	Load matched power generation system including a solid oxide fuel cell and a heat pump and an optional turbine
6187465	2001	245	9.32	Intellergy Corp	Process and system for converting carbonaceous feedstocks into energy without greenhouse gas emissions
6221117	2001	212	8.49	Ballard Power Systems Inc.	Hydrogen producing fuel processing system

As with the backward tracing element of the analysis, the patent-level results from the forward tracing focus on HFTO-funded hydrogen production patents. That said, within the forward tracing, it is also interesting to note the Other DOE-funded hydrogen production patent families linked to the largest number of subsequent patent families within and beyond hydrogen production technology. These Other DOE-funded hydrogen production families are shown in Table 5-9.

The patent family at the head of Table 5-9 (representative patent #5,525,322) is assigned to the University of California, through its management of Los Alamos National Laboratory. It describes the recovery of hydrogen from water and hydrocarbons, and is linked via citations to 1,716 subsequent patent families, including 414 families related to hydrogen production. This patent family was highlighted in the backward tracing element of the analysis, as was the patent family in second place in Table 5-9 (representative patent #5,498,278). The latter patent family is assigned to Bend Research (as is the patent family in third place in this table). It describes composite metal membranes for use in hydrogen separation, and is linked via citations to 1,282 subsequent patent families, 478 of which are related to hydrogen production. In general, the pattern of citation links in Table 5-9 suggests that the influence of the Other DOE-funded patent families can be seen both within and beyond hydrogen production technology.

Table 5-9 - Other DOE-funded Hydrogen Production Patent Families Linked via Citations to Largest Number of Subsequent Hydrogen Production/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Hyd Prodn Fams	Assignee	Title
23256817	1994	5525322	1716	414	Univ California (LANL)	Method for simultaneous recovery of hydrogen from water and from hydrocarbons
23415823	1990	5498278	1282	478	Bend Research Inc	Composite hydrogen separation element and module
27415983	1990	5217506	948	369	Bend Research Inc	Hydrogen-permeable composite metal membrane and uses thereof
26982829	1981	4504447	812	329	US Dept Energy	Slab reformer
22824550	1994	5821111	795	78	Bioengineering Resources Inc	Bioconversion of waste biomass to useful products
26887329	1985	4946667	708	300	Engelhard Corp	Method of steam reforming methanol to hydrogen
22056489	1993	5451386	706	293	Univ Oregon	Hydrogen-selective membrane
25104089	1996	5814112	653	275	Battelle Memorial Inst (PNNL)	Nickel/ruthenium catalyst and method for aqueous phase reactions
24565515	1996	6033632	532	114	Eltron Research Inc	Solid state oxygen anion and electron mediating membrane and catalytic membrane reactors containing them
25545367	2001	6699457	448	79	Wisconsin Alumni Res Found	Low-temperature hydrogen production from oxygenated hydrocarbons

The forward tracing element of the analysis thus shows that HFTO-funded and Other DOE-funded hydrogen production research has influenced subsequent innovations associated with a number of very large companies. This influence can be seen both within hydrogen production and in other technologies such as fuel cells, waste gas treatment and bioenergy.

Overall, the results from the hydrogen production analysis suggest that DOE-funded patenting in this technology has increased over time, with HFTO-funded patents representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded hydrogen production patents have had a relatively strong influence on subsequent innovations associated with the leading companies in hydrogen production technology. Meanwhile, the forward tracing reveals that their influence also extends beyond hydrogen production into other technologies, including fuel cells, waste gas treatment and bioenergy.

6. Results – Hydrogen Storage

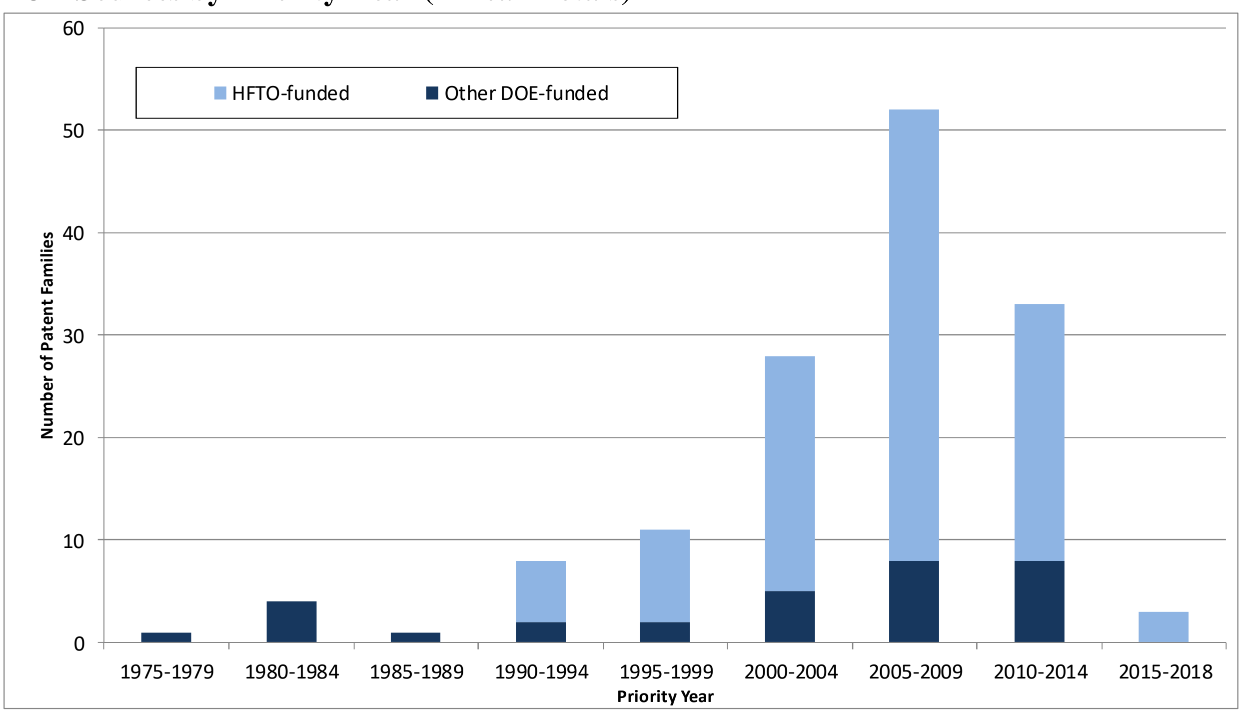
This section of the report outlines the results of an analysis tracing the influence of HFTO-funded and Other DOE-funded hydrogen storage research on subsequent developments both within and beyond hydrogen storage technology. The results are divided into three main sections. The first section examines trends in patenting over time in hydrogen storage, and assesses the distribution of HFTO-funded and Other DOE-funded patents across hydrogen storage technologies. The second section then reports the results of an analysis tracing backwards from hydrogen storage patents owned by the leading companies in this technology. The purpose of this analysis is to determine the extent to which hydrogen storage innovations developed by leading companies build upon earlier hydrogen storage research funded by HFTO (plus hydrogen storage research funded by the remainder of DOE). The third section reports the results of an analysis tracing forwards from HFTO-funded (and Other DOE-funded) hydrogen storage patents. The purpose of this analysis is to assess the broader influence of DOE-funded research upon subsequent developments within and beyond hydrogen storage technology.

Overall Trends in Hydrogen Storage Patenting

Trends in Hydrogen Storage Patenting over Time

Figure 6-1 shows the number of HFTO-funded and Other DOE-funded hydrogen storage patent families by priority year – i.e., the year of the first application in each patent family.

Figure 6-1 - Number of Hydrogen Storage Patent Families funded by HFTO and Other DOE Sources by Priority Year (5-Year Totals)

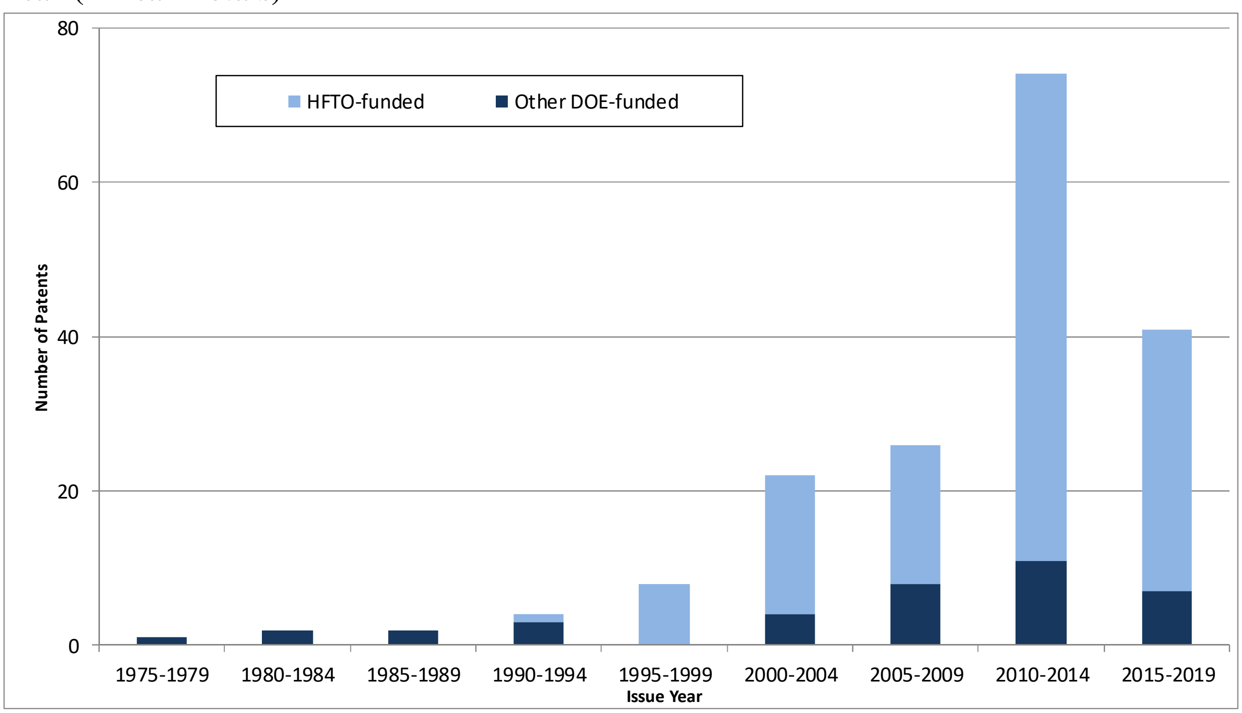


Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 6-1 reveals that, in the early years covered by the analysis, there was very little DOE-funded patenting in hydrogen storage, with only one patent family filed in 1975-1979, four in 1980-1984 and one in 1985-1989. None of these six patent families are defined as HFTO-funded. The number of DOE-funded hydrogen storage patent families then started to increase, slowly at first in the 1990s, and then much more rapidly in the 2000s, peaking at 52 patent families in 2005-2009 before declining to 33 patent families in 2010-2014. The final time period in Figure 6-1 is 2015-2018, which contains only partial data due to time lags associated with the patenting process. It should be noted that, out of the 135 DOE-funded hydrogen storage patent families filed since 1990, 110 (81%) are associated with HFTO funding.

Figure 6-2 shows the number of hydrogen storage granted U.S. patents funded by DOE. This figure follows a similar pattern to Figure 6-1, with very little patent activity prior to 1990, with none of the patents issued in this period being defined as HFTO-funded. The number of DOE-funded hydrogen storage patents then started to increase, peaking in 2010-2014 when 74 such patents were issued. The number of patents then declined in 2015-2019, although data from this period are incomplete (see note below Figure 6-2). HFTO-funded patents represent a high percentage of all DOE-funded hydrogen storage patents (79% overall; 81% among patents issued since 1990).

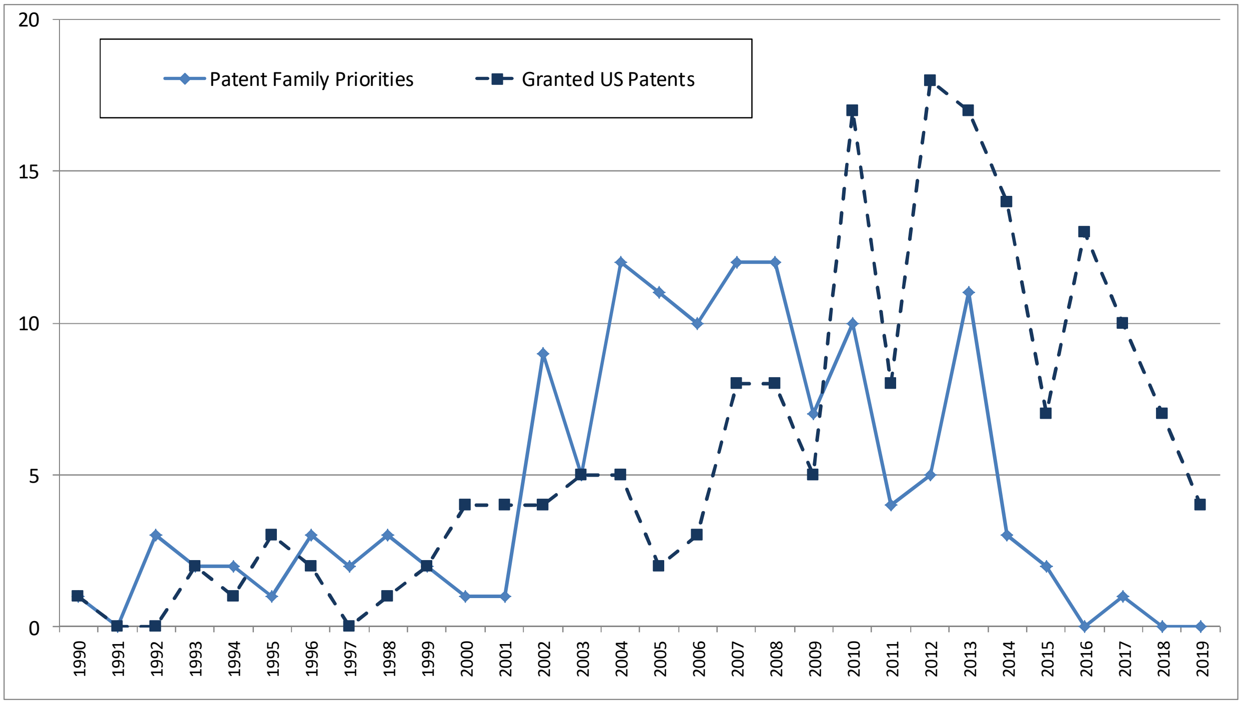
Figure 6-2 - Number of DOE-Funded Hydrogen Storage Granted U.S. Patents by Issue Year (5-Year Totals)



Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

Comparing Figures 6-1 and 6-2 shows the effect of time lags in the patenting process, with many of the patent families with priority dates in 2005-2009 (Figure 6-1) resulting in granted U.S. patents in 2010-2014 (Figure 6-2). These time lags can also be seen in Figure 6-3, which shows hydrogen storage patent family priority years alongside issue years for granted U.S. hydrogen storage patents (HFTO and Other DOE are combined in this figure, in order to simplify the presentation). In Figure 6-3, DOE-funded family priorities were at their highest level between 2004 and 2008, with peaks in granted U.S. patents occurring in 2010 and 2012-2013. In more recent years, the number of DOE-funded hydrogen storage patent families declined, leading to a subsequent decline in granted U.S. patents. Note that, due to the primary data collection for this analysis ending in 2018, the number granted U.S. patents declines further in 2019, and the number of patent families is zero.

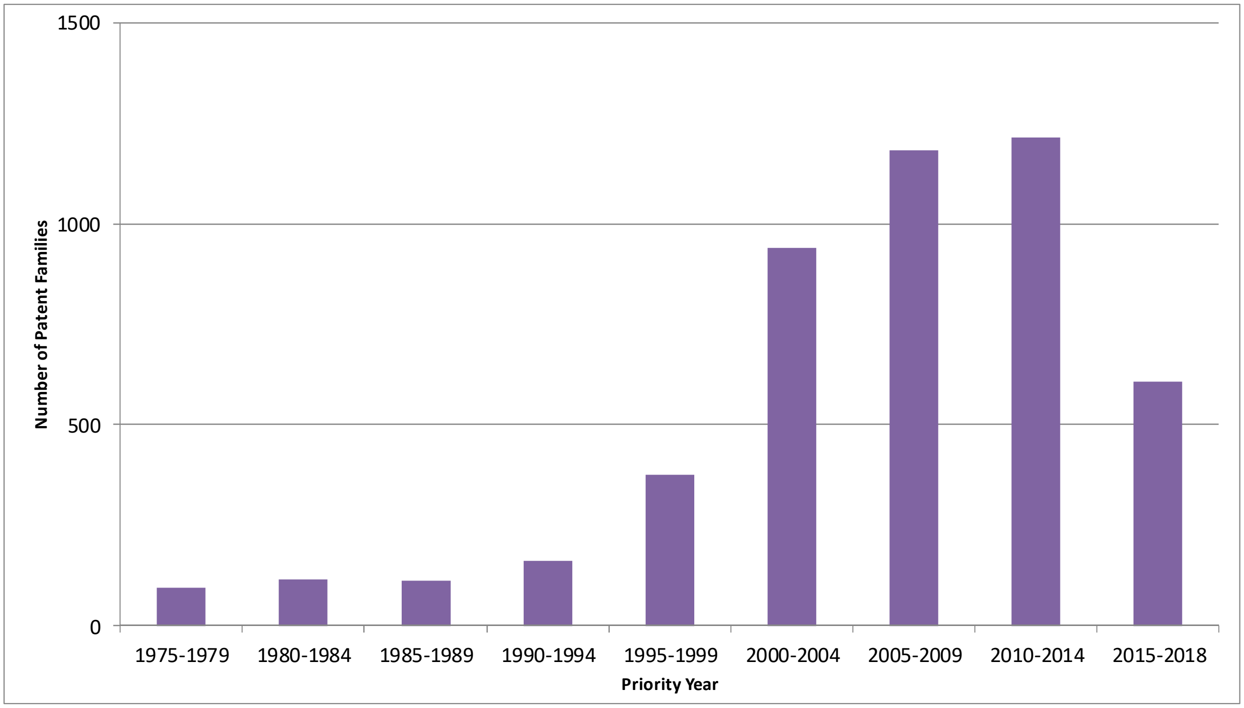
Figure 6-3 - Number DOE-funded Hydrogen Storage Patent Families (by Priority Year) and Granted U.S. Patents (by Issue Year)



Note: The data collection for this analysis ended with 2018. Some patents in the 2015-2019 column were issued in 2019. These are members of patent families with pre-2019 patents. No new patent search for 2019 was carried out.

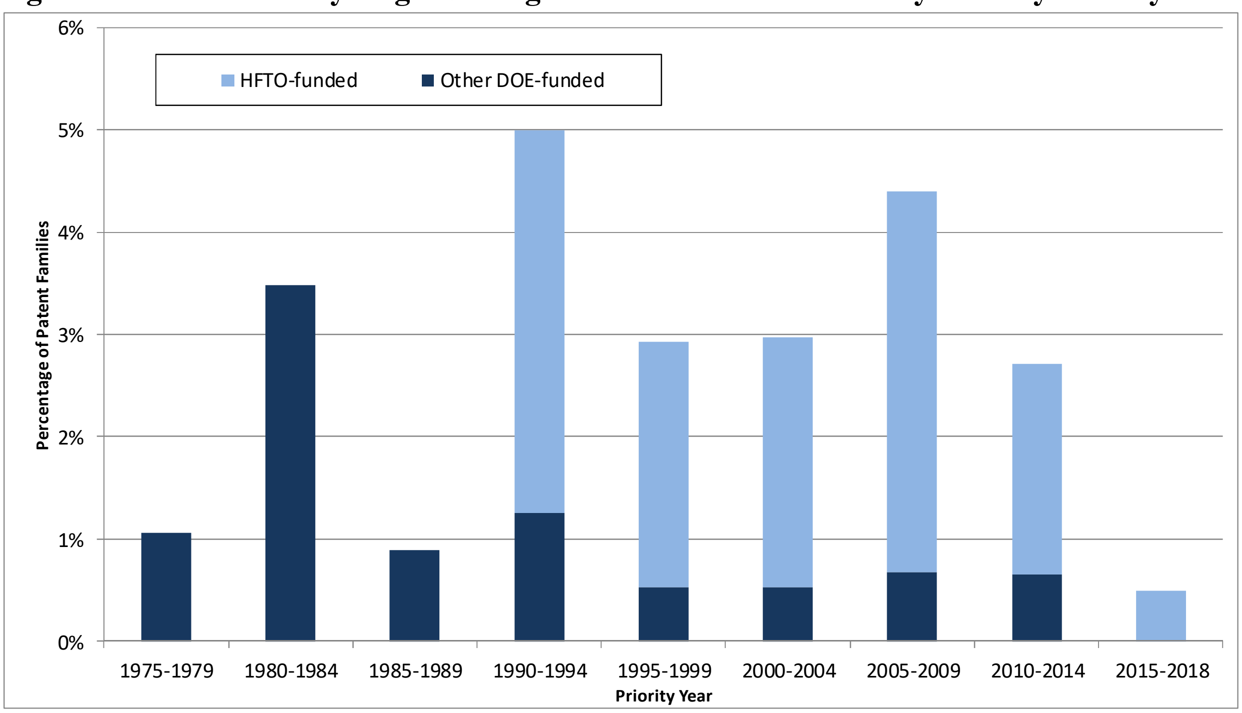
Figures 6-1 – 6-3 focus on DOE-funded hydrogen storage patent families. Figure 6-4 broadens the scope, and shows the overall number of hydrogen storage patent families by priority year (based on USPTO, EPO, and WIPO filings). This figure follows a relatively similar pattern to Figure 6-1, which focused on DOE-funded patents, albeit with one notable difference. Specifically, overall patenting in hydrogen storage was relatively sparse before 1990, before increasing slowly in the 1990s and much more rapidly after 2000. This is similar to the trend in DOE-funded hydrogen storage patenting. However, while the peak in DOE-funded patenting occurred in 2005-2009, followed by a decline in 2010-2014, overall hydrogen storage patenting remained high in the latter time period, indeed showing a slight increase (1,216 patent families were filed in 2010-2014, versus 1,182 in 2005-2009). Overall hydrogen storage patenting declined in 2015-2018, but data from this time period are incomplete.

Figure 6-4-Total No. of Hydrogen Storage Patent Families by Priority Year (5-Year Totals)



Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 6-5 -Percent of Hydrogen Storage Patent Families Funded by DOE by Priority Year



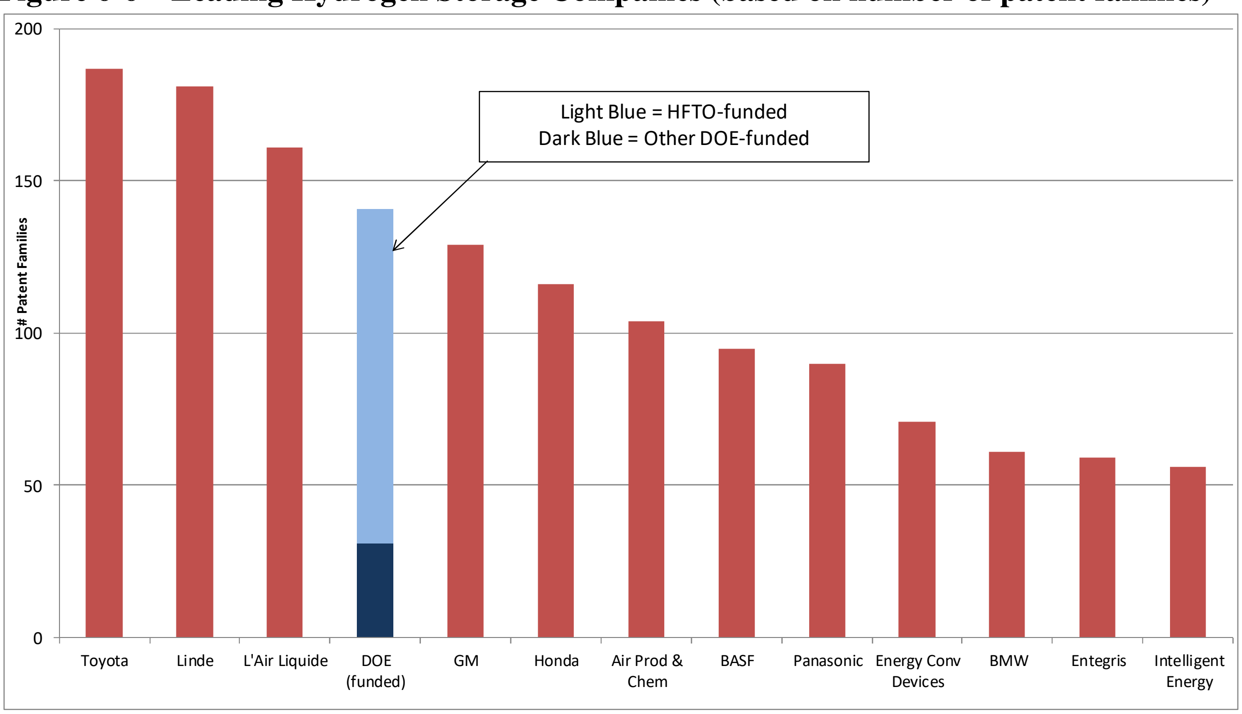
Note: The final time period in this figure (2015-2018) is shown for completeness, although data for this time period are incomplete. The primary data collection for this analysis covered patents issued through 2018. Due to time lags associated with the patenting process, only a fraction of the patent families filed in 2015-2018 are included.

Figure 6-5 shows the percentage of hydrogen storage patent families in each time period that were funded by DOE (HFTO plus Other DOE). In the early years in this figure, the numbers of patent families are low, so the percentages do not carry a great deal of meaning. From 1990 onwards, the numbers of patent families started to increase, so the results are of greater interest. Figure 6-5 reveals that approximately 3-5% of all hydrogen storage patent families in each time period between 1990 and 2009 were funded by DOE, with this percentage falling slightly to 2.8% in 2010-2014. Most of these DOE-funded patents were funded by HFTO, with HFTO-funded patents accounting for 2-4% of the overall total in each time period from 1990 to 2014. Overall, 2.9% of hydrogen storage patent families in the period 1976-2018 were funded by DOE.

Leading Hydrogen Storage Patenting Companies

The twelve leading patenting companies in hydrogen storage technology are listed above in Table 3-5, along with their number of hydrogen storage patent families. These top twelve companies are the basis for the backward tracing element of the analysis, as outlined below. Figure 6-6 shows the same information in graphical form, while also including DOE-funded patent families. This figure reveals that the Toyota has the largest hydrogen storage patent portfolio, containing 187 patent families, followed by Linde (181 families) and L'Air Liquide (161 families). The DOE-funded hydrogen storage portfolio of 141 patent families (110 HFTO-funded; 31 Other-DOE funded) is the fourth largest in Figure 6-6. The remaining leading company portfolios range in size from General Motors (129 patent families) to Intelligent Energy (56 families). One notable feature of Figure 6-6 is the wide geographical distribution of the leading companies, with five from Europe, four from the U.S. and three from Asia.

Figure 6-6 – Leading Hydrogen Storage Companies (based on number of patent families)



It should be noted that there is a small amount of double-counting of patent families in Figure 6-6. Specifically, six out of the 1,306 patent families assigned to the leading companies (three Toyota; two Energy Conversion Devices; one BASF) were funded, at least in part, by HFTO. These six patent families are counted in both the HFTO-funded segment of Figure 6-6 and in the respective company columns. This double-counting is appropriate, since these patent families are both funded by HFTO and assigned to a leading company.

Assignees of HFTO/Other DOE Hydrogen Storage Patents

The DOE-funded hydrogen storage patent portfolios are constructed somewhat differently from the portfolios of the top twelve companies listed in Figure 6-6. Specifically, DOE's 141 patent families are those funded by DOE, but they are not necessarily assigned to the agency. For example, HFTO (or another DOE office) may have partially or fully funded research projects at DOE labs or companies. In such cases, the assignees of any resulting patents may be the DOE lab managers or companies (as with the six leading company patent families discussed above).

Figure 6-7 shows the leading assignees on HFTO-funded hydrogen storage patent families. This figure is headed by two assignees associated with DOE's Savannah River National Laboratory (SRNL) – Savannah River Nuclear Solutions and Washington Savannah River Company – with thirteen and nine patent families respectively. The next three assignees are DOE lab managers – University of California (primarily Lawrence Berkeley National Laboratory), Los Alamos National Security LLC (Los Alamos National Laboratory) and Lawrence Livermore National Security LLC (Lawrence Livermore National Laboratory). This suggests that HFTO has funded hydrogen storage research across a variety of DOE national laboratories. The most prolific non-DOE lab manager in Figure 6-7 is Rohm & Haas, with five patent families.

Figure 6-7 - Assignees with Largest Number of HFTO-Funded Hydrogen Storage Patent Families

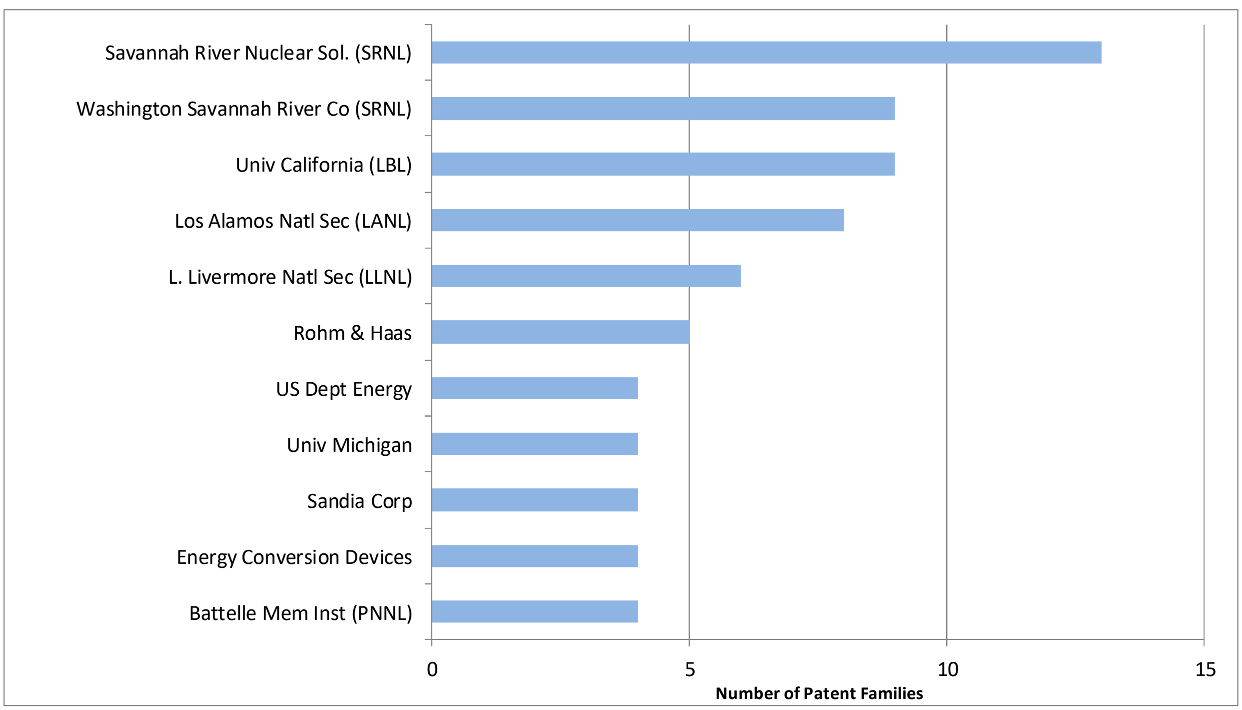
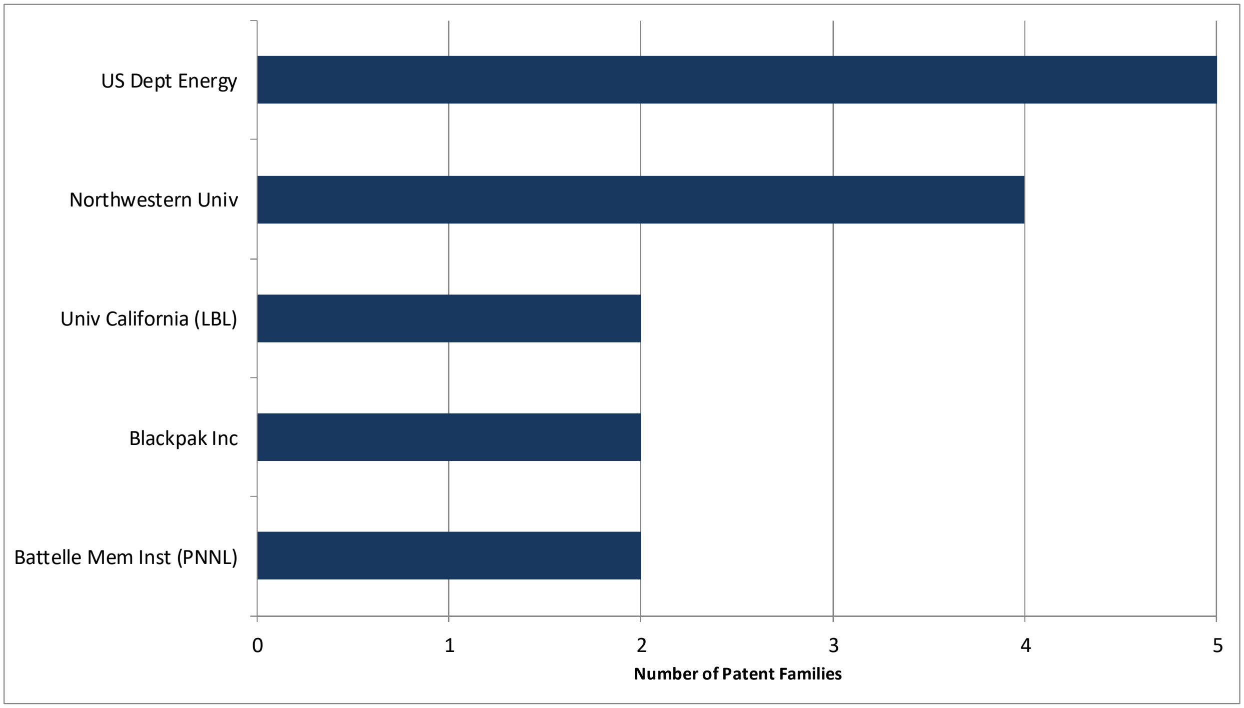


Figure 6-8 shows the leading assignees on Other DOE-funded hydrogen storage patent families. The numbers of patent families in this figure are low, which is not surprising given that there are only 31 Other DOE-funded hydrogen storage patent families in total. The most prolific assignee in Figure 6-8 is DOE itself, with five patent families. Such an assignment may occur for various reasons, including where the inventors are federal employees; where the funding recipient elects not to pursue patent protection for, or take title to, the invention; or where the funding recipient does not have the right to take title to the invention. The second most prolific assignee in Figure 6-8 is Northwestern University with four patent families. No other assignee has more than two Other DOE-funded hydrogen storage patent families.

Figure 6-8 - Assignees with Largest Number of Other DOE-funded Hydrogen Storage Patent Families



Distribution of Hydrogen Storage Patents across Patent Classifications

This section analyzes the distribution of HFTO-funded hydrogen storage U.S. patents across Cooperative Patent Classifications (CPCs).[20] The distribution is compared to those associated with Other DOE-funded hydrogen storage patents; hydrogen storage patents assigned to the twelve leading companies; and the universe of all hydrogen storage patents. This analysis provides insights into the technological focus of HFTO funding in hydrogen storage, versus the focus of the remainder of DOE, leading hydrogen storage companies, and hydrogen storage technology in general.

[20] The CPC is a patent classification system. Patent offices attach numerous CPC classifications to a patent, covering the different aspects of the subject matter in the claimed invention. In generating these charts, all CPCs associated with each patent are included.

The results from this CPC analysis are shown in two separate charts, each from a different perspective. The first chart (Figure 6-9) is based on the six CPCs that are most prevalent among HFTO-funded hydrogen storage patents. The purpose of this figure is thus to show the main focus areas of HFTO-funded hydrogen storage research, and the extent to which these areas translate to other portfolios (Other DOE-funded; leading hydrogen storage companies; all hydrogen storage). This figure shows that HFTO-funded research includes relatively balanced coverage across the six CPCs (which is not particularly surprising, since the HFTO-funded patent portfolio forms the basis for the CPCs included in the chart). The two most common CPCs among HFTO-funded hydrogen storage patents are Y02E 60/327 (Hydrogen storage in metals/alloys) and Y02E 60/321 (Hydrogen storage in containers), with 26% of HFTO-funded patents featuring the former CPC and 23% featuring the latter. A much higher percentage of all hydrogen storage patents, and those patents assigned to the leading companies, include CPC Y02E 60/321, which is a somewhat generic CPC for hydrogen storage containers. Meanwhile, one CPC where both HFTO-funded and Other DOE-funded patents have a greater focus than the other portfolios is C01B 3/0078 (Composite solid storage of hydrogen).

Figure 6-9 - Percentage of Hydrogen Storage U.S. Patents in Most Common Cooperative Patent Classifications (Among HFTO-Funded Patents)

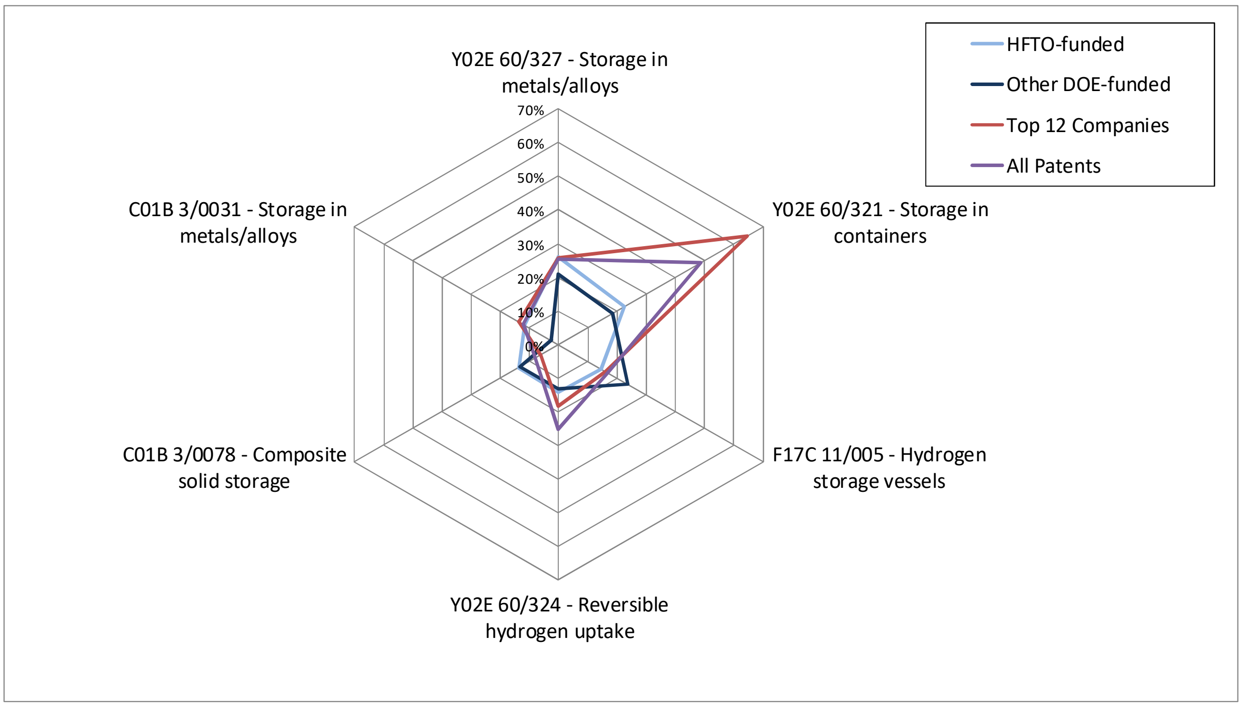


Figure 6-10 is similar to Figure 6-9, except that it is from the perspective of the most common CPCs among all hydrogen storage patents. Hence, the purpose of this chart is to show the main research areas within hydrogen storage as a whole, and how these areas are represented in selected hydrogen storage portfolios (HFTO-funded; Other DOE-funded; leading hydrogen storage companies). Five out of the six CPCs in Figure 6-9 also appear in Figure 6-10, suggesting that HFTO-funded hydrogen storage patents have been generally in line with broader technological trends in this industry. The one new CPC in Figure 6-10 is F17C 2221/012 (Hydrogen storage vessels). This CPC concerned primarily with the physical structure of hydrogen storage vessels, rather than the materials used in hydrogen storage.

Figure 6-10 - Percentage of Hydrogen Storage U.S. Patents in Most Common Cooperative Patent Classifications (Among All Hydrogen Storage Patents)

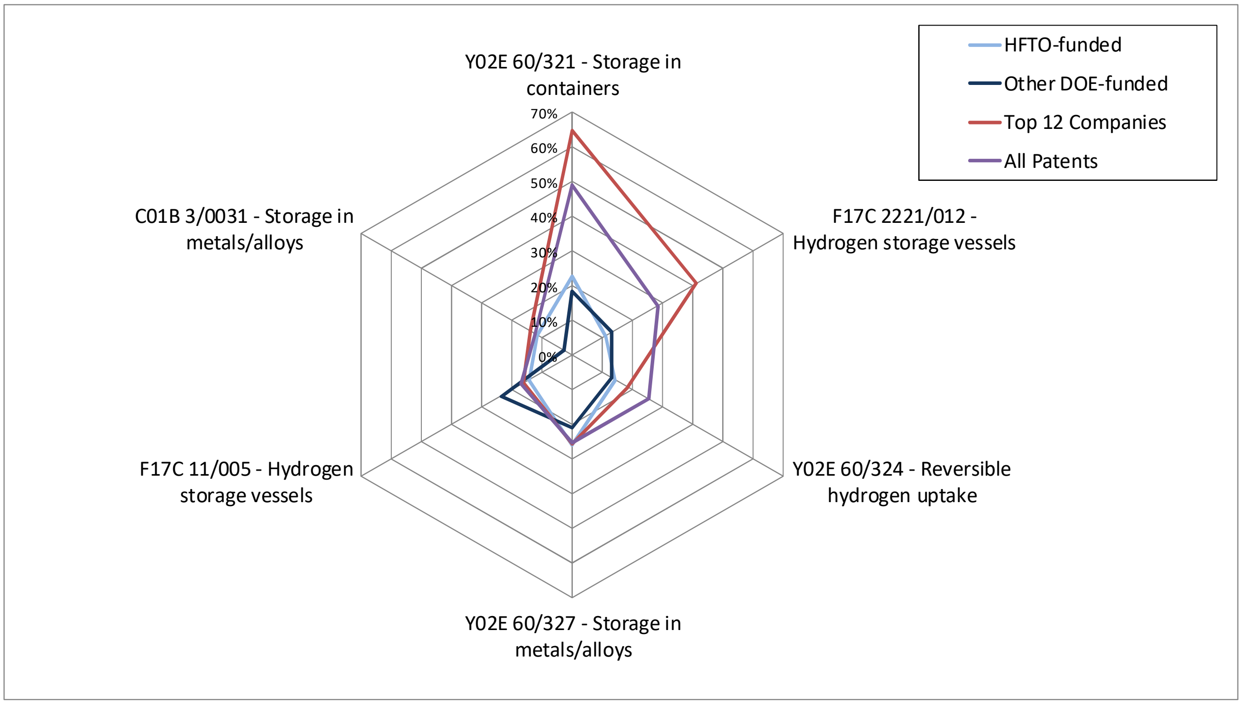


Figure 6-11 - Percentage of HFTO-funded Hydrogen Storage U.S. Patents in Most Common Cooperative Patent Classifications across Two Time Periods

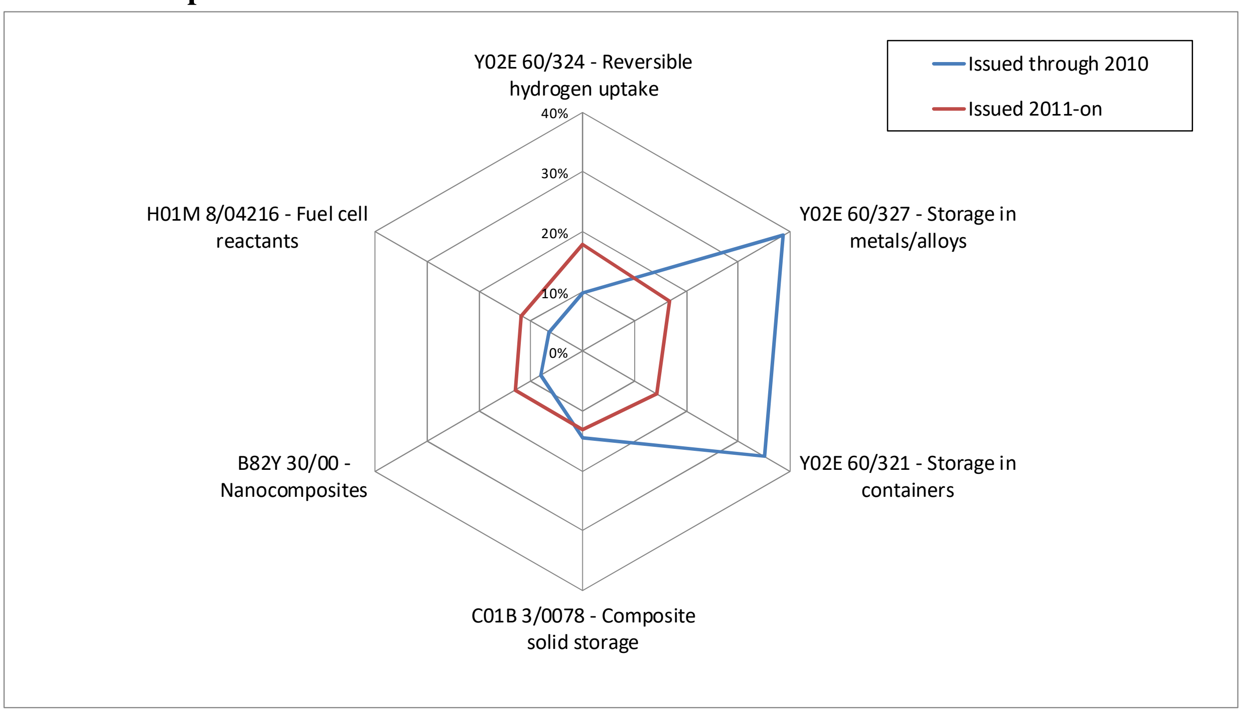


Figure 6-11 compares the CPC distribution of HFTO-funded hydrogen storage U.S. patents across two time periods – patents issued through 2010, and those issued from 2011 onwards. This figure suggests a change in emphasis in the more recent time period. While HFTO-funded patent families filed through 2010 focus on storage in metals and alloys (Y02E 60/327), plus the more generic hydrogen storage in containers (Y02E 60/321), the more recent time period shows a greater concentration on reversible hydrogen uptake (CPC Y02E 60/324), fuel cell reactants (CPC H01M 8/04216) and nanocomposites (CPC B82Y 30/00).

Tracing Backwards from Hydrogen Storage Patents Owned by Leading Companies

This section reports the results of an analysis tracing backwards in time from hydrogen storage patents owned by leading companies in this technology to earlier research, including that funded by HFTO (and by DOE in general). The results in this section are presented at two levels. First, results are reported at the organizational level. These results reveal the extent to which HFTO-funded (and Other DOE-funded) research forms a foundation for subsequent innovations associated with leading hydrogen storage companies. Second, there is a drill-down to the level of individual patents, with a particular focus on HFTO-funded hydrogen storage patents. These patent-level results highlight specific HFTO-funded patents that have had a particularly strong influence on subsequent patents owned by leading companies. They also highlight which hydrogen storage patents owned by these leading companies are linked particularly extensively to earlier HFTO-funded research.

Organizational Level Results

In the organizational level results, the influence of HFTO-funded and Other DOE-funded hydrogen storage research is compared against the influence of leading companies in this technology. The leading companies that build particularly extensively on DOE-funded hydrogen storage research are then identified.

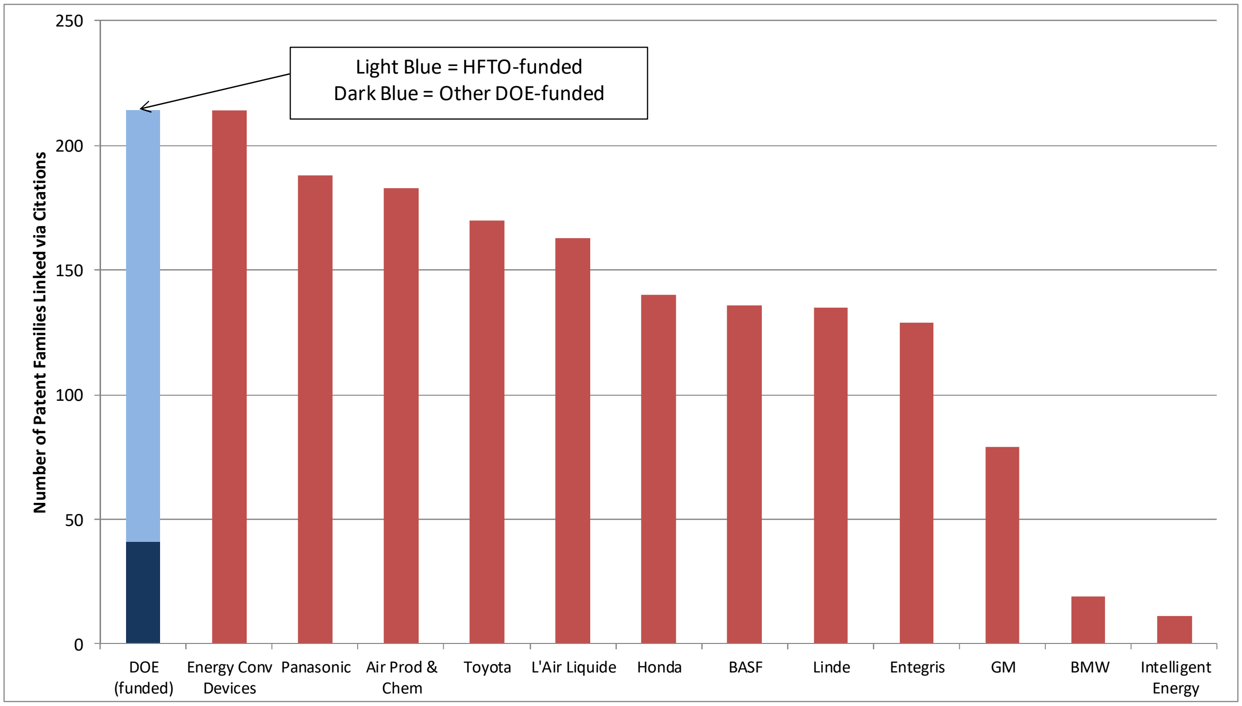
Figure 6-12 compares the influence of HFTO-funded and Other DOE-funded hydrogen storage research to the influence of research carried out by the top twelve hydrogen storage companies. Specifically, this figure shows the number of hydrogen storage patent families owned by the leading companies that are linked via citations to earlier hydrogen storage patent families assigned to each of these leading companies (plus patent families funded by DOE). In other words, this figure shows the companies whose patents have had the strongest influence upon subsequent innovations associated with leading companies in hydrogen storage technology.[21]

In total, 214 leading company hydrogen storage patent families (i.e., 16.4% of their 1,306 families) are linked via citations to earlier DOE-funded hydrogen storage patents. Out of these 214 families, 173 (i.e., 13.2% of the 1,306 leading company families) are linked to HFTO-

[21] This figure compares the influence of patents *funded* by HFTO/Other DOE against patents *owned* by (i.e. assigned to) organizations. Such a comparison is reasonable, since patents funded by organizations through their R&D budgets will be assigned to those organizations. Also, organizations cannot choose to reference the patents of a non-competitor (such as DOE) rather than the patents of a competitor in order to reduce the “credit” given to that competitor. Such an omission could lead to the invalidation of their patents. Note that, as in Figure 6-6, there is a small amount of double-counting in Figure 6-12, as some patent families assigned to the leading companies were funded by HFTO. Also, in Figures 6-12 – 6-15, leading company patent families linked to both HFTO-funded and Other DOE-funded patents are allocated to the HFTO-funded segment of the DOE column, in order to avoid double-counting these families.

funded hydrogen storage patents. This puts DOE-funded patents in first place in Figure 6-12, tied with Energy Conversion Devices. It is an impressive result for DOE (and HFTO in particular, whose patent families account for most of the citation links), especially since the DOE-funded patent portfolio is only the fourth largest among the leading companies (see Figure 6-6).

Figure 6-12 - Number of Leading Company Hydrogen Storage Patent Families Linked via Citations to Earlier Hydrogen Storage Patents from each Leading Company



Figures 6-13 through 6-15 examine which of the leading companies build particularly extensively on earlier HFTO-funded and Other DOE-funded hydrogen storage patents. Figure 6-13 shows how many hydrogen storage patent families owned by each of the leading companies are linked via citations to earlier DOE-funded hydrogen storage patents. Out of the twelve leading hydrogen storage companies, four have particularly strong citation links to earlier DOE-funded patents, suggesting that they build most extensively on DOE-funded hydrogen storage research. General Motors heads this list, with 38 patent families linked via citations to DOE-funded patents, 34 of which are linked to HFTO. BASF is second, with 36 patent families linked to DOE-funded patents (29 linked to HFTO-funded patents), followed by Toyota (29 linked to DOE; 24 to HFTO) and Energy Conversion Devices (28 linked to DOE; 24 to HFTO).

Figure 6-14 counts the total number of citation links from leading companies to earlier DOE-funded patents. This differs slightly from the count of linked families in Figure 6-13, since a single patent family may be linked to multiple earlier DOE-funded patents. The same four companies are again at the head of Figure 6-14, reinforcing their link to earlier DOE-funded hydrogen storage research. The biggest difference between Figures 6-13 and 6-14 is that General Motors leads by a greater margin in the latter figure, with a total of 93 citation links to earlier DOE-funded patents (70 of which are links to HFTO-funded patents).

Figure 6-13 - Number of Patent Families Assigned to Leading Hydrogen Storage Companies Linked via Citations to Earlier HFTO/Other DOE-funded Hydrogen Storage Patents

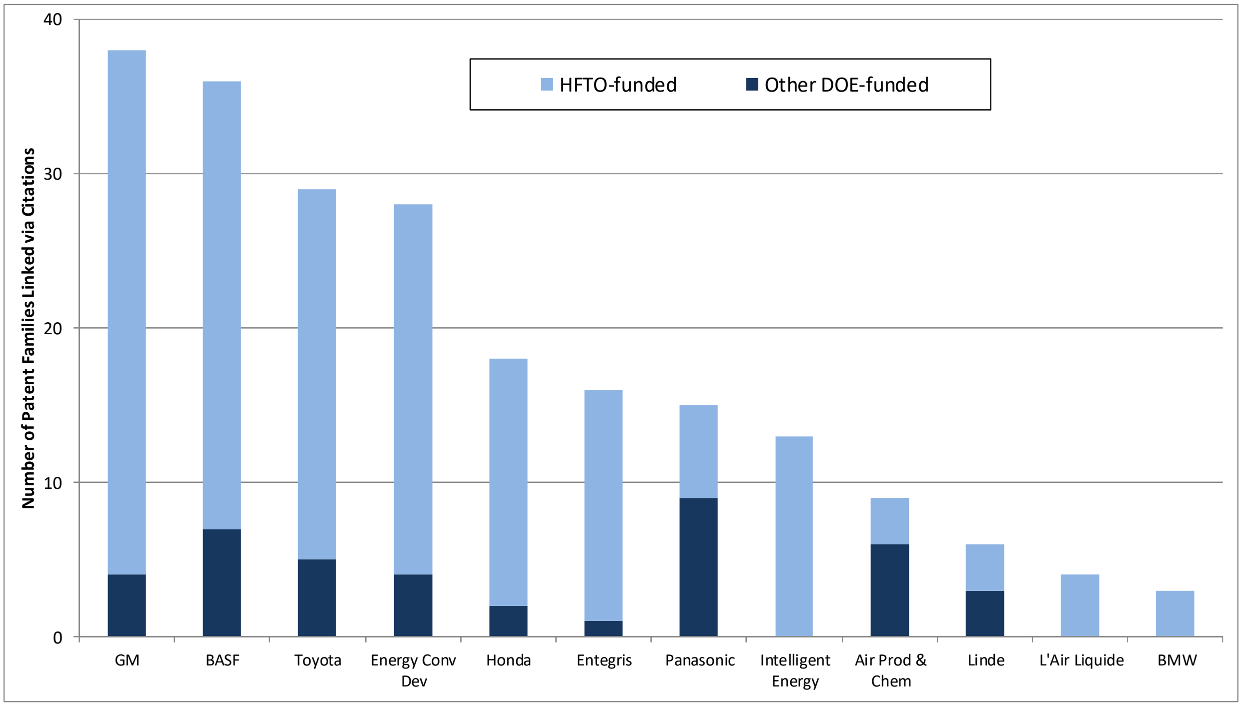
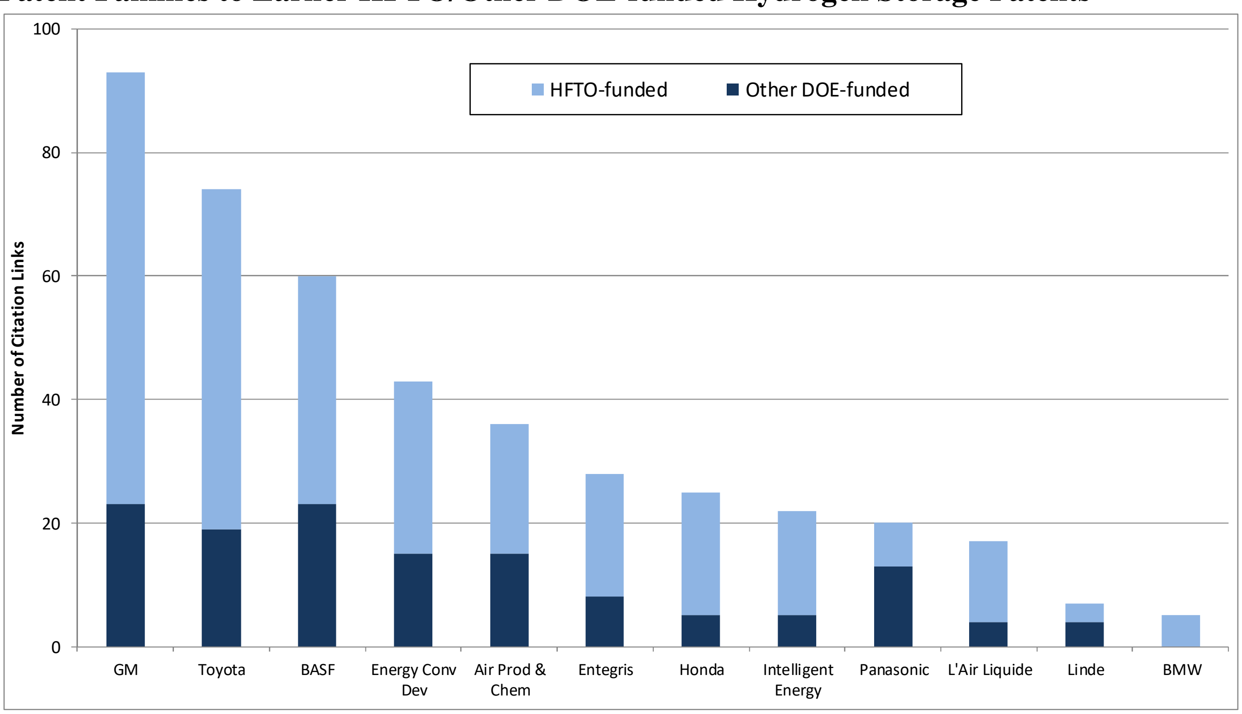


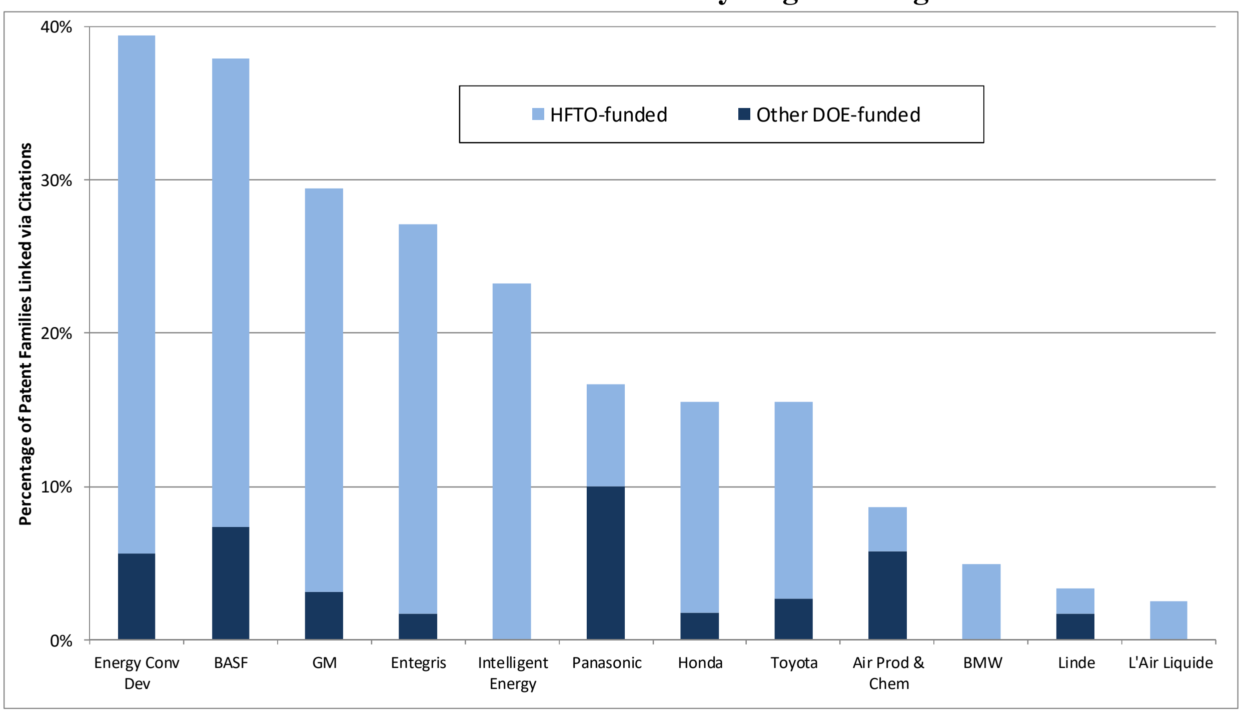
Figure 6-14 - Total Number of Citation Links from Leading Hydrogen Storage Company Patent Families to Earlier HFTO/Other DOE-funded Hydrogen Storage Patents



There is an element of portfolio size bias in the patent family counts in Figures 6-13 and 6-14. Companies with larger hydrogen storage patent portfolios are likely to have more patent families linked to DOE, simply because they have more families overall. Figure 6-15 accounts for this portfolio size bias by calculating the percentage of each leading company's hydrogen storage patent families that are linked via citations to earlier DOE-funded hydrogen storage patents, rather than their absolute number. This is a measure of how extensively each company builds on DOE-funded research, relative to their overall patent output.

Figure 6-15 reveals that five of the leading companies have more than 20% of their hydrogen storage patent families linked via citations to earlier DOE-funded hydrogen storage patents. Energy Conversion Devices heads this list, with 39.4% of its patent families linked via citations to DOE-funded patents (33.8% to HFTO-funded patents). BASF is second, with 37.9% of its families linked to DOE-funded patents (30.5% to HFTO), followed by General Motors (29.5% linked to DOE; 26.4% to HFTO), Entegris (27.1% linked to DOE; 25.4% to HFTO) and Intelligent Energy (23.2% to DOE, all of which are linked to HFTO). Toyota is less prominent in Figure 6-16, with 15.5% of its patent families linked via citations to DOE-funded patents. Its high position in Figures 6-13 and 6-14 is thus mainly due to its large number of patent families.

Figure 6-15 - Percentage of Leading Hydrogen Storage Company Patent Families Linked via Citations to Earlier HFTO/Other DOE-funded Hydrogen Storage Patents



Patent Level Results

The previous section of the report examined results at the level of entire patent portfolios. The purpose of this section is to drill down to identify individual DOE-funded hydrogen storage patent families (in particular HFTO-funded families) that have had an especially strong influence on subsequent hydrogen storage patents owned by leading companies in this technology. Looking in the opposite direction, it also identifies individual hydrogen storage patents owned by leading companies that have extensive links to earlier HFTO-funded research.

Table 6-1 shows the HFTO-funded hydrogen storage patent families linked via citations to the largest number of subsequent patent families owned by leading companies in this technology. The patent family at the head of this table (whose representative patent[22] is US #6,015,041) has a priority year of 1996 and is assigned Westinghouse Savannah River Company, through its management of DOE's Savannah River National Laboratory (SRNL). It describes a rechargeable device for storing and releasing hydrogen. Sixty-three hydrogen storage patent families assigned to the leading companies are linked via citations to this HFTO-funded patent family. These include patent families assigned to nine out of the twelve leading companies (all except BMW, Linde and Panasonic), and cover a range of technologies related to hydrogen storage.

The second place patent family in Table 6-1 (representative patent US #5,506,069) is assigned to Energy Conversion Devices (through its Ovonic subsidiary) and describes hydrogen storage alloys. It is linked via citations to 37 hydrogen storage patent families assigned to six of the twelve leading companies (Air Products & Chemicals; BASF; Energy Conversion Devices; General Motors; Panasonic; Toyota), with a particular focus on hydrogen-absorbing alloys. Table 6-1 also includes various other patent families for hydrogen storage materials and vessels, assigned to Johns Hopkins University, Thiokol, Safe Hydrogen LLC, University of Hawaii and DOE itself, the latter based on research from Savannah River National Laboratory (SRNL).

Table 6-1 – HFTO-Funded Hydrogen Storage Patent Families Linked via Citations to Most Subsequent Leading Company Hydrogen Storage Patent Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
24508779	6015041	1996	63	Westinghouse Savannah River Co (SRNL)	Apparatus and methods for storing and releasing hydrogen
22986412	5506069	1994	37	Energy Conversion Devices (Ovonic Battery Inc)	Electrochemical hydrogen storage alloys and batteries fabricated from Mg containing base alloys
22308343	6257360	1998	21	Johns Hopkins Univ	Compressed gas fuel storage system
23509238	5577630	1995	19	Thiokol Corp	Composite conformable pressure vessel
27808585	7052671	1999	19	Safe Hydrogen LLC	Storage, generation, and use of hydrogen
22097098	5411928	1993	17	US Dept Energy (SRNL)	Composition for absorbing hydrogen
22708952	5460745	1994	15	US Dept Energy (SRNL)	Hydride compositions
22225370	5443616	1993	14	US Dept Energy (SRNL)	Metal hydride composition and method of making
27377949	6471935	1998	12	Univ Hawaii	Hydrogen storage materials and method of making by dry homogenation
25484575	5958098	1997	11	Westinghouse Savannah River Co (SRNL)	Method and composition in which metal hydride particles are embedded in a silica network

[22] The representative patent is a single patent from a family, but it is not necessarily the priority filing.

Table 6-1 lists HFTO-funded patents linked to the largest number of subsequent hydrogen storage patent families owned by leading companies. Table 6-2 looks in the opposite direction, and lists hydrogen storage patent families owned by leading companies that are linked via citations to multiple HFTO families. General Motors has the patent family at the head of this table. This family (representative patent US #7,862,791) describes a hydrogen storage composition, and is linked via citations to eight earlier HFTO-funded patent families, including hydrogen storage patent families assigned to Westinghouse Savannah River Company (SRNL) and DOE itself (with the latter also resulting from SRNL research). Toyota has three patent families in Table 6-2 (for example, representative patent #8,377,555) describing various materials for hydrogen storage. These Toyota patent families are linked via citations to numerous earlier HFTO-funded patent families, particularly families associated with SRNL.

Table 6-2 - Leading Company Hydrogen Storage Patent Families Linked via Citations to Largest Number of HFTO-Funded Hydrogen Storage Patent Families

Patent Family #	Representative Patent #	Priority Year	# HFTO Fams	Assignee	Title
36119380	7862791	2005	8	General Motors	Hydrogen storage systems and compositions
40986126	8377555	2008	8	Toyota	Gas storage materials, including hydrogen storage materials
41201602	7914846	2008	7	Toyota	Method for encapsulating reactive metal hydrides
37087341	7784501	2006	7	Air Products & Chemicals	Efficient system and method for delivery of product and return of carrier
41164165	8105974	2009	5	Toyota	Destabilized and catalyzed borohydride for reversible hydrogen storage
59630729	9878278	2016	5	L'Air Liquide	Method of purifying hydrogen from a metal hydride storage system
37900222	7816413	2006	4	BASF	Carbon-based foam nanocomposite hydrogen storage material

High-impact hydrogen storage patents owned by leading companies that have citation links back to HFTO-funded patents were also identified.[23] The idea is to highlight important technologies owned by leading companies that are linked to earlier HFTO-funded hydrogen storage research. Table 6-3 lists leading company patents that are linked via citations to HFTO-funded patents,

[23] High-impact patents are identified using 1790's Citation Index metric. This metric is derived by first counting the number of times a patent is cited as prior art by subsequent patents. This number is then divided by the mean number of citations received by peer patents from the same issue year and technology (as defined by their first listed Cooperative Patent Classification). For example, the number of citations received by a 2010 patent in CPC Y02E 60/321 (Hydrogen Storage in Vessels) is divided by the mean number of citations received by all patents in that CPC issued in 2010. The expected Citation Index for an individual patent is one. The extent to which a patent's Citation Index is greater or less than one reveals whether it has been cited more or less frequently than expected, and by how much. For example, a Citation Index of 1.5 shows that a patent has been cited 50% more frequently than expected. Meanwhile a Citation Index of 0.7 reveals that a patent has been cited 30% less frequently than expected. By extension, the expected Citation Index for a portfolio of patents is also one, with values above one showing that a portfolio has been cited more than expected, and values below one showing that a portfolio has not been cited as frequently as expected. Note that the Citation Index is calculated for U.S. patents only, since citation rates differ across patent systems.

and in turn have been cited as prior art by at least 15 subsequent patents, resulting in a Citation Index value above two (i.e., they have each been cited at least twice as many times as expected given their age and technology). BASF has three of the first five patents listed in Table 6-3. The patent at the head of the table (US #8,158,556) was originally assigned to Energ2, along with the University of Washington. Energ2 was acquired by BASF in 2016. This patent describes carbon cryogels that can be used in gas storage. It has been cited as prior art by 24 subsequent patents, more than six times as many citations as expected given its age and technology. In turn, this BASF patent is linked via citations to earlier HFTO-funded hydrogen storage patents assigned to Safe Hydrogen LLC and Westinghouse Savannah River Co (through its management of SRNL). The other two BASF patents in Table 6-3 were assigned to the company itself, and describe metal organic frameworks for gas storage. Toyota has three highly-cited patents in this table (for example, US #8,287,629) describing hydrogen storage tanks and devices, while General Motors has two patents (for example, US #7,270,209) describing gas storage systems for vehicles.

Table 6-3 - Highly Cited Leading Company Hydrogen Storage Patents Linked via Citations to Earlier HFTO-funded Hydrogen Storage Patents

Patent	Issue Year	# Cites Received	Citation Index	Assignee	Title
8158556	2012	24	6.69	BASF (Energ2)	Activated carbon cryogels and related methods
8287629	2012	23	6.02	Toyota	Hydrogen gas storage device
7524444	2009	31	5.34	BASF	Shaped bodies containing metal-organic frameworks
7270209	2007	43	4.25	General Motors	Modular fuel storage system for a vehicle
7309380	2007	46	3.71	BASF	Gas storage system
7112239	2006	41	3.41	Toyota	Gas storage apparatus
6939394	2005	39	2.98	Entegris	Gas storage and dispensing system with monolithic carbon adsorbent
7431756	2008	20	2.76	Energy Conv Devices	Modular metal hydride hydrogen storage system
7624753	2009	16	2.59	General Motors	Container for gas storage tanks in a vehicle
6964821	2005	18	2.01	Toyota	Fuel cell fuel supply system and mobile body

While the patent-level results focus on HFTO-funded hydrogen storage patent families, it is also interesting to note the Other DOE-funded hydrogen storage families linked to the largest number of subsequent patent families owned by leading companies in this technology. These Other DOE-funded families are listed in Table 6-3. The patent family at the head of this table (representative patent US #4,960,450) is assigned to Syracuse University and describes the preparation of activated carbon for hydrogen storage. This patent family is linked via citations to 33 subsequent hydrogen storage patent families assigned to the leading companies, with eight of the twelve companies represented among these linked families. The second patent family in Table 6-4 (representative patent US #4,079,523) is the oldest DOE-funded hydrogen storage patent family in the analysis, with a priority year of 1976. This patent family, assigned to the International Nickel Company, describes a metallic alloy for hydrogen storage. It is linked via citations to 18 hydrogen storage patent families assigned to six of the leading companies, with Panasonic owning a number of these linked families. Other patent families in Table 6-4 focus largely on hydrogen storage materials, and are assigned to a variety of organizations, including Iowa State University, Th. Goldschmidt AG, and DOE itself.

Table 6-4 - Other DOE-Funded Hydrogen Storage Patent Families Linked via Citations to Most Subsequent Leading Company Hydrogen Storage Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
23620495	4960450	1989	33	Syracuse Univ	Selection and preparation of activated carbon for fuel gas storage
24972533	4079523	1976	18	Int'l Nickel Co Inc	Iron-titanium-mischmetal alloys for hydrogen storage
26704904	6074453	1996	15	Iowa State Univ	Ultrafine hydrogen storage powders
6419925	5198207	1990	14	Th. Goldschmidt AG	Method for the preparation of active magnesium hydride-magnesium hydrogen storage systems
27072099	4769225	1983	12	US Dept Energy	System for exchange of hydrogen between liquid and solid phases
22352024	4292265	1980	12	US Dept Energy	Method for preparing porous metal hydride compacts
25463457	5248649	1992	10	Westinghouse Savannah River Co (SRNL)	Palladium/kieselguhr composition and method
34838283	7316788	2004	7	Battelle Memorial Inst (PNNL)	Materials for storage and release of hydrogen and methods for preparing and using same
22440472	4360569	1980	6	US Dept Energy	Porous metal hydride composite and preparation and uses thereof

Overall, the backward tracing element of the analysis suggests that HFTO-funded and Other DOE-funded hydrogen production patents have had a strong influence on subsequent innovations associated with leading companies in this technology. This influence can be seen both over time, and across these leading companies, with a number of HFTO-funded patent families linked via citations to subsequent patent families assigned to many of the leading companies.

Tracing Forwards from DOE-funded Hydrogen Storage Patents

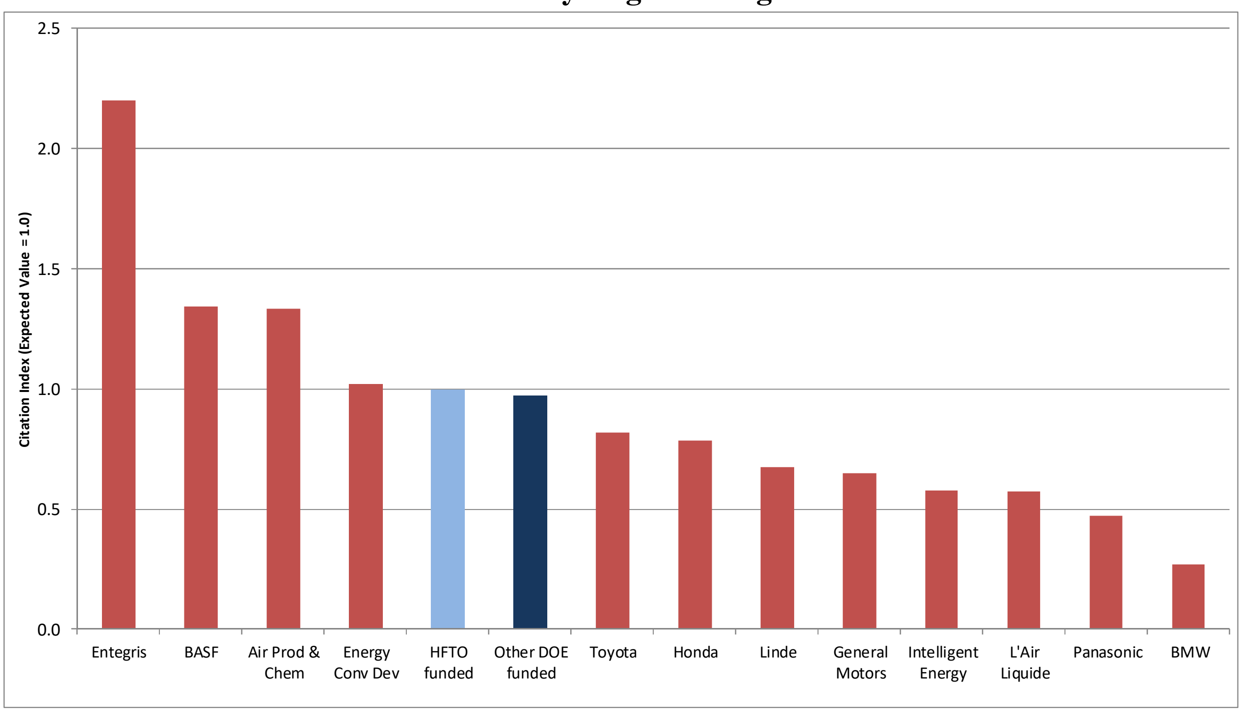
The previous section of the report examines the influence of DOE-funded hydrogen storage research upon technological developments associated with leading hydrogen storage companies. That analysis was based on tracing backwards in time from the patents of leading companies to previous generations of research. This section reports the results of an analysis tracing in the opposite direction – starting with HFTO-funded (and Other DOE-funded) hydrogen storage patents, and tracing forwards in time through two generations of citations. Hence, while the previous section of the report focuses on DOE's influence upon a specific patent set (i.e., patents owned by leading hydrogen storage companies), this section of the report focuses on the broader influence of HFTO-funded (and Other DOE-funded) hydrogen storage research, both within and beyond the hydrogen storage industry. Also, in order to avoid repeating earlier results, the forward tracing concentrates primarily on patents that are linked to DOE-funded hydrogen storage research, but are not owned by leading hydrogen storage companies.

Organizational Level Results

As a starting point for the forward tracing analysis, Figure 6-16 shows Citation Index values for the portfolios of HFTO-funded and Other DOE-funded hydrogen storage patents, compared to the Citation Indexes of the twelve leading hydrogen storage companies. These Citation Indexes are based on citations from all subsequent patents (unlike the backward tracing, which only included citations from patents owned by the leading hydrogen storage companies).

This figure reveals that Entegris has a Citation Index of 2.20, showing that its hydrogen storage patents have on average been cited more than twice as expected given their age and technology. This puts Entegris at the head of Figure 6-16 by a wide margin, ahead of BASF and Air Products & Chemicals, both of which have Citation Index values of 1.34 (i.e., 34% more citations than expected). HFTO-funded patents are in fifth place in Figure 6-16, with an average Citation Index of 1.0 (i.e., exactly as many citations as expected), while Other DOE-funded patents are in sixth place with a Citation Index of 0.97 (i.e., 3% fewer citations than expected). This suggests that HFTO-funded and Other DOE-funded hydrogen storage patents have had a moderately strong overall influence on subsequent innovations.

Figure 6-16 - Citation Index for Leading Companies' Hydrogen Storage Patents, plus HFTO-funded and Other DOE-funded Hydrogen Storage Patents



The Citation Index metric measures the overall influence of the DOE-funded hydrogen storage patent portfolios, but does not necessarily address the breadth of this influence across technologies. The Cooperative Patent Classifications (CPCs) of the patent families linked via citations to earlier HFTO-funded (and Other DOE-funded) hydrogen storage patent families were therefore identified.[24] These CPCs reflect the influence of DOE-funded research across technologies.

Figure 6-17 shows the CPCs with the largest number of patent families linked via citations to HFTO-funded hydrogen storage patents. The CPCs in this figure are shown in two different colors – i.e., dark green for CPCs related to hydrogen storage technology and light green for CPCs beyond hydrogen storage. Nine of the fifteen CPCs in this figure are related to hydrogen storage. This includes the three most common CPCs among patents linked to HFTO-funded hydrogen storage patents – Y02E 60/321 (Hydrogen storage in containers); F17C 11/005 (Gas solvents for hydrogen) and Y02E 60/327 (Hydrogen storage in metals/alloys). Beyond hydrogen storage, the most common CPCs in Figure 6-17 are concerned with metal/alloy dissolution (CPC H01M 8/065), hydrogen production (CPC Y02E 60/362 and C01B 3/065) and fuel crossover prevention (CPC H01M 8/04216 and H01M 8/04208).

Figure 6-17 - Number of Patent Families Linked via Citations to Earlier HFTO-Funded Hydrogen Storage Patents by CPC (Dark Green = Hydrogen Storage-related; Light Green = Other)

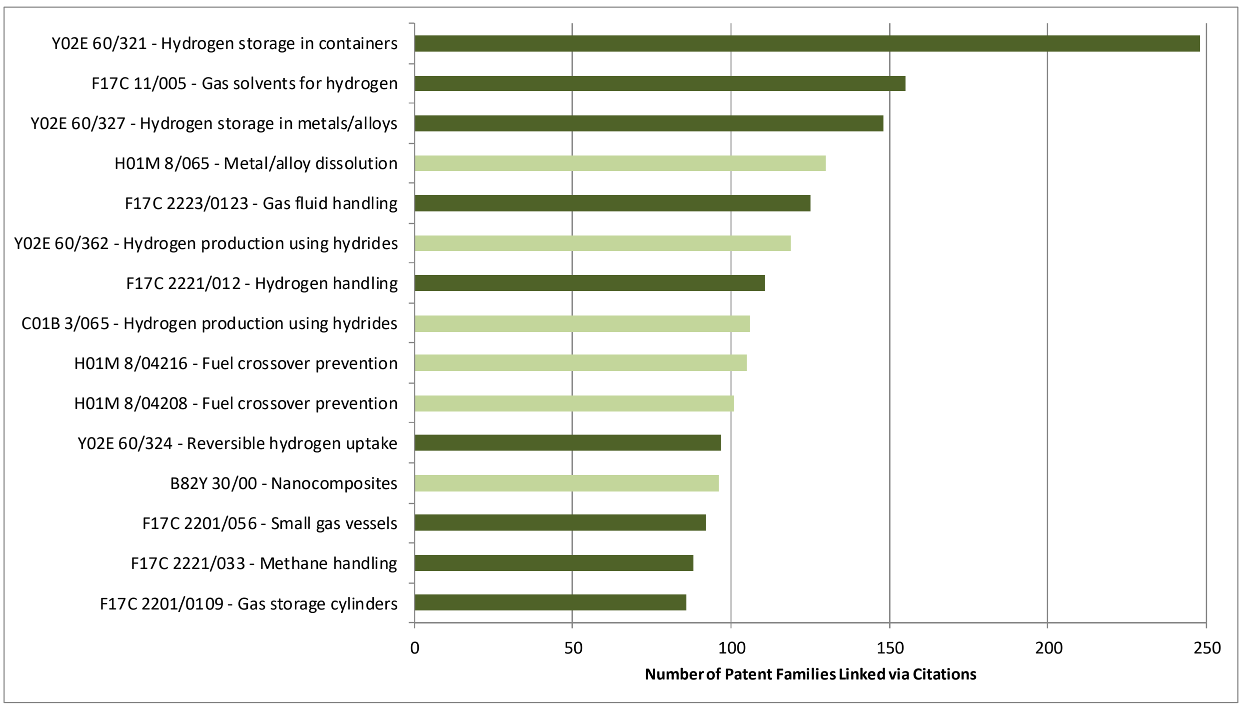
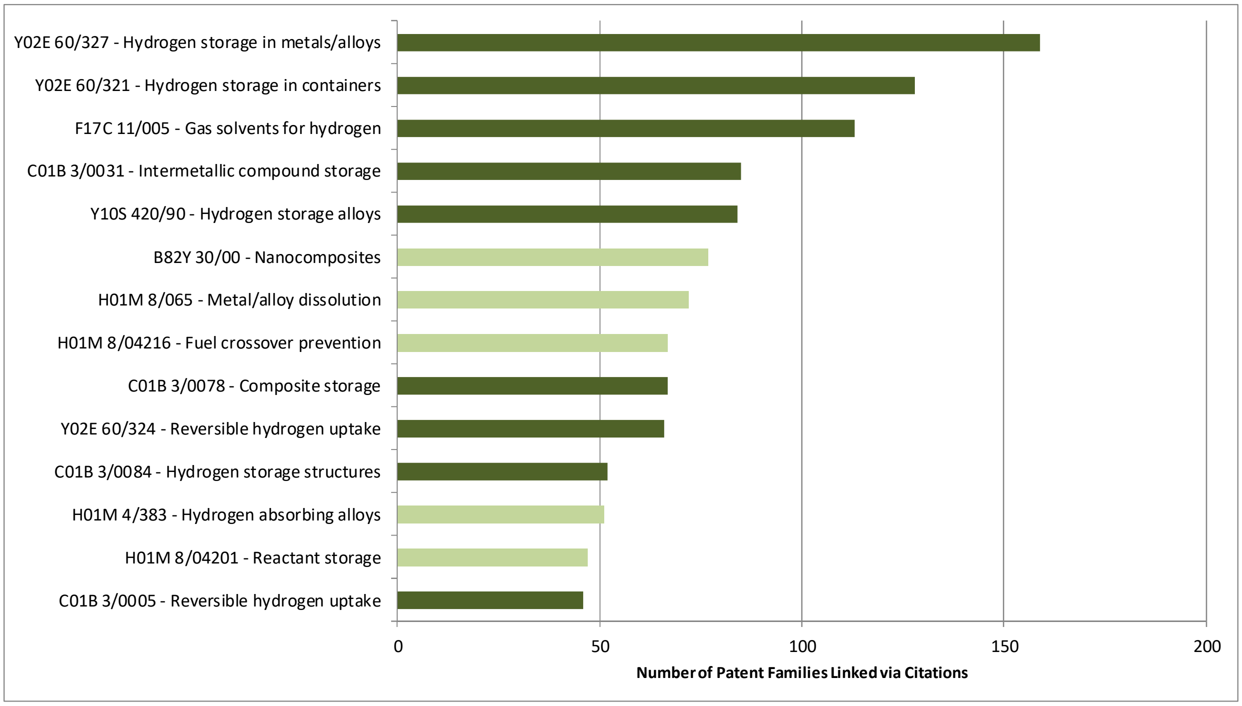


Figure 6-18 is similar to Figure 6-17, but is based on patent families linked to Other DOE-funded hydrogen storage patents, rather than HFTO-funded hydrogen storage patents. The CPCs at the head of Figure 6-18 are once again concerned with hydrogen storage, with the same CPCs occupying the first three places in this figure. Beyond hydrogen storage, the same CPCs related

[24] Patents typically have numerous CPCs attached to them, reflecting different aspects of the invention they describe. In this analysis, all CPCs attached to the patents linked to earlier DOE-funded hydrogen storage patent families are included.

to hydrogen production and metal dissolution are present. One difference is the greater prominence of CPC B82Y 30/00 (Nanocomposites) in Figure 6-18.

Figure 6-18 - Number of Patent Families Linked via Citations to Earlier Other DOE-Funded Hydrogen Storage Patents by CPC (Dark Green = Hydrogen Storage-related; Light Green = Other)



The organizations with the largest number of patent families linked via citations to earlier HFTO-funded hydrogen storage patents are shown in Figure 6-19. To avoid repeating the results from earlier, this figure excludes the twelve leading hydrogen storage companies used in the backward tracing element of the analysis. Also, note that Figure 6-19 includes all patent families assigned to each organization, not just their patent families describing hydrogen storage technology. Figure 6-19 contains various very large companies with interests in many technologies. This figure is headed by Honeywell, with 50 patent families linked via citations to earlier HFTO-funded hydrogen storage patents, many of them related to fuel cell technology. Lockheed Martin is tied for first place in Figure 6-19, also with 50 patent families linked to HFTO-funded patents. These Lockheed Martin patent families describe a range of technologies, such as energy storage, materials separation and carbon fiber materials. The remaining companies in Figure 6-19 include large automakers, energy companies and conglomerates.

Figure 6-20 shows the organizations with the largest number of patent families linked via citations to earlier Other DOE-funded hydrogen storage patents. This figure contains a number of the companies featured in Figure 6-20, which focused on patent families linked to earlier HFTO-funded hydrogen storage patents. These include Honeywell, ExxonMobil, Société BIC and General Electric. Figure 6-20 is headed by GreatPoint Energy, with 43 patent families linked via citations to earlier Other DOE-funded hydrogen storage patents, mainly focused on catalytic gasification of coal. The second place company in Figure 6-20 is General Compression, which has 42 patent families linked via citations to Other DOE-funded hydrogen storage patents. Many of these General Compression patent families describe compressed gas storage and recovery.

Figure 6-19 - Organizations with Largest No. of Patent Families Linked via Citations to HFTO-funded Hydrogen Storage Patents (excluding leading hydrogen storage companies)

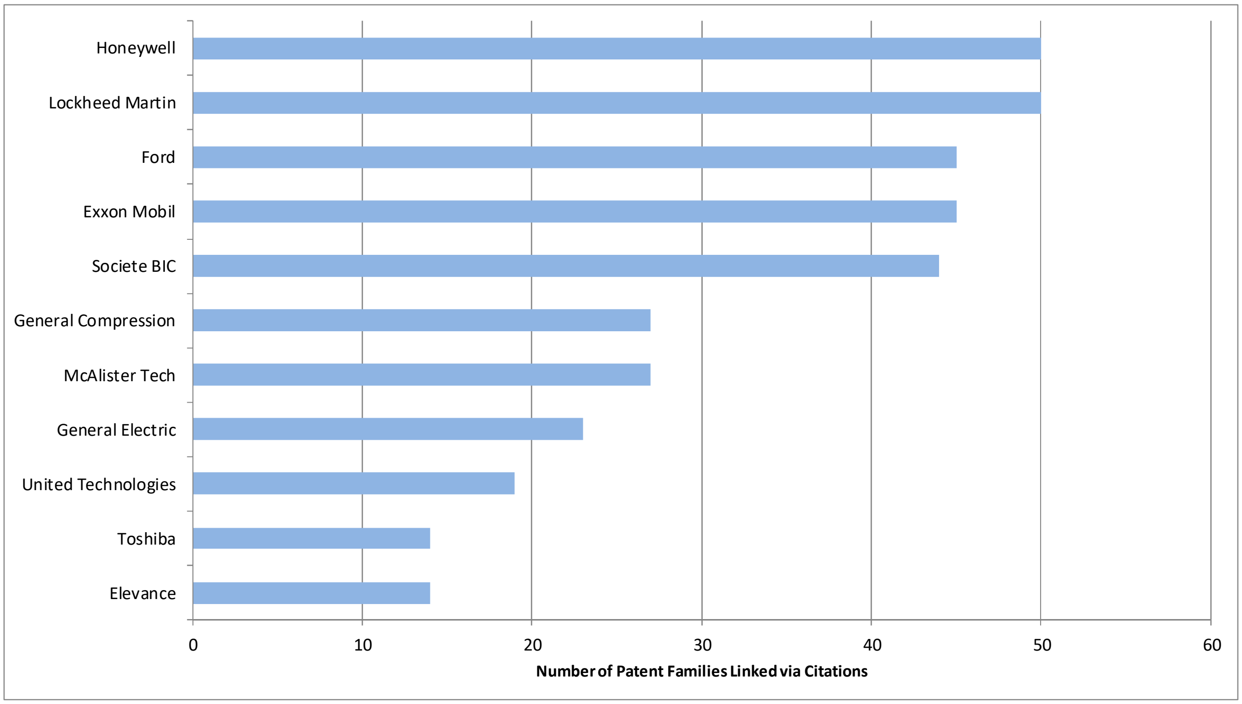
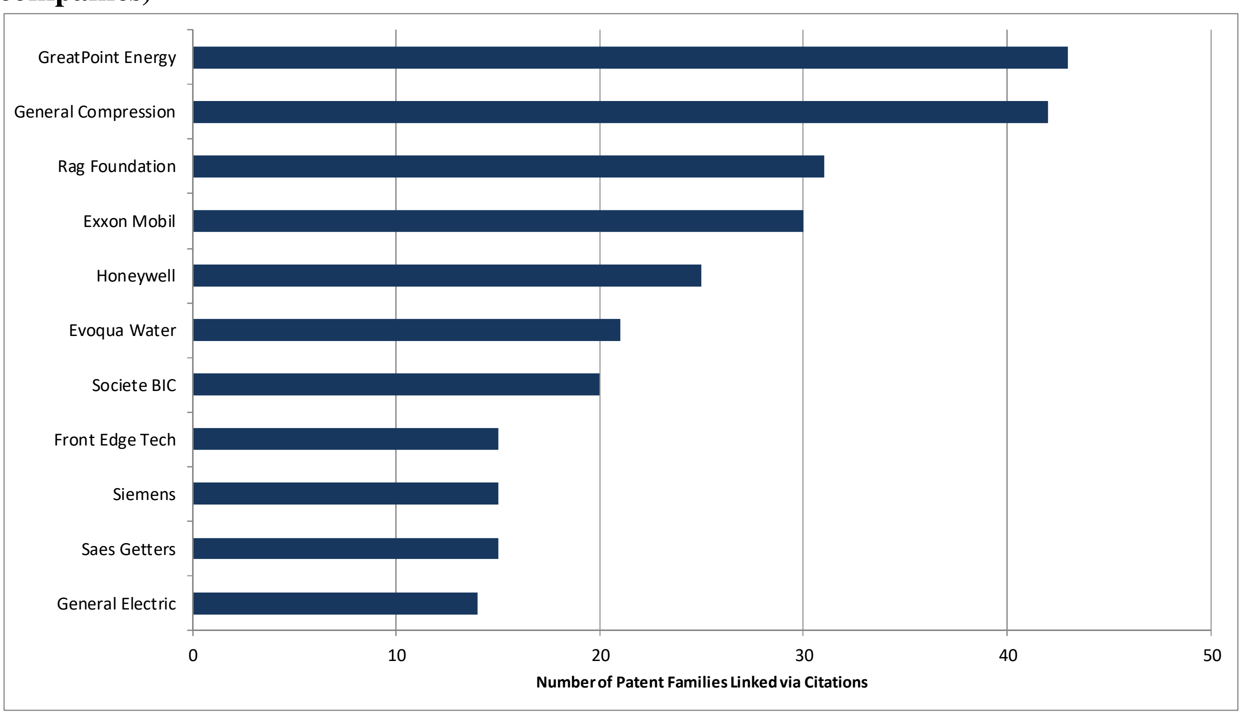


Figure 6-20 - Organizations with Largest No. of Patent Families Linked via Citations to Other DOE-funded Hydrogen Storage Patents (excluding leading hydrogen storage companies)



Patent Level Results

This section of the report drills down to identify individual DOE-funded (and particularly HFTO-funded) hydrogen storage patents whose influence on subsequent technological developments has been particularly strong. It also highlights patents that have extensive citation links to earlier HFTO-funded hydrogen storage research.

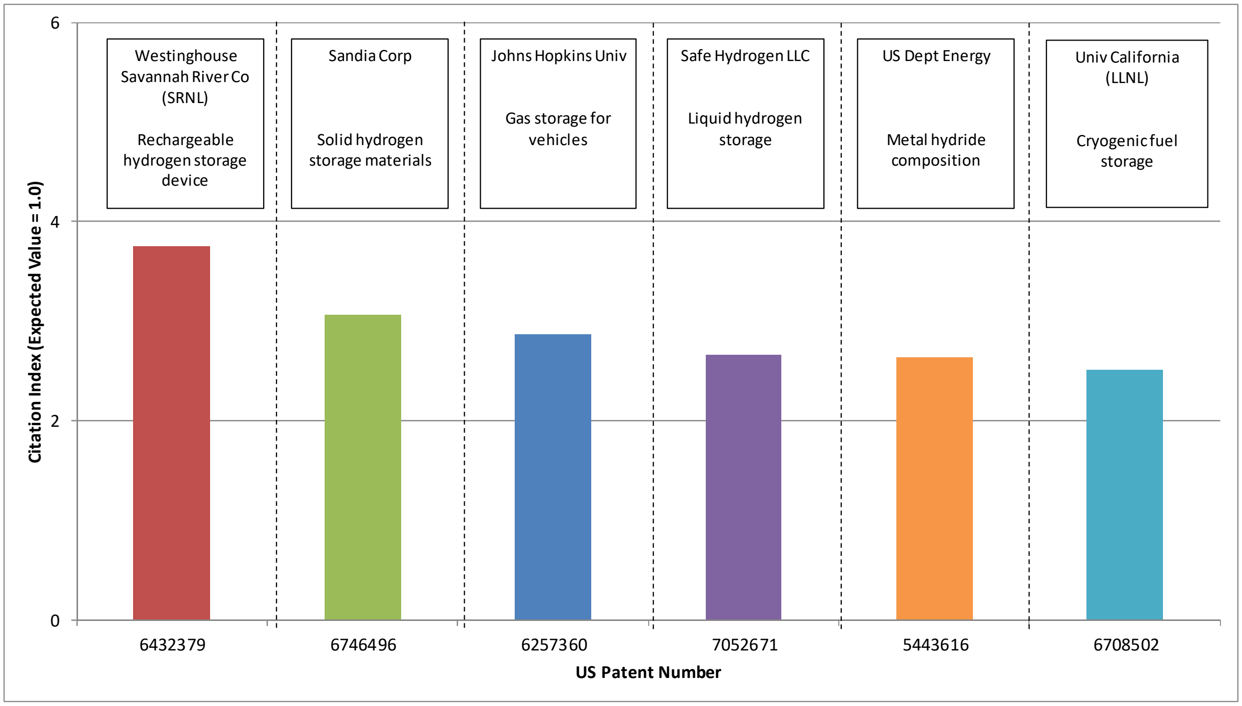
The simplest way of identifying high-impact HFTO-funded hydrogen storage patents is via overall Citation Indexes. The HFTO-funded patents with the highest Citation Index values are shown in Table 6-5, with selected patents also presented in Figure 6-21.

Table 6-5 – List of Highly Cited HFTO-Funded Hydrogen Storage Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
6432379	2002	55	3.75	Westinghouse Savannah River Co (SRNL)	Apparatus and methods for storing and releasing hydrogen
6746496	2004	58	3.07	Sandia Corp	Compact solid source of hydrogen gas
6257360	2001	64	2.87	Johns Hopkins Univ	Compressed gas fuel storage system
7052671	2006	28	2.66	Safe Hydrogen LLC	Storage, generation, and use of hydrogen
5443616	1995	29	2.63	US Dept Energy (SRNL)	Metal hydride composition and method of making
6708502	2004	34	2.51	Univ California (LLNL)	Lightweight cryogenic-compatible pressure vessels for vehicular fuel storage
6267229	2001	36	2.26	Westinghouse Savannah River Co (SRNL)	Apparatus and methods for storing and releasing hydrogen
6015041	2000	41	2.07	Westinghouse Savannah River Co (SRNL)	Apparatus and methods for storing and releasing hydrogen

The patent at the head of Table 6-5 (US #6,432,379) is assigned to Westinghouse Savannah River Company, through its management of DOE’s Savannah River National Laboratory (SRNL). This is one of three SRNL patents in Table 6-5 from the same patent family describing rechargeable devices for storing hydrogen. It has been cited as prior art by 55 subsequent patents, almost four times as many citations as expected. Sandia has the second-place patent in Table 6-5 (US #6,746,496) describing a storage source of hydrogen, particularly for micro fuel cells. This patent has been cited by 58 subsequent patents, over three times as many as expected. Other organizations with highly-cited HFTO-funded hydrogen storage patents in Table 6-5 include Johns Hopkins University, Safe Hydrogen LLC, and the University of California (LLNL).

Figure 6-21 – Examples of Highly-Cited HFTO-funded Hydrogen Storage Patents



The Citation Indexes in Table 6-5 are based on a single generation of citations to HFTO-funded hydrogen storage patents. Tables 6-6 and 6-7 extend this by examining a second generation of citations – i.e., they show the HFTO-funded hydrogen storage patents linked via citations to the largest number of subsequent patent families.[25] These subsequent families are divided into two groups, according to whether they are within or beyond hydrogen storage technology (i.e., whether they are in the hydrogen storage patent universe constructed in the initial step of this project). This provides insights into which HFTO-funded patent families have been particularly influential within hydrogen storage technology, and which have had a broader impact beyond hydrogen storage.

Table 6-6 contains older HFTO-funded patent families, with priority dates prior to 2000. The patent family at the head of this table (representative patent US #6,015,041) is assigned to Westinghouse Savannah River Company (SRNL) and contains the three highly-cited SRNL hydrogen storage patents highlighted in Table 6-5. This patent family is linked via citations to 531 subsequent patent families, 186 of which are within hydrogen storage. The patent family in second place in Table 6-6 (representative patent US #6,257,360) is assigned to Johns Hopkins University, and outlines a gas storage system for vehicles. This patent family is linked via citations to 282 subsequent patent families, 53 of them related to hydrogen storage. In general, the patent families in Table 6-6 have similar ratios of hydrogen storage and non-hydrogen storage patent families linked to them, with the latter group containing patents related to a variety

[25] The HFTO-funded patent families are divided into two tables based on their age, since older patents tend to be connected to larger numbers of subsequent patents, simply because there has been more time for them to become linked to future generations of technology.

of related technologies, such as fuel cells, hydrogen production, gas sensors, and advanced batteries.

Table 6-6 – Pre-2000 HFTO-funded Hydrogen Storage Patent Families Linked via Citations to Largest Number of Subsequent Hydrogen Storage/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Hyd Store Fams	Assignee	Title
24508779	1996	6015041	531	186	Westinghouse Savannah River Co (SRNL)	Apparatus and methods for storing and releasing hydrogen
22308343	1998	6257360	282	53	Johns Hopkins Univ	Compressed gas fuel storage system
23509238	1995	5577630	273	81	Thiokol Corp	Composite conformable pressure vessel
22986412	1994	5506069	251	98	Energy Conversion Devices (Ovonic Battery Inc)	Electrochemical hydrogen storage alloys and batteries fabricated from Mg containing base alloys
27808585	1999	7052671	250	81	Safe Hydrogen LLC	Storage, generation, and use of hydrogen
27377949	1998	6471935	158	63	Univ Hawaii	Hydrogen storage materials and method of making by dry homogenation
22225370	1993	5443616	152	61	US Dept Energy (SRNL)	Metal hydride composition and method of making
22097098	1993	5411928	147	69	US Dept Energy (SRNL)	Composition for absorbing hydrogen
25484575	1997	5958098	145	39	Westinghouse Savannah River Co (SRNL)	Method and composition in which metal hydride particles are embedded in a silica network
25493369	1992	5296438	136	39	US Dept Energy (SRNL)	Dimensionally stable metallic hydride composition

Table 6-7 contains more recent HFTO-funded patent families, with priority dates from 2000 onwards. One patent family stands out in this table, in terms of the number of subsequent patent families linked to it via citations. This patent family (representative patent US #6,746,496) is assigned to Sandia, and describes hydrogen storage, especially for micro fuel cells. It is linked to 241 subsequent patent families, 53 of which are related to hydrogen storage (this family also contains the highly-cited patent highlighted in Table 6-5). Table 6-7 also includes patent families from a range of other organizations. These include DOE lab managers (University of California (LBNL; LLNL) and Sandia); universities (University of Missouri), and companies (Energy Conversion Devices).

Table 6-7 – Post-1999 HFTO-funded Hydrogen Storage Patent Families Linked via Citations to Largest Number of Subsequent Hydrogen Storage/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Hyd Store Fams	Assignee	Title
32328688	2002	6746496	241	53	Sandia Corp	Compact solid source of hydrogen gas
38459807	2006	8314245	82	8	Univ Michigan / Univ California (LBNL)	Preparation of functionalized zeolitic frameworks
31887536	2002	6918382	81	13	Energy Conv Devices	Hydrogen powered scooter
31977912	2002	6708502	51	22	Univ California (LLNL)	Lightweight cryogenic-compatible pressure vessels for vehicular fuel storage
40341966	2007	8480792	45	10	Univ California (LBNL)	Preparation of functionalized zeolitic frameworks
27610474	2002	6793909	27	17	Sandia Corp	Direct synthesis of catalyzed hydride compounds
39365368	2006	8691177	20	4	Univ Missouri	High surface area carbon and process for its production
46245267	2010	9269473	19	3	Univ California	Conductive open frameworks

The tables above identify HFTO-funded patent families linked particularly strongly to subsequent technological developments. Table 6-8 looks in the opposite direction, and identifies highly-cited patents linked to earlier HFTO-funded hydrogen storage patents. As such, these are examples where HFTO-funded hydrogen storage research has formed part of the foundation for subsequent high-impact technologies. This table focuses on patent families not owned by the leading hydrogen storage companies, since those families were examined in the backward tracing element of the analysis.

Table 6-8 - Highly Cited Patents (not from Leading Hydrogen Storage Companies) Linked via Citations to Earlier HFTO-funded Hydrogen Storage Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
6572672	2003	210	18.35	PPG Industries (NanoProducts Corp)	Nanotechnology for biomedical products
8147599	2012	58	13.48	McAlister Technologies LLC	Apparatuses and methods for storing and/or filtering a substance
7169489	2007	99	11.77	FuelSell Technologies	Hydrogen storage, distribution, and recovery
7958731	2011	50	6.84	General Compression Inc	Systems and methods for combined thermal and compressed gas energy conversion
8158556	2012	24	6.69	University of Washington	Activated carbon cryogels and related methods
6699336	2004	36	4.94	3M Co	Amorphous electrode compositions
6589312	2003	43	4.49	Unassigned	Nanoparticles for hydrogen storage, transportation, and distribution
6676163	2004	54	4.32	Dynetek Industries	Replaceable fuel system module and method
7323043	2008	28	3.88	Deere & Co	Storage container associated with a thermal energy management system

The patent at the head of Table 6-8 (US #6,572,672) was assigned originally to NanoProducts Corporation in 2003, which was subsequently acquired in 2008 by PPG Industries. This patent describes nanomaterials for use in biomedical applications. It has been cited as prior art by 210 subsequent patents, more than eighteen times as many citations as expected given its age and technology. In turn, this NanoProducts patent is linked via citations to earlier HFTO-funded Energy Conversion Devices patents describing metallic alloys that can be used in hydrogen storage. The patent in second place in Table 6-8 (US #8,147,599) is more recent, having been issued in 2012. This patent, assigned to McAlister Technologies, describes a storage and filtration system. It has been cited as prior art by 58 subsequent patents, more than thirteen times as many citations as expected given its age and technology. In turn, this McAlister patent is linked via citations to numerous earlier HFTO-funded patents related to hydrogen storage materials. The remaining patents in Table 6-8 are assigned to a variety of organizations, and describe both hydrogen storage and related technologies, notably fuel cells and energy management.

As with the backward tracing element of the analysis, the patent-level results from the forward tracing focus on HFTO-funded hydrogen storage patents. That said, within the forward tracing, it is interesting to note the Other DOE-funded hydrogen storage patent families linked to the largest number of subsequent patent families within and beyond hydrogen storage technology. These Other DOE-funded hydrogen storage families are shown in Table 6-9.

Table 6-9 - Other DOE-funded Hydrogen Storage Patent Families Linked via Citations to Largest Number of Subsequent Hydrogen Storage/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Hyd Store Fams	Assignee	Title
23620495	1989	4960450	340	95	Syracuse Univ	Selection and preparation of activated carbon for fuel gas storage
26704904	1996	6074453	198	72	Iowa State Univ	Ultrafine hydrogen storage powders
40138500	2004	7471010	172	1	All for Sustain Energy (NREL)	Wind turbine tower for storing hydrogen and energy
22440472	1980	4360569	155	67	US Dept Energy	Porous metal hydride composite and preparation and uses thereof
24972533	1976	4079523	154	90	Int'l Nickel Company	Iron-titanium-mischmetal alloys for hydrogen storage
6419925	1990	5198207	140	45	Th. Goldschmidt Ag	Method for the preparation of active magnesium hydride-magnesium hydrogen storage systems
25463457	1992	5248649	110	45	Westinghouse Savannah River Co (SRNL)	Palladium/kieselguhr composition and method
22352024	1980	4292265	104	43	US Dept Energy	Method for preparing porous metal hydride compacts
27072099	1983	4769225	71	32	US Dept Energy	System for exchange of hydrogen between liquid and solid phases
27371589	1997	6494191	50	5	Bechtel BWXT Idaho (INL)	Systems and method for delivering liquefied gas to an engine

The patent family at the head of Table 6-9 (representative patent US #4,960,450) is assigned to Syracuse University and describes the preparation of activated carbon for hydrogen storage. This patent family was highlighted above in the backward tracing element of the analysis (see Table 6-4). It is linked via citations to 340 subsequent patent families, 95 of which are related to hydrogen storage. The patent family in second place in Table 6-9 (representative patent US #6,074,453) was also prominent in Table 6-4. This patent family is assigned to Iowa State University, and describes hydrogen storage powders. It is linked via citations to 198 subsequent patent families, 72 from within hydrogen storage. The patent family in third place in Table 6-9 (representative patent US #7,471,010) has a somewhat different citation pattern to most of the other families in the table, since only one of the 172 subsequent patent families linked to it via citations are from within hydrogen storage. This patent family is assigned to the Alliance for Sustainable Energy, through its management of the National Renewable Energy Laboratory (NREL). It describes a wind tower modified to store hydrogen, and many of the later patent families linked to it via citations describe wind energy technologies, rather than hydrogen storage.

The forward tracing element of the analysis shows that HFTO-funded and Other DOE-funded hydrogen storage patents are linked via citations to subsequent patents assigned to a number of very large companies. The influence of HFTO-funded and Other DOE-funded hydrogen storage research can also be seen across a range of technologies, including hydrogen production, nanocomposites and advanced materials.

Overall, the results from the hydrogen storage analysis suggest that DOE-funded patenting in this technology has increased over time, with HFTO-funded patents representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded hydrogen storage patents have had a particularly strong influence on subsequent innovations associated with the leading companies in fuel cell technology. Meanwhile, the forward tracing reveals that their influence can be detected in related technologies including hydrogen production, nanocomposites and advanced materials.

7. Conclusions

This report describes the results of an analysis tracing links between hydrogen and fuel cell research funded by DOE (HFTO plus Other DOE) and subsequent developments both within and beyond these technologies. This tracing is carried out both backwards and forwards in time. The purpose of the backward tracing is to determine the extent to which HFTO-funded (and Other DOE-funded) research forms a foundation for the technologies developed by leading hydrogen and fuel cell companies. The purpose of the forward tracing is to examine the influence of HFTO-funded (and Other DOE-funded) hydrogen and fuel cell research upon subsequent developments, both within and outside these technologies. The analysis focuses on three distinct technologies – fuel cells, hydrogen production, and hydrogen storage. Each of these technologies is examined individually, with separate findings for the three technologies.

The results from the fuel cell analysis suggest that DOE-funded patenting in this technology has increased over time, with HFTO-funded patents representing a growing percentage of the total.

The portfolios of HFTO-funded and Other DOE-funded fuel cell patents have had a strong influence on subsequent innovations associated with the leading companies in fuel cells technology. Their influence also extends beyond fuel cells into other technologies, including adjacent technologies such as hydrogen production, and other technologies including advanced batteries and nanomaterials.

The results from the hydrogen production analysis suggest that DOE-funded patenting in this technology has also increased over time, with HFTO-funded patents representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded hydrogen production patents have had a relatively strong influence on subsequent innovations associated with the leading companies in hydrogen production technology. Meanwhile, the forward tracing reveals that their influence also extends beyond hydrogen production into other technologies, including fuel cells, waste gas treatment and bioenergy.

Finally, the results from the hydrogen storage analysis suggest that DOE-funded patenting in this technology has also increased over time, with HFTO-funded patents again representing a growing percentage of the total. The backward tracing element of the analysis shows that the portfolios of HFTO-funded and Other DOE-funded hydrogen storage patents have had a particularly strong influence on subsequent innovations associated with the leading companies in fuel cell technology. Meanwhile, the forward tracing reveals that their influence can be detected in related technologies including hydrogen production, nanocomposites and advanced materials.

Appendix FC-A. Fuel Cell Patents in Families Associated with HFTO Funding

Patent #	Application Year	Issue / Publication Year	Original Assignee	Title
4202933	1978	1980	UNITED TECHNOLOGIES CORPORATION	METHOD FOR REDUCING FUEL CELL OUTPUT VOLTAGE TO PERMIT LOW POWER OPERATION
4233181	1979	1980	UNITED TECHNOLOGIES CORPORATION	AUTOMATED CATALYST PROCESSING FOR CLOUD ELECTRODE FABRICATION FOR FUEL CELLS
4233369	1979	1980	UNITED TECHNOLOGIES CORPORATION	FUEL CELL COOLER ASSEMBLY AND EDGE SEAL MEANS THEREFOR
4245009	1979	1981	UNITED TECHNOLOGIES CORPORATION	POROUS COOLANT TUBE HOLDER FOR FUEL CELL STACK
4269642	1979	1981	UNITED TECHNOLOGIES CORPORATION	METHOD OF FORMING DENSIFIED EDGE SEALS FOR FUEL CELL COMPONENTS
4345009	1979	1982	UNITED TECHNOLOGIES CORPORATION	FUEL CELL STACK COMPRESSIVE LOADING SYSTEM
4365008	1981	1982	UNITED TECHNOLOGIES CORPORATION	DENSIFIED EDGE SEALS FOR FUEL CELL COMPONENTS
4372759	1981	1983	UNITED TECHNOLOGIES CORPORATION	ELECTROLYTE VAPOR CONDENSER
4650727	1986	1987	UNITED STATES DEPARTMENT OF ENERGY	FUEL PROCESSOR FOR FUEL CELL POWER SYSTEM
4657829	1982	1987	UNITED TECHNOLOGIES CORPORATION	FUEL CELL POWER SUPPLY WITH OXIDANT AND FUEL GAS SWITCHING
4738905	1986	1988	INTERNATIONAL FUEL CELLS CORPORATION	MANIFOLD SEAL STRUCTURE FOR FUEL CELL STACK
4855193	1987	1989	UNITED TECHNOLOGIES CORPORATION	BIPOLAR FUEL CELL
4910099	1988	1990	UNITED STATES DEPARTMENT OF ENERGY	PREVENTING CO POISONING IN FUEL CELLS
4983472	1989	1991	INTERNATIONAL FUEL CELLS CORPORATION	FUEL CELL CURRENT COLLECTOR
WO1991008595	1990	1991	INTERNATIONAL FUEL CELLS CORPORATION	FUEL CELL CURRENT COLLECTOR
5149584	1990	1992	UNASSIGNED	CARBON FIBER STRUCTURES HAVING IMPROVED

				INTERLAMINAR PROPERTIES
EP0502125	1990	1992	INTERNATIONAL FUEL CELLS CORPORATION	FUEL CELL CURRENT COLLECTOR.
WO1992015121	1992	1992	UNITED STATES DEPARTMENT OF ENERGY	MEMBRANE CATALYST LAYER FOR FUEL CELLS
5208154	1991	1993	UNITED STATES DEPARTMENT OF ENERGY	REVERSIBLY IMMOBILIZED BIOLOGICAL MATERIALS IN MONOLAYER FILMS ON ELECTRODES
5211984	1991	1993	UNIVERSITY OF CALIFORNIA	MEMBRANE CATALYST LAYER FOR FUEL CELLS
5234777	1991	1993	UNIVERSITY OF CALIFORNIA	MEMBRANE CATALYST LAYER FOR FUEL CELLS
5248566	1991	1993	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL SYSTEM FOR TRANSPORTATION APPLICATIONS
5262034	1992	1993	INTERNATIONAL FUEL CELLS CORPORATION	ELECTROCHEMICAL SENSOR FOR MONITORING ELECTROCHEMICAL POTENTIALS OF FUEL CELL COMPONENTS
5272017	1992	1993	GENERAL MOTORS CORPORATION	MEMBRANE-ELECTRODE ASSEMBLIES FOR ELECTROCHEMICAL CELLS
EP0569062	1993	1993	GENERAL MOTORS CORPORATION	METHOD OF MAKING MEMBRANE-ELECTRODE ASSEMBLIES FOR ELECTROCHEMICAL CELLS AND ASSEMBLIES MADE THEREBY.
5316871	1993	1994	GENERAL MOTORS CORPORATION	METHOD OF MAKING MEMBRANE-ELECTRODE ASSEMBLIES FOR ELECTROCHEMICAL CELLS AND ASSEMBLIES MADE THEREBY
EP0600888	1992	1994	UNITED STATES DEPARTMENT OF ENERGY	MEMBRANE CATALYST LAYER FOR FUEL CELLS.
5443601	1993	1995	UNIVERSITY OF CALIFORNIA	METHOD FOR INTERCALATING ALKALI METAL IONS INTO CARBON ELECTRODES
5468573	1994	1995	INTERNATIONAL FUEL CELLS CORPORATION	ELECTROLYTE PASTE FOR MOLTEN CARBONATE FUEL CELLS
EP0689258	1995	1995	INTERNATIONAL FUEL CELLS CORPORATION	ELECTROLYTE PASTE FOR MOLTEN CARBONATE FUEL CELLS
WO1995006002	1994	1995	UNIVERSITY OF CALIFORNIA	METHOD FOR MAKING THIN CARBON FOAM

				ELECTRODES
WO1995020246	1995	1995	UNIVERSITY OF CALIFORNIA	CARBON AEROGEL ELECTRODES FOR DIRECT ENERGY CONVERSION
5514486	1995	1996	UNIVERSITY OF CALIFORNIA	ANNULAR FEED AIR BREATHING FUEL CELL STACK
5558961	1994	1996	UNIVERSITY OF CALIFORNIA	SECONDARY CELL WITH ORTHORHOMBIC ALKALI METAL/MANGANESE OXIDE PHASE ACTIVE CATHODE MATERIAL
5580839	1994	1996	UNIVERSITY OF KENTUCKY	BINARY FERRIHYDRITE CATALYSTS
EP0700108	1993	1996	GENERAL MOTORS CORPORATION	METHOD OF MAKING MEMBRANE-ELECTRODE ASSEMBLIES FOR ELECTROCHEMICAL CELLS AND ASSEMBLIES MADE THEREBY
5595834	1996	1997	UNIVERSITY OF CALIFORNIA	ANNULAR FEED AIR BREATHING FUEL CELL STACK
5601938	1994	1997	UNIVERSITY OF CALIFORNIA	CARBON AEROGEL ELECTRODES FOR DIRECT ENERGY CONVERSION
5624769	1995	1997	GENERAL MOTORS CORPORATION	CORROSION RESISTANT PEM FUEL CELL
5636437	1995	1997	UNIVERSITY OF CALIFORNIA	FABRICATING SOLID CARBON POROUS ELECTRODES FROM POWDERS
5641586	1995	1997	UNIVERSITY OF CALIFORNIA	FUEL CELL WITH INTERDIGITATED POROUS FLOW-FIELD
5654109	1995	1997	DOW GLOBAL TECHNOLOGIES INC.	COMPOSITE FUEL CELL MEMBRANES
EP0780916	1996	1997	GENERAL MOTORS CORPORATION	CORROSION RESISTANT ELECTRICAL CONTACT ELEMENTS FOR FUEL CELLS WITH POLYMER ELECTROLYTE MEMBRANE
WO1997037396	1997	1997	CASE WESTERN RESERVE UNIVERSITY	PROTON CONDUCTING POLYMER ELECTROLYTES PREPARED BY DIRECT ACID CASTING
5707755	1996	1998	GENERAL MOTORS CORPORATION	PEM/SPE FUEL CELL
5714404	1993	1998	UNIVERSITY OF CALIFORNIA	FABRICATION OF POLYCRYSTALLINE THIN FILMS BY PULSED LASER PROCESSING
5716727	1996	1998	CASE WESTERN RESERVE	PROTON CONDUCTING POLYMERS PREPARED BY

			UNIVERSITY	DIRECT ACID CASTING
5743646	1996	1998	GENERAL MOTORS CORPORATION	TEMPERATURE SENSOR WITH IMPROVED THERMAL BARRIER AND GAS SEAL BETWEEN THE PROBE AND HOUSING
5763113	1996	1998	GENERAL MOTORS CORPORATION	PEM FUEL CELL MONITORING SYSTEM
5776624	1996	1998	GENERAL MOTORS CORPORATION	BRAZED BIPOLAR PLATES FOR PEM FUEL CELLS
5783152	1997	1998	UNITED STATES DEPARTMENT OF ENERGY	THIN-FILM FIBER OPTIC HYDROGEN AND TEMPERATURE SENSOR SYSTEM
5798187	1997	1998	UNIVERSITY OF CALIFORNIA	FUEL CELL WITH METAL SCREEN FLOW-FIELD
EP0827226	1997	1998	GENERAL MOTORS CORPORATION	PEM FUEL CELL MONITORING SYSTEM
EP0847097	1997	1998	GENERAL MOTORS CORPORATION	POLYMER ELECTROLYTE MEMBRANE FUEL CELL
EP0851518	1997	1998	GENERAL MOTORS CORPORATION	BRAZED BIPOLAR PLATES FOR FUEL CELLS WITH POLYMER ELECTROLYTE
EP0862233	1997	1998	GENERAL MOTORS CORPORATION	MONITORING A FUEL CELL WITH POLYMER ELECTROLYTE BY COMPARING THE BEHAVIOUR PATTERNS OF AN AUXILIAIRE CELL
WO1998013891	1997	1998	UNIVERSITY OF CALIFORNIA	FUEL CELL WITH METAL SCREEN FLOW-FIELD
WO1998047197	1998	1998	PLUG POWER, L.L.C.	FUEL CELL FLUID FLOW PLATE WITH INSERTABLE FLUID FLOW PASSAGE BRIDGEPIECE
5912088	1997	1999	PLUG POWER, L.L.C.	GRADIENT ISOLATOR FOR FLOW FIELD OF FUEL CELL ASSEMBLY
5916710	1996	1999	UNIVERSITY OF CALIFORNIA	SODIUM COBALT BRONZE BATTERIES AND A METHOD FOR MAKING SAME
5932185	1993	1999	UNIVERSITY OF CALIFORNIA	METHOD FOR MAKING THIN CARBON FOAM ELECTRODES
5945229	1997	1999	GENERAL MOTORS CORPORATION	PATTERN RECOGNITION MONITORING OF PEM FUEL CELL
5952119	1997	1999	UNIVERSITY OF CALIFORNIA	FUEL CELL MEMBRANE HUMIDIFICATION
5981098	1997	1999	PLUG POWER, L.L.C.	FLUID FLOW PLATE FOR DECREASED DENSITY OF FUEL CELL ASSEMBLY
5998054	1997	1999	PLUG POWER, L.L.C.	FUEL CELL MEMBRANE HYDRATION AND FLUID METERING

6001499	1997	1999	GENERAL MOTORS CORPORATION	FUEL CELL CO SENSOR
6001502	1997	1999	PLUG POWER, L.L.C.	CURRENT CONDUCTING END PLATE OF FUEL CELL ASSEMBLY
6007933	1998	1999	PLUG POWER, L.L.C.	FUEL CELL ASSEMBLY UNIT FOR PROMOTING FLUID SERVICE AND ELECTRICAL CONDUCTIVITY
EP0907977	1997	1999	CASE WESTERN RESERVE UNIVERSITY	PROTON CONDUCTING POLYMER ELECTROLYTES PREPARED BY DIRECT ACID CASTING
EP0911629	1998	1999	GENERAL MOTORS CORPORATION	FUEL CELL CO SENSOR
EP0911898	1998	1999	GENERAL MOTORS CORPORATION	METHOD OF MONITORING CO CONCENTRATIONS IN HYDROGEN FEED TO A PEM FUEL CELL
EP0920064	1998	1999	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM WITH COMBUSTOR-HEATED REFORMER
EP0924786	1998	1999	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM COMBUSTOR
EP0928036	1999	1999	DE NORA ELETTRODI S.P.A.	CARBON-CLOTH-BASED ELECTROCATALYTIC GAS DIFFUSION ELECTRODES OF ELECTROCHEMICAL CELLS AND METHOD OF MANUFACTURE
EP0948069	1999	1999	GENERAL MOTORS CORPORATION	FUEL CELL FLOODING DETECTION AND CORRECTION
WO1999000186	1998	1999	BATTELLE MEMORIAL INSTITUTE	ACTIVE MICROCHANNEL HEAT EXCHANGER
WO1999000862	1998	1999	PLUG POWER, L.L.C.	CURRENT CONDUCTING END PLATE OF FUEL CELL ASSEMBLY
WO1999005740	1998	1999	PLUG POWER, L.L.C.	FUEL CELL MEMBRANE HYDRATION AND FLUID METERING
WO1999005741	1998	1999	EMPRISE CORPORATION	FUEL CELL GAS MANAGEMENT SYSTEM
WO1999013128	1998	1999	SOUTHWEST RESEARCH INSTITUTE	A METHOD OF DEPOSITING AN ELECTROCATALYST AND ELECTRODES FORMED BY SUCH METHOD
WO1999016542	1998	1999	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL LAMINATED MASS EXCHANGER AND METHOD OF MAKING
WO1999053557	1999	1999	DE NORA ELETTRODI S.P.A.	IMPROVED COMPOSITION OF A SELECTIVE

				OXIDATION CATALYST FOR USE IN FUEL CELLS
WO1999064147	1999	1999	BATTELLE MEMORIAL INSTITUTE	MICROCOMPONENT ASSEMBLY FOR EFFICIENT CONTACTING OF FLUID
6013385	1997	2000	EMPRISE CORPORATION	FUEL CELL GAS MANAGEMENT SYSTEM
6017648	1997	2000	PLUG POWER, L.L.C.	INSERTABLE FLUID FLOW PASSAGE BRIDGEPIECE AND METHOD
6025085	1998	2000	CASE WESTERN RESERVE UNIVERSITY	PROTON CONDUCTING SOLID POLYMER ELECTROLYTES PREPARED BY DIRECT ACID CASTING
6037072	1998	2000	UNIVERSITY OF CALIFORNIA	FUEL CELL WITH METAL SCREEN FLOW FIELD
6037073	1996	2000	LOCKHEED MARTIN ENERGY RESEARCH CORPORATION	BIPOLAR PLATE/DIFFUSER FOR A PROTON EXCHANGE MEMBRANE FUEL CELL
6063516	1997	2000	GENERAL MOTORS CORPORATION	METHOD OF MONITORING CO CONCENTRATIONS IN HYDROGEN FEED TO A PEM FUEL CELL
6066408	1997	2000	PLUG POWER, L.L.C.	FUEL CELL COOLER-HUMIDIFIER PLATE
6074692	1998	2000	GENERAL MOTORS CORPORATION	METHOD OF MAKING MEA FOR PEM/SPE FUEL CELL
6077620	1997	2000	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM WITH COMBUSTOR-HEATED REFORMER
6096450	1998	2000	PLUG POWER, L.L.C.	FUEL CELL ASSEMBLY FLUID FLOW PLATE HAVING CONDUCTIVE FIBERS AND RIGIDIZING MATERIAL THEREIN
6099984	1998	2000	GENERAL MOTORS CORPORATION	MIRRORED SERPENTINE FLOW CHANNELS FOR FUEL CELL
6099988	2000	2000	CASE WESTERN RESERVE UNIVERSITY	PROTON CONDUCTING POLYMER ELECTROLYTE PREPARED BY DIRECT ACID CASTING
6103077	1998	2000	DE NORA ELETTRODI S.P.A.	STRUCTURES AND METHODS OF MANUFACTURE FOR GAS DIFFUSION ELECTRODES AND ELECTRODE COMPONENTS
6103409	1998	2000	GENERAL MOTORS CORPORATION	FUEL CELL FLOODING DETECTION AND CORRECTION
6110612	1999	2000	PLUG POWER, L.L.C.	STRUCTURE FOR COMMON ACCESS AND SUPPORT OF FUEL CELL STACKS
6117577	1998	2000	UNIVERSITY OF	AMBIENT PRESSURE FUEL

			CALIFORNIA	CELL SYSTEM
6126723	1998	2000	BATTELLE MEMORIAL INSTITUTE	MICROCOMPONENT ASSEMBLY FOR EFFICIENT CONTACTING OF FLUID
6129973	1997	2000	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL LAMINATED MASS EXCHANGER AND METHOD OF MAKING
6149782	1999	2000	DE NORA ELETTRODI S.P.A.	RHODIUM ELECTROCATALYST AND METHOD OF PREPARATION
6159533	1997	2000	SOUTHWEST RESEARCH INSTITUTE	METHOD OF DEPOSITING A CATALYST ON A FUEL CELL ELECTRODE
6159626	1999	2000	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM LOGIC FOR DIFFERENTIATING BETWEEN RAPID AND NORMAL SHUTDOWN COMMANDS
6165636	1999	2000	DE NORA ELETTRODI S.P.A.	COMPOSITION OF A SELECTIVE OXIDATION CATALYST FOR USE IN FUEL CELLS
EP0991465	1998	2000	BATTELLE MEMORIAL INSTITUTE	ACTIVE MICROCHANNEL HEAT EXCHANGER
EP0995230	1998	2000	PLUG POWER, L.L.C.	CURRENT CONDUCTING END PLATE OF FUEL CELL ASSEMBLY
EP1017489	1998	2000	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL LAMINATED MASS EXCHANGER AND METHOD OF MAKING
EP1021590	1998	2000	SOUTHWEST RESEARCH INSTITUTE	A METHOD OF DEPOSITING AN ELECTROCATALYST AND ELECTRODES FORMED BY SUCH METHOD
EP1025602	1998	2000	EMPRISE CORPORATION	FUEL CELL GAS MANAGEMENT SYSTEM
EP1043791	2000	2000	GENERAL MOTORS CORPORATION	WATER INJECTED FUEL CELL SYSTEM COMPRESSOR
EP1045467	2000	2000	GENERAL MOTORS CORPORATION	LAYERED CARBON ELECTRODE FOR ELECTROCHEMICAL CELLS
WO2000005570	1998	2000	WESTINGHOUSE SAVANNAH RIVER COMPANY	HYDROGEN GAS AND TEMPERATURE FIBER OPTIC SENSOR SYSTEM
WO2000011745	1999	2000	UNIVERSITY OF CALIFORNIA	AMBIENT PRESSURE FUEL CELL SYSTEM
WO2000016880	1999	2000	ALLIEDSIGNAL INC.	ELECTROCATALYTIC METHOD AND DEVICE FOR REMOVING CARBON

				MONOXIDE FROM HYDROGEN-RICH GAS
WO2000017952	1999	2000	ENERGY PARTNERS, L.C.	SELF-HUMIDIFYING FUEL CELL
WO2000022684	1999	2000	FOSTER-MILLER, INC.	COMPOSITE SOLID POLYMER ELECTROLYTE MEMBRANES
WO2000025372	1999	2000	UNIVERSITY OF CALIFORNIA	COMPOSITE BIPOLAR PLATE FOR ELECTROCHEMICAL CELLS
WO2000030202	1999	2000	ENERGY PARTNERS, L.C.	FUEL CELL COLLECTOR PLATE AND METHOD OF FABRICATION
WO2000030203	1999	2000	ENERGY PARTNERS, L.C.	COMPOUNDING AND MOLDING PROCESS FOR FUEL CELL COLLECTOR PLATES
WO2000039358	1999	2000	UNIVERSITY OF CALIFORNIA	COLLOIDAL SPRAY METHOD FOR LOW COST THIN COATING DEPOSITION
WO2000042671	2000	2000	ENERGY PARTNERS, L.C.	METHOD AND APPARATUS FOR MAINTAINING NEUTRAL WATER BALANCE IN A FUEL CELL SYSTEM
WO2000043772	2000	2000	ADVANCED TECHNOLOGY MATERIALS, INC.	MICRO-MACHINED THIN FILM HYDROGEN GAS SENSOR, AND METHOD OF MAKING AND USING THE SAME
WO2000054346	2000	2000	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-PALLADIUM ALLOYS FOR USE AS A FUEL CELL CATALYST
WO2000055928	2000	2000	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-NICKEL ALLOY FOR USE AS A FUEL CELL CATALYST
WO2000063997	2000	2000	PLUG POWER, L.L.C.	STRUCTURE FOR COMMON ACCESS AND SUPPORT OF FUEL CELL STACKS
WO2000070700	1999	2000	3M INNOVATIVE PROPERTIES COMPANY	HYBRID MEMBRANE ELECTRODE ASSEMBLIES
WO2000073538	2000	2000	DE NORA ELETTRODI S.P.A.	RHODIUM ELECTROCATALYST AND METHOD OF PREPARATION
6171720	1998	2001	UT-BATTELLE, LLC	BIPOLAR PLATE/DIFFUSER FOR A PROTON EXCHANGE MEMBRANE FUEL CELL
6179897	1999	2001	BROOKHAVEN SCIENCE ASSOCIATES LLC	METHOD FOR THE GENERATION OF VARIABLE DENSITY

				METAL VAPORS WHICH BYPASSES THE LIQUIDUS PHASE
6180275	1998	2001	ENERGY PARTNERS, L.C.	FUEL CELL COLLECTOR PLATE AND METHOD OF FABRICATION
6183894	1999	2001	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYST FOR ALCOHOL OXIDATION IN FUEL CELLS
6192596	1999	2001	BATTELLE MEMORIAL INSTITUTE	ACTIVE MICROCHANNEL FLUID PROCESSING UNIT AND METHOD OF MAKING
6199519	1998	2001	SANDIA CORPORATION	FREE-PISTON ENGINE
6200536	1997	2001	BATTELLE MEMORIAL INSTITUTE	ACTIVE MICROCHANNEL HEAT EXCHANGER
6200698	1999	2001	PLUG POWER, L.L.C.	END PLATE ASSEMBLY HAVING A TWO-PHASE FLUID-FILLED BLADDER AND METHOD FOR COMPRESSING A FUEL CELL STACK
6207310	1999	2001	UNIVERSITY OF CALIFORNIA	FUEL CELL WITH METAL SCREEN FLOW-FIELD
6207312	1998	2001	ENERGY PARTNERS, L.C.	SELF-HUMIDIFYING FUEL CELL
6232005	1997	2001	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM COMBUSTOR
6238534	1999	2001	3M INNOVATIVE PROPERTIES COMPANY	HYBRID MEMBRANE ELECTRODE ASSEMBLY
6245214	1999	2001	ALLIEDSIGNAL INC.	ELECTRO-CATALYTIC OXIDATION (ECO) DEVICE TO REMOVE CO FROM REFORMATE FOR FUEL CELL APPLICATION
6248467	1999	2001	UNIVERSITY OF CALIFORNIA	COMPOSITE BIPOLAR PLATE FOR ELECTROCHEMICAL CELLS
6248469	1999	2001	FOSTER-MILLER, INC.	COMPOSITE SOLID POLYMER ELECTROLYTE MEMBRANES
6255012	1999	2001	UNIVERSITY OF CALIFORNIA	PLEATED METAL BIPOLAR ASSEMBLY
6265092	2000	2001	GENERAL MOTORS CORPORATION	METHOD OF CONTROLLING INJECTION OF OXYGEN INTO HYDROGEN-RICH FUEL CELL FEED STREAM
6265222	1999	2001	UNASSIGNED	MICRO-MACHINED THIN FILM HYDROGEN GAS SENSOR, AND METHOD OF MAKING AND USING THE SAME

6268074	1999	2001	GENERAL MOTORS CORPORATION	WATER INJECTED FUEL CELL SYSTEM COMPRESSOR
6277513	1999	2001	GENERAL MOTORS CORPORATION	LAYERED ELECTRODE FOR ELECTROCHEMICAL CELLS
6296964	1999	2001	UNIVERSITY OF CALIFORNIA	ENHANCED METHANOL UTILIZATION IN DIRECT METHANOL FUEL CELL
6306531	2000	2001	GENERAL MOTORS CORPORATION	COMBUSTOR AIR FLOW CONTROL METHOD FOR FUEL CELL APPARATUS
6322919	1999	2001	ALLIEDSIGNAL INC.	FUEL CELL AND BIPOLAR PLATE FOR USE WITH SAME
EP1065740	2000	2001	GENERAL MOTORS CORPORATION	FLEXIBLE METHOD FOR MONITORING FUEL CELL VOLTAGE
EP1067614	2000	2001	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM LOGIC FOR DIFFERENTIATING BETWEEN RAPID AND NORMAL SHUTDOWN COMMANDS
EP1069636	2000	2001	GENERAL MOTORS CORPORATION	FUEL CELL STACK MONITORING AND SYSTEM CONTROL
EP1069637	2000	2001	GENERAL MOTORS CORPORATION	COMBUSTOR AIR FLOW CONTROL METHOD FOR FUEL CELL APPARATUS
EP1078406	1999	2001	DE NORA ELETTRODI S.P.A.	IMPROVED COMPOSITION OF A SELECTIVE OXIDATION CATALYST FOR USE IN FUEL CELLS
EP1093175	2000	2001	GENERAL MOTORS CORPORATION	CONTROLLED AIR INJECTION TO CATALYZE THE OXIDATION OF CARBON MONOXIDE IN A FUEL CELL SYSTEM
EP1093398	1999	2001	BATTELLE MEMORIAL INSTITUTE	MICROCOMPONENT ASSEMBLY FOR EFFICIENT CONTACTING OF FLUID
EP1107340	2000	2001	GENERAL MOTORS CORPORATION	CORROSION RESISTANT CONTACT ELEMENT FOR A PEM FUEL CELL
EP1110264	1999	2001	UNIVERSITY OF CALIFORNIA	AMBIENT PRESSURE FUEL CELL SYSTEM
EP1115470	1999	2001	ALLIEDSIGNAL INC.	ELECTROCATALYTIC METHOD FOR REMOVING CARBON MONOXIDE FROM HYDROGEN-RICH GAS
EP1116297	1999	2001	ENERGY PARTNERS, L.C.	SELF-HUMIDIFYING FUEL CELL
EP1122805	2000	2001	GENERAL MOTORS CORPORATION	METHOD FOR OPERATING A COMBUSTOR IN A FUEL CELL SYSTEM

EP1124275	2000	2001	GENERAL MOTORS CORPORATION	METHOD AND APPARATUS FOR CONTROLLING COMBUSTOR TEMPERATURE OF A FUEL CELL SYSTEM DURING TRANSIENT LOAD CHANGES
EP1124276	2000	2001	GENERAL MOTORS CORPORATION	CONTROLLED SHUTDOWN OF A FUEL CELL SYSTEM
EP1135823	1999	2001	ENERGY PARTNERS, L.C.	MOLDING PROCESS FOR FUEL CELL COLLECTOR PLATES
EP1144726	1999	2001	UNIVERSITY OF CALIFORNIA	COLLOIDAL SPRAY METHOD FOR LOW COST THIN COATING DEPOSITION
EP1153291	2000	2001	ADVANCED TECHNOLOGY MATERIALS, INC.	MICRO-MACHINED THIN FILM HYDROGEN GAS SENSOR, AND METHOD OF MAKING AND USING THE SAME
RE037284	2000	2001	GENERAL MOTORS CORPORATION	CORROSION RESISTANT PEM FUEL CELL
WO2001005571	2000	2001	ENERGY PARTNERS, L.C.	IMPROVED CONDUCTIVITY FUEL CELL COLLECTOR PLATE AND METHOD OF FABRICATION
WO2001009968	2000	2001	UNIVERSITY OF CALIFORNIA	STRUCTURES AND FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
WO2001013441	2000	2001	ALLIEDSIGNAL INC.	FUEL CELL HAVING IMPROVED CONDENSATION AND REACTION PRODUCT MANAGEMENT CAPABILITIES
WO2001013449	2000	2001	ALLIEDSIGNAL INC.	FUEL CELL AND BIPOLAR PLATE FOR USE WITH SAME
WO2001028019	2000	2001	ALLIEDSIGNAL INC.	CORROSION RESISTANT COATED FUEL CELL BIPOLAR PLATE WITH FILLED-IN FINE SCALE POROSITIES AND METHOD OF MAKING THE SAME
WO2001028020	2000	2001	ALLIEDSIGNAL INC.	CORROSION RESISTANT COATED FUEL CELL BIPOLAR PLATE WITH GRAPHITE PROTECTIVE BARRIER AND METHOD OF MAKING THE SAME
WO2001048853	2000	2001	UNIVERSITY OF	ENHANCED METHANOL

			CALIFORNIA	UTILIZATION IN DIRECT METHANOL FUEL CELL
WO2001059865	2001	2001	HONEYWELL INTERNATIONAL INC.	WICKING STRANDS FOR A POLYMER ELECTROLYTE MEMBRANE FUEL CELL
WO2001084649	2001	2001	ELECTRIC AUTO CORPORATION	MULTI-CELLULAR ELECTRICAL BATTERY
WO2001089013	2001	2001	HONEYWELL INTERNATIONAL INC.	NANOCOMPOSITE FOR FUEL CELL BIPOLAR PLATE
WO2001091214	2001	2001	UNIVERSITY OF CALIFORNIA	METHOD FOR IMPROVING FUEL CELL PERFORMANCE
WO2001095409	2001	2001	NUVERA FUEL CELLS, INC.	JOINT-CYCLE HIGH-EFFICIENCY FUEL CELL SYSTEM WITH POWER GENERATING TURBINE
6352577	2000	2002	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL LAMINATED MASS EXCHANGER AND METHOD OF MAKING
6358381	2000	2002	DE NORA ELETTRODI S.P.A.	RHODIUM ELECTROCATALYST AND METHOD OF PREPARATION
6358567	1999	2002	UNIVERSITY OF CALIFORNIA	COLLOIDAL SPRAY METHOD FOR LOW COST THIN COATING DEPOSITION
6368476	2000	2002	UNASSIGNED	STRUCTURES AND METHODS OF MANUFACTURE FOR GAS DIFFUSION ELECTRODES AND ELECTRODE COMPONENTS
6372376	1999	2002	GENERAL MOTORS CORPORATION	CORROSION RESISTANT PEM FUEL CELL
6376112	2000	2002	GENERAL MOTORS CORPORATION	CONTROLLED SHUTDOWN OF A FUEL CELL
6379834	2000	2002	DE NORA ELETTRODI S.P.A.	COMPOSITION OF A SELECTIVE OXIDATION CATALYST FOR USE IN FUEL CELLS
6395414	2000	2002	GENERAL MOTORS CORPORATION	STAGED VENTING OF FUEL CELL SYSTEM DURING RAPID SHUTDOWN
6413661	1999	2002	GENERAL MOTORS CORPORATION	METHOD FOR OPERATING A COMBUSTOR IN A FUEL CELL SYSTEM
6413662	2000	2002	GENERAL MOTORS CORPORATION	FUEL CELL SYSTEM SHUTDOWN WITH ANODE PRESSURE CONTROL
6416893	2000	2002	GENERAL MOTORS CORPORATION	METHOD AND APPARATUS FOR CONTROLLING COMBUSTOR TEMPERATURE DURING TRANSIENT LOAD

				CHANGES
6436561	2000	2002	GENERAL MOTORS CORPORATION	METHANOL TAILGAS COMBUSTOR CONTROL METHOD
6436562	1999	2002	EMPRISE CORPORATION	FUEL-CELL ENGINE STREAM CONDITIONING SYSTEM
6444602	2000	2002	DENORA S.P.A.	STRUCTURES AND METHODS OF MANUFACTURE FOR GAS DIFFUSION ELECTRODES AND ELECTRODE COMPONENTS
6451465	2000	2002	GENERAL MOTORS CORPORATION	METHOD FOR OPERATING A COMBUSTOR IN A FUEL CELL SYSTEM
6451471	2000	2002	TELEDYNE ENERGY SYSTEMS, INC.	CONDUCTIVITY FUEL CELL COLLECTOR PLATE AND METHOD OF FABRICATION
6454922	2000	2002	UNIVERSITY OF CALIFORNIA	CORROSION TEST CELL FOR BIPOLAR PLATES
6455180	1999	2002	GENERAL MOTORS CORPORATION	FLEXIBLE METHOD FOR MONITORING FUEL CELL VOLTAGE
6458479	2000	2002	UNIVERSITY OF CALIFORNIA	AIR BREATHING DIRECT METHANOL FUEL CELL
6488837	2000	2002	UNIVERSITY OF CALIFORNIA	METHANOL SENSOR OPERATED IN A PASSIVE MODE
6490812	2000	2002	BATTELLE MEMORIAL INSTITUTE	ACTIVE MICROCHANNEL FLUID PROCESSING UNIT AND METHOD OF MAKING
6492052	2000	2002	UNIVERSITY OF CALIFORNIA	AIR BREATHING DIRECT METHANOL FUEL CELL
6494326	2000	2002	SANDIA CORPORATION	COMPOSITE ZEOLITE MEMBRANES
6497970	1999	2002	GENERAL MOTORS CORPORATION	CONTROLLED AIR INJECTION FOR A FUEL CELL SYSTEM
6498121	2000	2002	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-PALLADIUM ALLOYS FOR USE AS A FUEL CELL CATALYST
EP1166379	2000	2002	ENERGY PARTNERS, L.C.	METHOD AND APPARATUS FOR MAINTAINING NEUTRAL WATER BALANCE IN A FUEL CELL SYSTEM
EP1181397	2000	2002	DE NORA ELETTRODI S.P.A.	RHODIUM ELECTROCATALYST AND METHOD OF PREPARATION
EP1200244	2000	2002	TELEDYNE ENERGY SYSTEMS, INC.	IMPROVED CONDUCTIVITY FUEL CELL COLLECTOR PLATE

				AND METHOD OF FABRICATION
EP1222703	2000	2002	ALLIEDSIGNAL INC.	FUEL CELL AND BIPOLAR PLATE FOR USE WITH SAME
EP1228546	2000	2002	UNIVERSITY OF CALIFORNIA	STRUCTURES AND FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
EP1230702	2000	2002	ALLIEDSIGNAL INC.	FUEL CELL HAVING IMPROVED CONDENSATION AND REACTION PRODUCT MANAGEMENT CAPABILITIES
EP1240678	2000	2002	ALLIEDSIGNAL INC.	CORROSION RESISTANT COATED FUEL CELL BIPOLAR PLATE WITH GRAPHITE PROTECTIVE BARRIER AND METHOD OF MAKING THE SAME
EP1258048	2001	2002	HONEYWELL INTERNATIONAL INC.	WICKING STRANDS FOR A POLYMER ELECTROLYTE MEMBRANE FUEL CELL
EP1267435	1998	2002	GENERAL MOTORS CORPORATION	METHOD OF MONITORING CO CONCENTRATIONS IN HYDROGEN FEED TO A PEM FUEL CELL
WO2002009214	2001	2002	APOLLO ENERGY SYSTEMS, INCORPORATED	ELECTRODES FOR ALKALINE FUEL CELLS WITH CIRCULATING ELECTROLYTE
WO2002009221	2001	2002	APOLLO ENERGY SYSTEMS, INCORPORATED	ADDITIVES TO THE GAS SUPPLY OF FUEL CELLS WITH CIRCULATING ELECTROLYTES AND MEANS TO REGENERATE USED STACKS
WO2002027827	2001	2002	OSRAM SYLVANIA INC.	TUNGSTEN-CONTAINING FUEL CELL CATALYST AND METHOD OF MAKING SAME
WO2002037592	2001	2002	TELEDYNE ENERGY SYSTEMS, INC.	FUEL CELL COLLECTOR PLATES WITH IMPROVED MASS TRANSFER CHANNELS
WO2002039514	2001	2002	HONEYWELL INTERNATIONAL INC.	A THREE-WHEEL AIR TURBOCOMPRESSOR FOR PEM FUEL CELL SYSTEMS
WO2002045188	2001	2002	UNIVERSITY OF CALIFORNIA	CATALYST INKS AND METHOD OF APPLICATION FOR DIRECT METHANOL FUEL CELLS
WO2002046732	2001	2002	UNIVERSITY OF	A METHANOL SENSOR

			CALIFORNIA	OPERATED IN A PASSIVE MODE
WO2002064248	2002	2002	BATTELLE MEMORIAL INSTITUTE	INTEGRATED REACTORS, METHODS OF MAKING SAME, AND METHODS OF CONDUCTING SIMULTANEOUS EXOTHERMIC AND ENDOTHERMIC REACTIONS
WO2002073730	2002	2002	UNIVERSITY OF CALIFORNIA	HIGH POWER DENSITY SOLID OXIDE FUEL CELLS AND METHOD OF FABRICATION
WO2002078110	2002	2002	UNIVERSITY OF CHICAGO	IMPROVED PROTON CONDUCTING MEMBRANE FOR FUEL CELLS
WO2002091504	2002	2002	UNIVERSITY OF CALIFORNIA	FUEL CELL ANODE CONFIGURATION FOR CO TOLERANCE
WO2002091508	2002	2002	NUVERA FUEL CELLS, INC	COGENERATION OF POWER AND HEAT BY AN INTEGRATED FUEL CELL POWER SYSTEM
6503654	2001	2003	UNASSIGNED	THIN GRAPHITE BIPOLAR PLATE WITH ASSOCIATED GASKETS AND CARBON CLOTH FLOW-FIELD FOR USE IN AN IONOMER MEMBRANE FUEL CELL
6517965	2000	2003	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-NICKEL ALLOY FOR USE AS A FUEL CELL CATALYST
6521202	1999	2003	UNIVERSITY OF CHICAGO	OXYGEN ION CONDUCTING MATERIALS
6528198	1999	2003	PLUG POWER, L.L.C.	FUEL CELL MEMBRANE HYDRATION AND FLUID METERING
6533840	2001	2003	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL LAMINATED MASS EXCHANGER AND METHOD OF MAKING
6551736	2000	2003	TELEDYNE ENERGY SYSTEMS, INC.	FUEL CELL COLLECTOR PLATES WITH IMPROVED MASS TRANSFER CHANNELS
6555262	2000	2003	HYBRID POWER GENERATION SYSTEMS, LLC	WICKING STRANDS FOR A POLYMER ELECTROLYTE MEMBRANE
6572997	2000	2003	HYBRID POWER GENERATION SYSTEMS, LLC	NANOCOMPOSITE FOR FUEL CELL BIPOLAR PLATE
6576359	2001	2003	GENERAL MOTORS CORPORATION	CONTROLLED AIR INJECTION FOR A FUEL CELL SYSTEM

6586561	2000	2003	CASE WESTERN RESERVE UNIVERSITY	RIGID ROD ION CONDUCTING COPOLYMERS
6596422	2002	2003	UNIVERSITY OF CALIFORNIA	AIR BREATHING DIRECT METHANOL FUEL CELL
6602624	2000	2003	GENERAL MOTORS CORPORATION	CONTROL APPARATUS AND METHOD FOR EFFICIENTLY HEATING A FUEL PROCESSOR IN A FUEL CELL SYSTEM
6605316	2000	2003	UNIVERSITY OF CALIFORNIA	STRUCTURES AND FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
6607854	2000	2003	HONEYWELL INTERNATIONAL INC.	THREE-WHEEL AIR TURBOCOMPRESSOR FOR PEM FUEL CELL SYSTEMS
6617065	2001	2003	TELEDYNE ENERGY SYSTEMS, INC.	METHOD AND APPARATUS FOR MAINTAINING NEUTRAL WATER BALANCE IN A FUEL CELL SYSTEM
6635369	2001	2003	UNIVERSITY OF CALIFORNIA	METHOD FOR IMPROVING FUEL CELL PERFORMANCE
6635378	1999	2003	HYBRID POWER GENERATION SYSTEMS, LLC	FUEL CELL HAVING IMPROVED CONDENSATION AND REACTION PRODUCT MANAGEMENT CAPABILITIES
6649031	1999	2003	HYBRID POWER GENERATION SYSTEMS, LLC	CORROSION RESISTANT COATED FUEL CELL BIPOLAR PLATE WITH FILLED-IN FINE SCALE POROSITIES AND METHOD OF MAKING THE SAME
6656870	2001	2003	OSRAM SYLVANIA INC.	TUNGSTEN-CONTAINING FUEL CELL CATALYST AND METHOD OF MAKING SAME
6670301	2001	2003	BROOKHAVEN SCIENCE ASSOCIATES LLC	CARBON MONOXIDE TOLERANT ELECTROCATALYST WITH LOW PLATINUM LOADING AND A PROCESS FOR ITS PREPARATION
6670305	2001	2003	UNIVERSITY OF CHICAGO	FREE-STANDING MONOLITHIC CATALYST WITH MICRO-SCALE CHANNEL DIMENSIONS
EP1287573	2001	2003	HONEYWELL INTERNATIONAL INC.	NANOCOMPOSITE FOR FUEL CELL BIPOLAR PLATE
EP1314218	2001	2003	NUVERA FUEL	JOINT-CYCLE HIGH-

			CELLS, INC.	EFFICIENCY FUEL CELL SYSTEM WITH POWER GENERATING TURBINE
EP1336212	2001	2003	HONEYWELL INTERNATIONAL INC.	A THREE-WHEEL AIR TURBOCOMPRESSOR FOR PEM FUEL CELL SYSTEMS
EP1358687	2001	2003	OSRAM SYLVANIA INC.	TUNGSTEN-CONTAINING FUEL CELL CATALYST AND METHOD OF MAKING SAME
EP1360001	2002	2003	BATTELLE MEMORIAL INSTITUTE	INTEGRATED REACTORS, METHODS OF MAKING SAME, AND METHODS OF CONDUCTING SIMULTANEOUS EXOTHERMIC AND ENDOTHERMIC REACTIONS
WO2003026053	2002	2003	3M INNOVATIVE PROPERTIES COMPANY	FLOW FIELD
WO2003033983	2002	2003	BATTELLE MEMORIAL INSTITUTE	FLUID PROCESSING DEVICE AND METHOD
WO2003040435	2002	2003	DE NORA ELETTRODI S.P.A.	IMPROVED RHODIUM ELECTROCATALYST AND METHOD OF PREPARATION
WO2003054994	2002	2003	3M INNOVATIVE PROPERTIES COMPANY	AMINE OXIDE COATING COMPOSITIONS
WO2003067696	2003	2003	BATTELLE MEMORIAL INSTITUTE	METHODS OF REMOVING CONTAMINANTS FROM A FUEL CELL ELECTRODE
WO2003082956	2003	2003	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	SULFONATED POLYMER COMPOSITION FOR FORMING FUEL CELL ELECTRODES
WO2003096445	2003	2003	UNIVERSITY OF CALIFORNIA	DIRECT METHANOL FUEL CELL AND SYSTEM
WO2003107455	2003	2003	UNIVERSITY OF CHICAGO	COMPOSITIONALLY GRADED METALLIC PLATES FOR PLANAR SOLID OXIDE FUEL CELLS
6682837	2002	2004	SYMYX TECHNOLOGIES, INC.	METHOD FOR PRODUCING ELECTRICITY USING A PLATINUM-RUTHENIUM-PALLADIUM CATALYST IN A FUEL CELL
6686084	2002	2004	HYBRID POWER GENERATION SYSTEMS, LLC	GAS BLOCK MECHANISM FOR WATER REMOVAL IN FUEL CELLS
6692851	2001	2004	GENERAL MOTORS CORPORATION	FUEL CELL STACK MONITORING AND SYSTEM CONTROL
6696382	2000	2004	UNIVERSITY OF	CATALYST INKS AND

			CALIFORNIA	METHOD OF APPLICATION FOR DIRECT METHANOL FUEL CELLS
6703068	2001	2004	3M INNOVATIVE PROPERTIES COMPANY	AMINE OXIDE COATING COMPOSITIONS
6723462	2001	2004	GAS TECHNOLOGY INSTITUTE	LOW COST METAL BIPOLAR PLATES AND CURRENT COLLECTORS FOR POLYMER ELECTROLYTE MEMBRANE FUEL CELLS
6723678	2002	2004	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-NICKEL ALLOY FOR USE AS A FUEL CELL CATALYST
6780536	2001	2004	3M INNOVATIVE PROPERTIES COMPANY	FLOW FIELD
6790548	2002	2004	GENERAL MOTORS CORPORATION	STAGED VENTING OF FUEL CELL SYSTEM DURING RAPID SHUTDOWN
6803141	2002	2004	UNIVERSITY OF CALIFORNIA	HIGH POWER DENSITY SOLID OXIDE FUEL CELLS
6808838	2002	2004	UNIVERSITY OF CALIFORNIA	DIRECT METHANOL FUEL CELL AND SYSTEM
6818341	2001	2004	UNIVERSITY OF CALIFORNIA	FUEL CELL ANODE CONFIGURATION FOR CO TOLERANCE
6821498	2002	2004	UNIVERSITY OF CHICAGO	OXYGEN ION CONDUCTING MATERIALS
6828057	2002	2004	ENERGY CONVERSION DEVICES, INC.	FUEL CELL WITH FRAMED ELECTRODES
EP1394883	2003	2004	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING TEMPERING OF FUEL CELL STACKS BY EXHAUST GAS
EP1397633	2002	2004	BATTELLE MEMORIAL INSTITUTE	FLUID PROCESSING DEVICE AND METHOD
EP1401040	2003	2004	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL MODULE FOR A FUEL CELL STACK
EP1416563	2003	2004	ADVANCED FLUID TECHNOLOGIES, INC.	FUEL CELL AND FUEL CELL COOLANT COMPOSITION
EP1428279	2002	2004	3M INNOVATIVE PROPERTIES COMPANY	FLOW FIELD
EP1430557	2002	2004	NUVERA FUEL CELLS, INC.	COGENERATION OF POWER AND HEAT BY AN INTEGRATED FUEL CELL POWER SYSTEM
EP1444384	2002	2004	DE NORA ELETTRODI S.P.A.	RHODIUM ELECTROCATALYST AND

				METHOD OF PREPARATION
EP1485963	2002	2004	3M INNOVATIVE PROPERTIES COMPANY	AMINE OXIDE COATING COMPOSITIONS
WO2004019434	2003	2004	FUELCELL ENERGY, INC.	DUAL-POROSITY RIBBED FUEL CELL CATHODE
WO2004045010	2003	2004	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL STACK
WO2004062001	2003	2004	NUVERA FUEL CELLS, INC.	HIGH-EFFICIENCY FUEL CELL POWER SYSTEM WITH POWER GENERATING EXPANDER
WO2004095619	2004	2004	UNIVERSITY OF CALIFORNIA	IMPROVED DIRECT METHANOL FUEL CELL STACK
WO2004100288	2004	2004	GAS TECHNOLOGY INSTITUTE	FOLDED METAL BIPOLAR SHEETS FOR FUEL CELLS
WO2004106591	2004	2004	DE NORA ELETTRODI S.P.A.	CATALYST FOR OXYGEN REDUCTION
6843960	2002	2005	UNIVERSITY OF CHICAGO	COMPOSITIONALLY GRADED METALLIC PLATES FOR PLANAR SOLID OXIDE FUEL CELLS
6846558	2002	2005	UNIVERSITY OF CALIFORNIA	COLLOIDAL SPRAY METHOD FOR LOW COST THIN COATING DEPOSITION
6847188	2004	2005	GENERAL MOTORS CORPORATION	FUEL CELL STACK MONITORING AND SYSTEM CONTROL
6855660	2002	2005	DE NORA ELETTRODI S.P.A.	RHODIUM ELECTROCATALYST AND METHOD OF PREPARATION
6861169	2002	2005	NUVERA FUEL CELLS, INC.	COGENERATION OF POWER AND HEAT BY AN INTEGRATED FUEL CELL POWER SYSTEM
6864004	2004	2005	UNIVERSITY OF CALIFORNIA	DIRECT METHANOL FUEL CELL STACK
6864007	1999	2005	HYBRID POWER GENERATION SYSTEMS, LLC	CORROSION RESISTANT COATED FUEL CELL PLATE WITH GRAPHITE PROTECTIVE BARRIER AND METHOD OF MAKING THE SAME
6890679	2002	2005	FUELCELL ENERGY, INC.	DUAL-POROSITY RIBBED FUEL CELL CATHODE
6905793	2003	2005	GAS TECHNOLOGY INSTITUTE	FOLDED METAL BIPOLAR SHEETS FOR FUEL CELLS
6916564	2002	2005	NUVERA FUEL CELLS, INC.	HIGH-EFFICIENCY FUEL CELL POWER SYSTEM WITH POWER GENERATING EXPANDER

6916570	2004	2005	UNIVERSITY OF CHICAGO	OXYGEN ION CONDUCTING MATERIALS
6921595	2001	2005	NUVERA FUEL CELLS, INC.	JOINT-CYCLE HIGH-EFFICIENCY FUEL CELL SYSTEM WITH POWER GENERATING TURBINE
6921605	2004	2005	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-NICKEL FUEL CELL ELECTROCATALYST
6926986	2002	2005	ENERGY CONVERSION DEVICES, INC.	FUEL CELL WITH ENCAPSULATED ELECTRODES
6956083	2002	2005	UNIVERSITY OF CALIFORNIA	SINGLE ION CONDUCTOR CROSS-LINKED POLYMERIC NETWORKS
6962760	2003	2005	UNIVERSITY OF CALIFORNIA	METHODS OF CONDITIONING DIRECT METHANOL FUEL CELLS
6969506	2002	2005	BATTELLE MEMORIAL INSTITUTE	METHODS OF CONDUCTING SIMULTANEOUS EXOTHERMIC AND ENDOTHERMIC REACTIONS
6977122	2002	2005	UNIVERSITY OF CHICAGO	PROTON CONDUCTING MEMBRANE FOR FUEL CELLS
6979511	2002	2005	UNIVERSITY OF CALIFORNIA	STRUCTURES AND FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
EP1500158	2003	2005	BATTELLE MEMORIAL INSTITUTE	METHODS OF REMOVING CONTAMINANTS FROM A FUEL CELL ELECTRODE
EP1505120	2004	2005	ARKEMA INC.	RESIN COMPOSITIONS CONTAINING IONIC OR IONIZABLE GROUPS WITH SMALL DOMAIN SIZES AND IMPROVED CONDUCTIVITY
EP1537614	2003	2005	FUELCELL ENERGY, INC.	DUAL-POROSITY RIBBED FUEL CELL CATHODE
EP1563565	2003	2005	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL STACK
EP1579520	2003	2005	NUVERA FUEL CELLS, INC.	HIGH-EFFICIENCY FUEL CELL POWER SYSTEM WITH POWER GENERATING EXPANDER
WO2005001953	2004	2005	UNIVERSITY OF CALIFORNIA	METHODS OF CONDITIONING DIRECT METHANOL FUEL CELLS
WO2005001979	2004	2005	E.I. DU PONT DE NEMOURS AND	FLUORINATED SULFONAMIDE

			COMPANY	COMPOUNDS AND POLYMER ELECTROLYTE MEMBRANES PEPARED THEREFROM FOR USE IN ELECTROCHEMICAL CELLS
WO2005035123	2004	2005	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL CATHODE CATALYST
WO2005049204	2004	2005	E.I. DU PONT DE NEMOURS AND COMPANY	TRIFLUOROSTYRENE CONTAINING COMPOUNDS GRAFTED TO BASE POLYMERS, AND THEIR USE AS POLYMER ELECTROLYTE MEMBRANES
WO2005113621	2004	2005	E.I. DU PONT DE NEMOURS AND COMPANY	STABLE TRIFLUOROSTYRENE CONTAINING COMPOUNDS GRAFTED TO BASE POLYMERS
WO2005124905	2005	2005	DE NORA ELETTRODI S.P.A.	GAS DIFFUSION ELECTRODES, MEMBRANE-ELECTRODE ASSEMBLIES AND METHOD FOR THE PRODUCTION THEREOF
6986961	2002	2006	UNIVERSITY OF CALIFORNIA	FUEL CELL STACK WITH PASSIVE AIR SUPPLY
6986963	2001	2006	UT-BATTELLE, LLC	METALLIZATION OF BACTERIAL CELLULOSE FOR ELECTRICAL AND ELECTRONIC DEVICE MANUFACTURE
6994829	2002	2006	BATTELLE MEMORIAL INSTITUTE	FLUID PROCESSING DEVICE AND METHOD
6995114	2004	2006	SYMYX TECHNOLOGIES, INC.	PLATINUM-RUTHENIUM-PALLADIUM FUEL CELL ELECTROCATALYST
7014931	2002	2006	UNIVERSITY OF CALIFORNIA	METHANOL-TOLERANT CATHODE CATALYST COMPOSITE FOR DIRECT METHANOL FUEL CELLS
7014944	2003	2006	APOLLO ENERGY SYSTEMS, INCORPORATED	ELECTRODES FOR ALKALINE FUEL CELLS WITH CIRCULATING ELECTROLYTE
7018604	2003	2006	IOWA STATE UNIVERSITY	COMPOUNDS FOR NOVEL PROTON CONDUCTING MEMBRANES AND METHODS OF MAKING SAME
7022810	2003	2006	SANDIA CORPORATION	PROTON EXCHANGE MEMBRANE MATERIALS FOR THE ADVANCEMENT

				OF DIRECT METHANOL FUEL-CELL TECHNOLOGY
7033637	2001	2006	MICROCOATING TECHNOLOGIES, INC.	EPITAXIAL THIN FILMS
7037620	2002	2006	APOLLO ENERGY SYSTEMS, INCORPORATED	MULTI-CELLULAR ELECTRICAL BATTERY
7052793	2000	2006	FOSTER-MILLER, INC.	COMPOSITE SOLID POLYMER ELECTROLYTE MEMBRANES
7060648	2003	2006	OSRAM SYLVANIA INC.	TUNGSTEN-CONTAINING FUEL CELL CATALYST AND METHOD OF MAKING SAME
7101527	2004	2006	IOWA STATE UNIVERSITY	MIXED ANION MATERIALS AND COMPOUNDS FOR NOVEL PROTON CONDUCTING MEMBRANES
7101635	2002	2006	UNIVERSITY OF CALIFORNIA	METHANOL-TOLERANT CATHODE CATALYST COMPOSITE FOR DIRECT METHANOL FUEL CELLS
7101643	2002	2006	UNIVERSITY OF CALIFORNIA	POLYMERIC ELECTROLYTES BASED ON HYDROSILYATION REACTIONS
7118777	2005	2006	UNIVERSITY OF CALIFORNIA	STRUCTURES AND FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
7128990	2003	2006	APOLLO ENERGY SYSTEMS, INCORPORATED	ADDITIVES TO THE GAS SUPPLY OF FUEL CELLS WITH CIRCULATING ELECTROLYTES AND MEANS TO REGENERATE USED STACKS
7135537	2004	2006	E.I. DU PONT DE NEMOURS AND COMPANY	SULFONIMIDE-CONTAINING POLY(ARYLENE ETHER)S AND POLY(ARYLENE ETHER SULFONE)S, METHODS FOR PRODUCING THE SAME, AND USES THEREOF
7138199	2002	2006	ADVANCED FLUID TECHNOLOGIES, INC.	FUEL CELL AND FUEL CELL COOLANT COMPOSITIONS
7147214	2003	2006	UT-BATTELLE, LLC	HUMIDIFIER FOR FUEL CELL USING HIGH CONDUCTIVITY CARBON FOAM
EP1629140	2004	2006	DE NORA	METHOD FOR PRODUCING

			ELETTRODI S.P.A.	A GAS DIFFUSION ELECTRODE
EP1637222	1998	2006	BATTELLE MEMORIAL INSTITUTE	ACTIVE MICROCHANNEL HEAT EXCHANGER
EP1667793	2004	2006	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL CATHODE CATALYST
EP1724869	2006	2006	DELPHI TECHNOLOGIES, INC.	ANODE TAIL GAS RECYCLE COOLER AND RE-HEATER FOR A SOLID OXIDE FUEL CELL STACK ASSEMBLY
WO2006019508	2005	2006	ARKEMA INC.	MULTI-LAYER POLYELECTROLYTE MEMBRANE
WO2006031953	2005	2006	UNIVERSITY OF CHICAGO	DEVICES USING RESIN WAFERS AND APPLICATIONS THEREOF
WO2006034014	2005	2006	3M INNOVATIVE PROPERTIES COMPANY	DURABLE FUEL CELL
WO2006036237	2005	2006	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL DURABILITY
WO2006036888	2005	2006	GINER ELECTROCHEMICAL SYSTEMS, LLC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING LASER MICROMACHINED POROUS SUPPORT
WO2006036957	2005	2006	GINER ELECTROCHEMICAL SYSTEMS, LLC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING PLASMA ETCHED POROUS SUPPORT
WO2006044777	2005	2006	INTEMATIX CORPORATION	PRODUCTION OF NANO-POWDER BASED COMBINATORIAL LIBRARIES
WO2006065413	2005	2006	3M INNOVATIVE PROPERTIES COMPANY	METHOD OF TESTING A FUEL CELL BY INFRARED THERMOGRAPHY
WO2006073474	2005	2006	FOSTER-MILLER, INC.	COMPOSITE SOLID POLYMER ELECTROLYTE MEMBRANES
WO2006086457	2006	2006	BROOKHAVEN SCIENCE ASSOCIATES LLC	PALLADIUM-COBALT PARTICLES AS OXYGEN-REDUCTION ELECTROCATALYSTS
WO2006089180	2006	2006	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL CATALYST
WO2006102671	2006	2006	E.I. DU PONT DE NEMOURS AND COMPANY	PROCESS TO PREPARE STABLE TRIFLUOROSTYRENE

				CONTAINING COMPOUNDS GRAFTED TO BASE POLYMERS USING A SOLVENT/WATER MIXTURE
WO2006105130	2006	2006	TOYOTA MOTOR CORP	NOVEL ELECTROLYTES TO ENHANCE OXYGEN REDUCTION REACTION (ORR) IN THE CATHODE LAYER OF PEM FUEL CELL
WO2006108668	2006	2006	PEMEAS GMBH	GAS DIFFUSION ELECTRODES, MEMBRANE-ELECTRODE ASSEMBLIES AND METHOD FOR THE PRODUCTION THEREOF
WO2006110686	2006	2006	UT-BATTELLE, LLC	STACK CONFIGURATIONS FOR TUBULAR SOLID OXIDE FUEL CELLS
WO2006124959	2006	2006	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYST FOR OXYGEN REDUCTION WITH REDUCED PLATINUM OXIDATION AND DISSOLUTION RATES
WO2006127309	2006	2006	ARKEMA INC.	BLEND OF IONIC (CO) POLYMER RESINS AND MATRIX (CO) POLYMERS
WO2006130336	2006	2006	FUELCELL ENERGY, INC.	CARBONATE FUEL CELL AND COMPONENTS THEREOF FOR IN-SITU DELAYED ADDITION OF ELECTROLYTE
WO2006135372	2005	2006	UNASSIGNED	COMBINATORIAL METHOD AND APPARATUS FOR SCREENING ELECTROCHEMICAL MATERIALS
WO2006135396	2005	2006	BROOKHAVEN SCIENCE ASSOCIATES LLC	HYDROGEN ABSORPTION INDUCED METAL DEPOSITION ON PALLADIUM AND PALLADIUM-ALLOY PARTICLES
7163761	2002	2007	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL STACK
7195835	2005	2007	UCHICAGO ARGONNE, LLC	PROTON CONDUCTING MEMBRANE FOR FUEL CELLS
7211346	2003	2007	UT-BATTELLE, LLC	CORROSION RESISTANT METALLIC BIPOLAR PLATE
7214442	2004	2007	LOS ALAMOS NATIONAL SECURITY, LLC	HIGH SPECIFIC POWER, DIRECT METHANOL FUEL CELL STACK
7247403	2005	2007	UT-BATTELLE, LLC	SURFACE MODIFIED STAINLESS STEELS FOR

				PEM FUEL CELL BIPOLAR PLATES
7255798	2005	2007	ION POWER, INC.	RECYCLING OF USED PERFLUOROSULFONIC ACID MEMBRANES
7255955	2003	2007	US NAVY	HYDROUS PHOSPHATE CATALYSTS WITH LOW PLATINUM
7264778	2003	2007	SANDIA CORPORATION	CARBON MONOXIDE SENSOR AND METHOD OF USE THEREOF
7270906	2002	2007	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL MODULE FOR A FUEL CELL STACK
7301002	2004	2007	SANDIA CORPORATION	SULFONATED POLYPHENYLENE POLYMERS
7306934	2003	2007	UCHICAGO ARGONNE, LLC	POROUS SOLID ION EXCHANGE WAFER FOR IMMOBILIZING BIOMOLECULES
EP1786055	2006	2007	GENERAL ELECTRIC COMPANY	SOFC SEAL AND CELL THERMAL MANAGEMENT
EP1786056	2006	2007	GENERAL ELECTRIC COMPANY	METHOD AND MATERIALS FOR BONDING ELECTRODES TO INTERCONNECT LAYERS IN SOLID OXIDE FUEL CELL STACKS
EP1790028	2005	2007	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL DURABILITY
EP1792360	2005	2007	3M INNOVATIVE PROPERTIES COMPANY	DURABLE FUEL CELL
EP1794823	2005	2007	ARKEMA INC.	MULTI-LAYER POLYELECTROLYTE MEMBRANE
EP1797610	2005	2007	PEMEAS GMBH	GAS DIFFUSION ELECTRODES, MEMBRANE-ELECTRODE ASSEMBLIES AND METHOD FOR THE PRODUCTION THEREOF
EP1807342	2005	2007	INTEMATIX CORPORATION	PRODUCTION OF NANO-POWDER BASED COMBINATORIAL LIBRARIES
EP1817811	2005	2007	3M INNOVATIVE PROPERTIES COMPANY	METHOD OF TESTING A FUEL CELL BY INFRARED THERMOGRAPHY
EP1838480	2005	2007	BROOKHAVEN SCIENCE ASSOCIATES LLC	HYDROGEN ABSORPTION INDUCED METAL DEPOSITION ON PALLADIUM AND PALLADIUM-ALLOY

				PARTICLES
EP1849200	2006	2007	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL CATALYST
EP1849201	2006	2007	BROOKHAVEN SCIENCE ASSOCIATES LLC	PALLADIUM-COBALT PARTICLES AS OXYGEN-REDUCTION ELECTROCATALYSTS
WO2007005675	2006	2007	UT-BATTELLE, LLC	TUBULAR SOLID OXIDE FUEL CELL CURRENT COLLECTOR
WO2007035188	2006	2007	3M INNOVATIVE PROPERTIES COMPANY	OXIDATIVELY STABLE MICROLAYERS OF GAS DIFFUSION LAYERS
WO2007035294	2006	2007	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTROLYTE MEMBRANE WITH BASIC POLYMER
WO2007047262	2006	2007	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL NANOCATALYST
WO2007058913	2006	2007	PRAXAIR TECHNOLOGY, INC.	HYDROGEN TRANSPORT MEMBRANE FABRICATION METHOD
WO2007075299	2006	2007	DOW GLOBAL TECHNOLOGIES INC.	POLYDENTATE HETEROATOM LIGAND CONTAINING METAL COMPLEXES, CATALYSTS AND METHODS OF MAKING AND USING THE SAME
WO2007075366	2006	2007	ACUMENTRICS CORPORATION	INTERCONNECTION OF BUNDLED SOLID OXIDE FUEL CELLS
WO2007075437	2006	2007	INTEMATIX CORPORATION	LOW PLATINUM FUEL CELLS, CATALYSTS, AND METHOD FOR PREPARING THE SAME
WO2007084155	2006	2007	UNIVERSITY OF CALIFORNIA	ANION-CONDUCTING POLYMER, COMPOSITION, AND MEMBRANE
WO2007084759	2007	2007	UNIVERSITY OF TEXAS	CHLORINE RESISTANT DESALINATION MEMBRANES BASED ON DIRECTLY SULFONATED POLY(ARYLENE ETHER SULFONE) COPOLYMERS
WO2007086954	2006	2007	LOS ALAMOS NATIONAL SECURITY, LLC	METAL-POLYMER COMPOSITE CATALYSTS AND METHOD OF MAKING
WO2007112435	2007	2007	OHIO UNIVERSITY	SOLID OXIDE FUEL CELL PROCESS AND APPARATUS
WO2007120189	2006	2007	3M INNOVATIVE PROPERTIES COMPANY	HIGH DURABILITY FUEL CELL COMPONENTS WITH CERIUM SALT ADDITIVES
WO2007120190	2006	2007	3M INNOVATIVE PROPERTIES	HIGH DURABILITY FUEL CELL COMPONENTS WITH

			COMPANY	CERIUM OXIDE ADDITIVES
WO2007124200	2007	2007	3M INNOVATIVE PROPERTIES COMPANY	OXYGEN-REDUCING CATALYST LAYER
WO2007142944	2007	2007	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF MAKING CHALCOGEN CATALYSTS FOR POLYMER ELECTROLYTE FUEL CELLS
WO2007149904	2007	2007	BASF CORPORATION	PROCESS FOR RECYCLING COMPONENTS OF A PEM FUEL CELL MEMBRANE ELECTRODE ASSEMBLY
7351444	2004	2008	INTEMATIX CORPORATION	LOW PLATINUM FUEL CELL CATALYSTS AND METHOD FOR PREPARING THE SAME
7351488	2006	2008	UNIVERSITY OF CALIFORNIA	STRUCTURES AND FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
7361729	2001	2008	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	ION-CONDUCTING SULFONATED POLYMERIC MATERIALS
7365121	2004	2008	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	HIGHLY CONDUCTIVE THERMOPLASTIC COMPOSITES FOR RAPID PRODUCTION OF FUEL CELL BIPOLAR PLATES
7373819	2005	2008	HONEYWELL INTERNATIONAL INC.	STRESS SENSITIVE HUMIDITY SENSOR BASED ON A MEMS STRUCTURE
7375176	2005	2008	UNASSIGNED	LIQUID CRYSTAL POLY(PHENYLENE SULFONIC ACIDS)
7396880	2006	2008	ARKEMA INC.	BLEND OF IONIC (CO)POLYMER RESINS AND MATRIX (CO)POLYMERS
7413687	2005	2008	UT-BATTELLE, LLC	LOW TEMPERATURE PROTON CONDUCTING OXIDE DEVICES
7419546	2005	2008	BASF CORPORATION	GAS DIFFUSION ELECTRODES, MEMBRANE-ELECTRODE ASSEMBLIES AND METHOD FOR THE PRODUCTION THEREOF
7419741	2003	2008	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL CATHODE CATALYST
7422766	2004	2008	LAWRENCE LIVERMORE NATIONAL	METHOD OF FABRICATION OF HIGH POWER DENSITY SOLID OXIDE FUEL CELLS

			SECURITY, LLC	
7439275	2006	2008	LOS ALAMOS NATIONAL SECURITY, LLC	ANION-CONDUCTING POLYMER, COMPOSITION, AND MEMBRANE
7449111	2004	2008	ARKEMA INC.	RESINS CONTAINING IONIC OR IONIZABLE GROUPS WITH SMALL DOMAIN SIZES AND IMPROVED CONDUCTIVITY
7456314	2007	2008	E.I. DU PONT DE NEMOURS AND COMPANY	PARTIALLY FLUORINATED IONIC COMPOUNDS
EP1875538	2006	2008	BASF CORPORATION	METHOD FOR THE PRODUCTION OF GAS DIFFUSION ELECTRODES
EP1878082	2006	2008	UT-BATTELLE, LLC	STACK CONFIGURATIONS FOR TUBULAR SOLID OXIDE FUEL CELLS
EP1880440	2006	2008	3M INNOVATIVE PROPERTIES COMPANY	OXIDATIVELY STABLE MICROLAYERS OF GAS DIFFUSION LAYERS
EP1883468	2006	2008	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYST FOR OXYGEN REDUCTION WITH REDUCED PLATINUM OXIDATION AND DISSOLUTION RATES
EP1889322	2006	2008	ARKEMA INC.	BLEND OF IONIC (CO) POLYMER RESINS AND MATRIX (CO) POLYMERS
EP1889323	2006	2008	FUELCELL ENERGY, INC.	CARBONATE FUEL CELL AND COMPONENTS THEREOF FOR IN-SITU DELAYED ADDITION OF ELECTROLYTE
EP1908142	2006	2008	UT-BATTELLE, LLC	TUBULAR SOLID OXIDE FUEL CELL CURRENT COLLECTOR
EP1922777	2006	2008	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYSTS HAVING GOLD MONOLAYERS ON PLATINUM NANOPARTICLE CORES, AND USES THEREOF
EP1946400	2006	2008	3M INNOVATIVE PROPERTIES COMPANY	HIGH DURABILITY FUEL CELL COMPONENTS WITH CERIUM OXIDE ADDITIVES
EP1954367	2006	2008	PRAXAIR TECHNOLOGY, INC.	HYDROGEN TRANSPORT MEMBRANE FABRICATION METHOD
EP1972024	2006	2008	E.I. DU PONT DE NEMOURS AND COMPANY	CHEMICALLY STABILIZED IONOMERS CONTAINING INORGANIC FILLERS
EP1973655	2006	2008	DOW GLOBAL TECHNOLOGIES INC.	POLYDENTATE HETEROATOM LIGAND CONTAINING METAL

				COMPLEXES, CATALYSTS AND METHODS OF MAKING AND USING THE SAME
EP1979974	2006	2008	ACUMENTRICS CORPORATION	INTERCONNECTION OF BUNDLED SOLID OXIDE FUEL CELLS
WO2008008409	2007	2008	UNIVERSITY OF PENNSYLVANIA	HIGH-PERFORMANCE CERAMIC ANODES FOR USE WITH STRATEGIC AND OTHER HYDROCARBON FUELS
WO2008013783	2007	2008	CERAMATEC, INC.	EFFICIENT REVERSIBLE ELECTRODES FOR SOLID OXIDE ELECTROLYZER CELLS
WO2008013877	2007	2008	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF IMPROVING FUEL CELL PERFORMANCE
WO2008030246	2006	2008	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTROLYTE MEMBRANE WITH ACIDIC POLYMER
WO2008033113	2006	2008	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYSTS HAVING GOLD MONOLAYERS ON PLATINUM NANOPARTICLE CORES, AND USES THEREOF
WO2008033421	2007	2008	UNIVERSITY OF AKRON	CATALYSTS COMPOSITIONS FOR USE IN FUEL CELLS
WO2008054414	2006	2008	LOS ALAMOS NATIONAL SECURITY, LLC	CHALCOGEN CATALYSTS FOR POLYMER ELECTROLYTE FUEL CELL
WO2008054420	2006	2008	E.I. DU PONT DE NEMOURS AND COMPANY	CHEMICALLY STABILIZED IONOMERS CONTAINING INORGANIC FILLERS
WO2008076637	2007	2008	ARKEMA INC.	HIGH TEMPERATURE STABLE POLYELECTROLYTES HAVING BACKBONE AROMATIC GROUPS
WO2008079529	2007	2008	POLYFUEL, INC.	PASSIVE RECOVERY OF LIQUID WATER PRODUCED BY FUEL CELLS
WO2008091801	2008	2008	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	MULTISTAGE COMBUSTOR AND METHOD FOR STARTING A FUEL CELL SYSTEM
WO2008127215	2005	2008	UNIVERSITY OF TENNESSEE	COPOLYMERS OF FLUORINATED POLYDIENES AND SULFONATED POLYSTYRENE
WO2008127320	2007	2008	E.I. DU PONT DE NEMOURS AND	ARYLENE-FLUORINATED-SULFONIMIDE IONOMERS

			COMPANY	AND MEMBRANES FOR FUEL CELLS
WO2008127828	2008	2008	3M INNOVATIVE PROPERTIES COMPANY	HIGH PERFORMANCE, HIGH DURABILITY NON-PRECIOUS METAL FUEL CELL CATALYSTS
7473714	2005	2009	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	MATERIALS FOR USE AS PROTON CONDUCTING MEMBRANES FOR FUEL CELLS
7482083	2003	2009	GENERAL ELECTRIC COMPANY	CORROSION RESISTANT COATED FUEL CELL BIPOLAR PLATE WITH FILLED-IN FINE SCALE POROSITIES
7507318	2005	2009	UCHICAGO ARGONNE, LLC	DEVICES USING RESIN WAFERS AND APPLICATIONS THEREOF
7507495	2004	2009	BROOKHAVEN SCIENCE ASSOCIATES LLC	HYDROGEN ABSORPTION INDUCED METAL DEPOSITION ON PALLADIUM AND PALLADIUM-ALLOY PARTICLES
7517604	2005	2009	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTROLYTE MEMBRANE WITH ACIDIC POLYMER
7531215	2005	2009	PRAXAIR TECHNOLOGY, INC.	HYDROGEN TRANSPORT MEMBRANE FABRICATION METHOD
7544764	2005	2009	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	SULFONATED POLYMER COMPOSITION FOR FORMING FUEL CELL ELECTRODES
7550216	2004	2009	FOSTER-MILLER, INC.	COMPOSITE SOLID POLYMER ELECTROLYTE MEMBRANES
7550223	2006	2009	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF MAKING METAL-POLYMER COMPOSITE CATALYSTS
7553401	2004	2009	FARADAY TECHNOLOGY, INC.	ELECTROPLATING CELL WITH HYDRODYNAMICS FACILITATING MORE UNIFORM DEPOSITION ACROSS A WORKPIECE DURING PLATING
7562588	2006	2009	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR CONTROLLING MASS FLOW RATE OF RECYCLED ANODE TAIL GAS IN SOLID OXIDE FUEL CELL SYSTEM
7563532	2004	2009	E.I. DU PONT DE NEMOURS AND COMPANY	TRIFLUOROSTYRENE CONTAINING COMPOUNDS, AND THEIR USE IN POLYMER ELECTROLYTE

				MEMBRANES
7566410	2006	2009	NANOTEK INSTRUMENTS, INC.	HIGHLY CONDUCTIVE NANO-SCALED GRAPHENE PLATE NANOCOMPOSITES
7572534	2004	2009	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL MEMBRANE ELECTRODE ASSEMBLY
7575824	2006	2009	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF IMPROVING FUEL CELL PERFORMANCE BY REMOVING AT LEAST ONE METAL OXIDE CONTAMINANT FROM A FUEL CELL ELECTRODE
7582683	2008	2009	LOS ALAMOS NATIONAL SECURITY, LLC	ANION-CONDUCTING POLYMER, COMPOSITION, AND MEMBRANE
7588849	2002	2009	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING TEMPERING OF FUEL CELL STACKS BY EXHAUST GAS
7588857	2005	2009	LOS ALAMOS NATIONAL SECURITY, LLC	CHALCOGEN CATALYSTS FOR POLYMER ELECTROLYTE FUEL CELL
7589047	2006	2009	LOS ALAMOS NATIONAL SECURITY, LLC	COMPOSITE MATERIALS AND METHOD OF MAKING
7601216	2005	2009	BASF CORPORATION	GAS DIFFUSION ELECTRODES, MEMBRANE-ELECTRODE ASSEMBLIES AND METHOD FOR THE PRODUCTION THEREOF
7608334	2005	2009	3M INNOVATIVE PROPERTIES COMPANY	OXIDATIVELY STABLE MICROLAYERS OF GAS DIFFUSION LAYERS
7615294	2004	2009	BATTELLE MEMORIAL INSTITUTE	METHODS OF REMOVING CONTAMINANTS FROM A FUEL CELL ELECTRODE
7618915	2007	2009	UNIVERSITY OF SOUTH CAROLINA	COMPOSITE CATALYSTS SUPPORTED ON MODIFIED CARBON SUBSTRATES AND METHODS OF MAKING THE SAME
7619036	2005	2009	UNIVERSITY OF TENNESSEE	COPOLYMERS OF FLUORINATED POLYDIENES AND SULFONATED POLYSTYRENE
7622217	2005	2009	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL NANOCATALYST
7629285	2007	2009	UNIVERSITY OF SOUTH CAROLINA	CARBON-BASED COMPOSITE ELECTROCATALYSTS FOR LOW TEMPERATURE FUEL CELLS

7629426	2008	2009	ARKEMA INC.	BLEND OF IONIC (CO)POLYMER RESINS AND MATRIX (CO)POLYMERS
7632593	2006	2009	UCHICAGO ARGONNE, LLC	BIPOLAR PLATE SUPPORTED SOLID OXIDE FUEL CELL WITH A SEALED ANODE COMPARTMENT
7632595	2004	2009	GENERAL ELECTRIC COMPANY	COMPLIANT FUEL CELL SYSTEM
7632601	2005	2009	BROOKHAVEN SCIENCE ASSOCIATES LLC	PALLADIUM-COBALT PARTICLES AS OXYGEN-REDUCTION ELECTROCATALYSTS
7633267	2005	2009	FARASIS ENERGY, INC.	APPARATUS FOR COMBINATORIAL SCREENING OF ELECTROCHEMICAL MATERIALS
7635534	2007	2009	BASF CORPORATION	SIMPLIFIED PROCESS FOR LEACHING PRECIOUS METALS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
EP2013931	2007	2009	3M INNOVATIVE PROPERTIES COMPANY	OXYGEN-REDUCING CATALYST LAYER
EP2036153	2007	2009	BASF CORPORATION	PROCESS FOR RECYCLING COMPONENTS OF A PEM FUEL CELL MEMBRANE ELECTRODE ASSEMBLY
EP2059965	2007	2009	UNIVERSITY OF AKRON	CATALYSTS COMPOSITIONS FOR USE IN FUEL CELLS
EP2069556	2007	2009	CERAMATEC, INC.	EFFICIENT REVERSIBLE ELECTRODES FOR SOLID OXIDE ELECTROLYZER CELLS
EP2104958	2007	2009	POLYFUEL, INC.	PASSIVE RECOVERY OF LIQUID WATER PRODUCED BY FUEL CELLS
EP2117678	2007	2009	ARKEMA INC.	HIGH TEMPERATURE STABLE POLYELECTROLYTES HAVING BACKBONE AROMATIC GROUPS
EP2127009	2008	2009	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	MULTISTAGE COMBUSTOR AND METHOD FOR STARTING A FUEL CELL SYSTEM
EP2135313	2008	2009	3M INNOVATIVE PROPERTIES COMPANY	HIGH PERFORMANCE, HIGH DURABILITY NON-PRECIOUS METAL FUEL CELL CATALYSTS
WO2009005881	2008	2009	TOYOTA MOTOR	PROTON EXCHANGE

			CORP	MEMBRANE FOR FUEL CELL
WO2009029463	2008	2009	BASF CORPORATION	SIMPLIFIED PROCESS FOR LEACHING PRECIOUS METALS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
WO2009073055	2008	2009	CHEMSULTANTS INTERNATIONAL, INC.	MULTILAYERED COMPOSITE PROTON EXCHANGE MEMBRANE AND A PROCESS FOR MANUFACTURING THE SAME
WO2009108222	2008	2009	3M INNOVATIVE PROPERTIES COMPANY	POLYMER ELECTROLYTES INCLUDING HETEROPOLYACIDS
WO2009117246	2009	2009	UT-BATTELLE, LLC	MULTIPLE PASS AND MULTIPLE LAYER FRICTION STIR WELDING AND MATERIAL ENHANCEMENT PROCESSES
WO2009132241	2009	2009	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
WO2009149241	2009	2009	BASF CORPORATION	METHOD AND APPARATUS FOR RECOVERING CATALYTIC ELEMENTS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
WO2009149245	2009	2009	BASF CORPORATION	METHOD FOR MEASURING RECOVERY OF CATALYTIC ELEMENTS FROM FUEL CELLS
7645535	2005	2010	GENERAL ELECTRIC COMPANY	METHOD AND MATERIALS FOR BONDING ELECTRODES TO INTERCONNECT LAYERS IN SOLID OXIDE FUEL CELL STACKS
7648784	2006	2010	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR CONTROLLING A FUEL CELL SYSTEM HAVING A VARIABLE NUMBER OF PARALLEL-CONNECTED MODULES
7652479	2007	2010	SCRIBNER ASSOCIATES, INC.	ELECTROLYTE MEASUREMENT DEVICE AND MEASUREMENT PROCEDURE
7659026	2005	2010	E.I. DU PONT DE NEMOURS AND COMPANY	FLUORINATED SULFONAMIDE COMPOUNDS AND POLYMER ELECTROLYTE MEMBRANES PREPARED

				THEREFROM FOR USE IN ELECTROCHEMICAL CELLS
7670988	2007	2010	STC.UNM	NANOSTRUCTURED ANODE PT-RU ELECTROCATALYSTS FOR DIRECT METHANOL FUEL CELLS
7678728	2007	2010	STC.UNM	SELF SUPPORTING STRUCTURALLY ENGINEERED NON-PLATINUM ELECTROCATALYST FOR OXYGEN REDUCTION IN FUEL CELLS
7687176	2004	2010	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL
7691770	2005	2010	GENERAL ELECTRIC COMPANY	ELECTRODE STRUCTURE AND METHODS OF MAKING SAME
7691780	2004	2010	BROOKHAVEN SCIENCE ASSOCIATES LLC	PLATINUM- AND PLATINUM ALLOY-COATED PALLADIUM AND PALLADIUM ALLOY PARTICLES AND USES THEREOF
7695849	2005	2010	CALIFORNIA INSTITUTE OF TECHNOLOGY	LOW PT CONTENT DIRECT METHANOL FUEL CELL ANODE CATALYST: NANOPHASE PTRUNIZR
7699916	2008	2010	UNITED STATES DEPARTMENT OF ENERGY	CORROSION-RESISTANT, ELECTRICALLY-CONDUCTIVE PLATE FOR USE IN A FUEL CELL STACK
7700072	2006	2010	PURDUE RESEARCH FOUNDATION	CATALYTIC HYDROGEN PRODUCTION FROM HYDROLYTIC OXIDATION OF ORGANOSILANES
7704918	2007	2010	BROOKHAVEN SCIENCE ASSOCIATES LLC	SYNTHESIS OF METAL-METAL OXIDE CATALYSTS AND ELECTROCATALYSTS USING A METAL CATION ADSORPTION/REDUCTION AND ADATOM REPLACEMENT BY MORE NOBLE ONES
7704919	2005	2010	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYSTS HAVING GOLD MONOLAYERS ON PLATINUM NANOPARTICLE CORES, AND USES THEREOF
7709133	2005	2010	UT-BATTELLE, LLC	ELECTRICALLY CONDUCTIVE CELLULOSE

				COMPOSITE
7709135	2008	2010	BASF CORPORATION	EFFICIENT PROCESS FOR PREVIOUS METAL RECOVERY FROM CELL MEMBRANE ELECTRODE ASSEMBLIES
7723260	2007	2010	TOSHIBA CORP	METHANOL OXIDATION CATALYST
7732084	2004	2010	GENERAL ELECTRIC COMPANY	SOLID OXIDE FUEL CELL WITH INTERNAL REFORMING, CATALYZED INTERCONNECT FOR USE THEREWITH, AND METHODS
7737190	2006	2010	E.I. DU PONT DE NEMOURS AND COMPANY	PROCESS TO PREPARE STABLE TRIFLUOROSTYRENE CONTAINING COMPOUNDS GRAFTED TO BASE POLYMERS USING A SOLVENT/WATER MIXTURE
7754656	2005	2010	INTEMATIX CORPORATION	PRODUCTION OF NANO-POWDER BASED COMBINATORIAL LIBRARIES
7758783	2007	2010	NANOTEK INSTRUMENTS, INC.	CONTINIOUS PRODUCTION OF EXFOLIATED GRAPHITE COMPOSITE COMPOSITIONS AND FLOW FIELD PLATES
7758921	2006	2010	UCHICAGO ARGONNE, LLC	METHOD OF FABRICATING ELECTRODE CATALYST LAYERS WITH DIRECTIONALLY ORIENTED CARBON SUPPORT FOR PROTON EXCHANGE MEMBRANE FUEL CELL
7758993	2005	2010	WORLDWIDE ENERGY, INC. OF DELAWARE	TUBULAR SOLID OXIDE FUEL CELL CURRENT COLLECTOR
7762447	2008	2010	UT-BATTELLE, LLC	MULTIPLE PASS AND MULTIPLE LAYER FRICTION STIR WELDING AND MATERIAL ENHANCEMENT PROCESSES
7767610	2004	2010	SANDIA CORPORATION	METAL NANOPARTICLES AS A CONDUCTIVE CATALYST
7767616	2006	2010	UCHICAGO ARGONNE, LLC	ALIGNED CARBON NANOTUBE WITH ELECTRO-CATALYTIC ACTIVITY FOR OXYGEN REDUCTION REACTION

7781049	2009	2010	PRAXAIR TECHNOLOGY, INC.	HYDROGEN TRANSPORT MEMBRANE FABRICATION METHOD
7781364	2009	2010	LOS ALAMOS NATIONAL SECURITY, LLC	CHALCOGEN CATALYSTS FOR POLYMER ELECTROLYTE FUEL CELL
7781529	2008	2010	ARKEMA INC.	BLEND OF IONIC (CO)POLYMER RESINS AND MATRIX (CO)POLYMERS
7785454	2008	2010	BASF CORPORATION	GAS DIFFUSION ELECTRODES, MEMBRANE-ELECTRODE ASSEMBLIES AND METHOD FOR THE PRODUCTION THEREOF
7785747	2005	2010	WORLDWIDE ENERGY, INC. OF DELAWARE	STACK CONFIGURATIONS FOR TUBULAR SOLID OXIDE FUEL CELLS
7790285	2007	2010	NANOTEK INSTRUMENTS, INC.	NANO-SCALED GRAPHENE PLATELETS WITH A HIGH LENGTH-TO-WIDTH ASPECT RATIO
7790314	2009	2010	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	SULFONATED POLYMER COMPOSITION FOR FORMING FUEL CELL ELECTRODES
7790837	2008	2010	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	ION-CONDUCTING SULFONATED POLYMERIC MATERIALS
7794170	2005	2010	BATTELLE MEMORIAL INSTITUTE	JOINT WITH APPLICATION IN ELECTROCHEMICAL DEVICES
7799548	2007	2010	UCHICAGO ARGONNE, LLC	METHOD OF STRIPPING GENETICALLY TAGGED BIOMOLECULES FROM POROUS SOLID ION EXCHANGE WAFER
7803325	2005	2010	BATTELLE MEMORIAL INSTITUTE	INTEGRATED REACTORS, METHODS OF MAKING SAME, AND METHODS OF CONDUCTING SIMULTANEOUS EXOTHERMIC AND ENDOTHERMIC REACTIONS
7803477	2005	2010	UT-BATTELLE, LLC	METALLIZATION OF BACTERIAL CELLULOSE FOR ELECTRICAL AND ELECTRONIC DEVICE MANUFACTURE
7803493	2004	2010	GENERAL ELECTRIC COMPANY	FUEL CELL SYSTEM WITH SEPARATING STRUCTURE BONDED TO ELECTROLYTE
7803847	2009	2010	3M INNOVATIVE	FUEL CELL MEMBRANE

			PROPERTIES COMPANY	ELECTRODE ASSEMBLY
7803891	2008	2010	ARKEMA INC.	BLEND OF IONIC (CO)POLYMER RESINS AND MATRIX (CO)POLYMERS
7807063	2004	2010	GINER ELECTROCHEMICAL SYSTEMS, LLC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING PLASMA ETCHED POROUS SUPPORT
7815986	2008	2010	ARKEMA INC.	BLEND OF IONIC (CO)POLYMER RESINS AND MATRIX (CO)POLYMERS
7820132	2005	2010	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	HOT WIRE PRODUCTION OF SINGLE-WALL AND MULTI-WALL CARBON NANOTUBES
7824651	2007	2010	NANOTEK INSTRUMENTS, INC.	METHOD OF PRODUCING EXFOLIATED GRAPHITE, FLEXIBLE GRAPHITE, AND NANO-SCALED GRAPHENE PLATELETS
7829194	2006	2010	UT-BATTELLE, LLC	IRON-BASED ALLOY AND NITRIDATION TREATMENT FOR PEM FUEL CELL BIPOLAR PLATES
7829603	2004	2010	E.I. DU PONT DE NEMOURS AND COMPANY	STABLE TRIFLUOROSTYRENE CONTAINING COMPOUNDS GRAFTED TO BASE POLYMERS, AND THEIR USE AS POLYMER ELECTROLYTE MEMBRANES
7829652	2008	2010	GENERAL ELECTRIC COMPANY	POLYARYLETHER COMPOSITION AND MEMBRANE
7838138	2005	2010	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTROLYTE MEMBRANE WITH BASIC POLYMER
7838612	2007	2010	E.I. DU PONT DE NEMOURS AND COMPANY	ARYLENE FLUORINATED SULFONIMIDE COMPOSITIONS
7846862	2007	2010	TOSHIBA CORP	METHANOL OXIDATION CATALYST
7846980	2009	2010	LOS ALAMOS NATIONAL SECURITY, LLC	ANION-CONDUCTING POLYMER, COMPOSITION, AND MEMBRANE
7851399	2006	2010	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF MAKING CHALCOGEN CATALYSTS FOR POLYMER ELECTROLYTE FUEL CELLS
7855021	2005	2010	BROOKHAVEN	ELECTROCATALYSTS

			SCIENCE ASSOCIATES LLC	HAVING PLATIUM MONOLAYERS ON PALLADIUM, PALLADIUM ALLOY, AND GOLD ALLOY CORE-SHELL NANOPARTICLES, AND USES THEREOF
7858250	2009	2010	BATTELLE MEMORIAL INSTITUTE	METHODS OF REMOVING CONTAMINANTS FROM A FUEL CELL ELECTRODE
EP2191026	2008	2010	BASF CORPORATION	SIMPLIFIED PROCESS FOR LEACHING PRECIOUS METALS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
EP2218130	2008	2010	3M INNOVATIVE PROPERTIES COMPANY	POLYMER ELECTROLYTES INCLUDING HETEROPOLYACIDS
EP2254185	2005	2010	3M INNOVATIVE PROPERTIES COMPANY	POLYMER ELECTROLYTE MEMBRANES FOR FUEL CELLS
WO2010005773	2009	2010	BROOKHAVEN SCIENCE ASSOCIATES LLC	UNDERPOTENTIAL DEPOSITION-MEDIATED LAYER-BY-LAYER GROWTH OF THIN FILMS
WO2010025118	2009	2010	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL NANOCATALYST WITH VOLTAGE REVERSAL TOLERANCE
WO2010107496	2010	2010	LOS ALAMOS NATIONAL SECURITY, LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
WO2010123607	2010	2010	UNIVERSITY OF TENNESSEE	MATERIALS COMPRISING POLYDIENES AND HYDROPHILIC POLYMERS AND RELATED METHODS
WO2010132156	2010	2010	BASF CORPORATION	METHOD FOR RECOVERING CATALYTIC ELEMENTS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
WO2010138138	2009	2010	JOHNS HOPKINS UNIVERSITY	POROUS METAL CATALYSTS FOR OXYGEN REDUCTION
WO2010147867	2010	2010	ARKEMA INC.	ORGANIC/INORGANIC COMPOSITE BLEND MEMBRANE COMPOSITIONS OF POLYELECTROLYE BLENDS WITH NANOPARTICLES
7867648	2006	2011	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL CATALYST
7867669	2004	2011	GINER	SOLID POLYMER

			ELECTROCHEMICAL SYSTEMS, LLC	ELECTROLYTE COMPOSITE MEMBRANE COMPRISING LASER MICROMACHINED POROUS SUPPORT
7868086	2007	2011	E.I. DU PONT DE NEMOURS AND COMPANY	ARYLENE FLUORINATED SULFONIMIDE POLYMERS AND MEMBRANES
7871738	2008	2011	UCHICAGO ARGONNE, LLC	NANOSEGREGATED SURFACES AS CATALYSTS FOR FUEL CELLS
7879753	2004	2011	DE NORA ELETTRODI S.P.A.	CATALYST FOR OXYGEN REDUCTION
7887927	2007	2011	NANOTEK INSTRUMENTS, INC.	HIGHLY CONDUCTIVE, MULTI-LAYER COMPOSITE PRECURSOR COMPOSITION TO FUEL CELL FLOW FIELD PLATE OR BIPOLAR PLATE
7896949	2008	2011	GENERAL ELECTRIC COMPANY	MEMBRANES FOR SEPARATION OF CARBON DIOXIDE
7897293	2003	2011	US NAVY	PLATINUM-IMPREGNATED HYDROUS TIN OXIDE CATALYSTS
7901940	2008	2011	BASF CORPORATION	METHOD FOR MEASURING RECOVERY OF CATALYTIC ELEMENTS FROM FUEL CELLS
7902299	2005	2011	UNIVERSITY OF CALIFORNIA	SINGLE ION CONDUCTOR CROSS-LINKED POLYMERIC NETWORKS
7906251	2006	2011	3M INNOVATIVE PROPERTIES COMPANY	OXYGEN-REDUCING CATALYST LAYER
7910653	2007	2011	E.I. DU PONT DE NEMOURS AND COMPANY	PROCESS FOR THE PREPARATION OF ARYLENE FLUORINATED SULFONIMIDE POLYMERS AND MEMBRANES
7927748	2010	2011	UCHICAGO ARGONNE, LLC	CATALYTIC MEMBRANES FOR FUEL CELLS
7939219	2005	2011	FUELCELL ENERGY, INC.	CARBONATE FUEL CELL AND COMPONENTS THEREOF FOR IN-SITU DELAYED ADDITION OF CARBONATE ELECTROLYTE
7943266	2005	2011	GENERAL ELECTRIC COMPANY	SOFC SEAL AND CELL THERMAL MANAGEMENT
7943675	2008	2011	TOYOTA MOTOR CORP	ELECTROLYTES TO ENHANCE OXYGEN REDUCTION REACTION (ORR) IN THE CATHODE LAYER OF PEM FUEL CELL
7955759	2010	2011	UT-BATTELLE, LLC	METALLIZATION OF

				BACTERIAL CELLULOSE FOR ELECTRICAL AND ELECTRONIC DEVICE MANUFACTURE
7972422	2007	2011	DELPHI TECHNOLOGIES, INC.	SYSTEM FOR CONTINUOUS REMOVAL OF A SPECIFIC GAS FROM A FLOWING MIXTURE OF GASES
7976686	2007	2011	CERAMATEC, INC.	EFFICIENT REVERSIBLE ELECTRODES FOR SOLID OXIDE ELECTROLYZER CELLS
7981319	2009	2011	LOS ALAMOS NATIONAL SECURITY, LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
7998632	2005	2011	DELPHI TECHNOLOGIES, INC.	ANODE TAIL GAS RECYCLE COOLER AND RE-HEATER FOR A SOLID OXIDE FUEL CELL STACK ASSEMBLY
8011598	2009	2011	DELPHI TECHNOLOGIES, INC.	SOFC POWER SYSTEM WITH A/C SYSTEM AND HEAT PUMP FOR STATIONARY AND TRANSPORTATION APPLICATIONS
8021795	2006	2011	GENERAL ELECTRIC COMPANY	METHOD FOR MANUFACTURING SOLID OXIDE ELECTROCHEMICAL DEVICES
8021799	2007	2011	UNIVERSITY OF PENNSYLVANIA	HIGH-PERFORMANCE CERAMIC ANODES FOR USE WITH STRATEGIC AND OTHER HYDROCARBON FUELS
8028842	2007	2011	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	CHLORINE RESISTANT DESALINATION MEMBRANES BASED ON DIRECTLY SULFONATED POLY(ARYLENE ETHER SULFONE) COPOLYMERS
8029942	2005	2011	CASE WESTERN RESERVE UNIVERSITY	FUEL CELL SYSTEM WITH FLOW FIELD CAPABLE OF REMOVING LIQUID WATER FROM THE HIGH-PRESSURE CHANNELS
8039160	2004	2011	ARKEMA INC.	MULTI-LAYER POLYELECTROLYTE MEMBRANE
8048548	2007	2011	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYST FOR ALCOHOL OXIDATION AT FUEL CELL ANODES
8057949	2007	2011	FORD GLOBAL TECHNOLOGIES,	FUEL CELL STACK FLOW DIVERSION

			LLC	
8057951	2007	2011	OHIO UNIVERSITY	SOLID OXIDE FUEL CELL PROCESS AND APPARATUS
8058383	2007	2011	E.I. DU PONT DE NEMOURS AND COMPANY	ARYLENE-FLUORINATED-SULFONIMIDE IONOMERS AND MEMBRANES FOR FUEL CELLS
8061533	2009	2011	UNIVERSITY OF TENNESSEE	MATERIALS COMPRISING POLYDIENES AND HYDROPHILIC POLYMERS AND RELATED METHODS
8061579	2010	2011	UT-BATTELLE, LLC	FRICTION STIR METHOD FOR FORMING STRUCTURES AND MATERIALS
8062552	2005	2011	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYST FOR OXYGEN REDUCTION WITH REDUCED PLATINUM OXIDATION AND DISSOLUTION RATES
8062868	2010	2011	UT-BATTELLE, LLC	METHOD OF FORMING AN ELECTRICALLY CONDUCTIVE CELLULOSE COMPOSITE
8063111	2010	2011	LOS ALAMOS NATIONAL SECURITY, LLC	ANION-CONDUCTING POLYMER, COMPOSITION, AND MEMBRANE
8071701	2006	2011	DOW GLOBAL TECHNOLOGIES INC.	POLYDENTATE HETEROATOM LIGAND CONTAINING METAL COMPLEXES, CATALYSTS AND METHODS OF MAKING AND USING THE SAME
EP2276728	2009	2011	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
EP2302305	2010	2011	DELPHI TECHNOLOGIES, INC.	SOFC POWER SYSTEM WITH A/C SYSTEM AND HEAT PUMP FOR STATIONARY AND TRANSPORTATION APPLICATIONS
EP2303452	2009	2011	BROOKHAVEN SCIENCE ASSOCIATES LLC	UNDERPOTENTIAL DEPOSITION-MEDIATED LAYER-BY-LAYER GROWTH OF THIN FILMS
EP2308587	2006	2011	PRAXAIR TECHNOLOGY, INC.	HYDROGEN TRANSPORT MEMBRANE FABRICATION METHOD
EP2338193	2009	2011	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL NANOCATALYST WITH VOLTAGE REVERSAL TOLERANCE
EP2357267	2004	2011	DE NORA ELETTRODI S.P.A.	CATALYST FOR OXYGEN REDUCTION

EP2359930	2006	2011	DOW GLOBAL TECHNOLOGIES INC.	A POLYMER PREPARED IN THE PRESENCE OF METAL COMPLEXES BEARING A POLYDENTATE HETEROATOM LIGAND
EP2380228	2010	2011	FLORIDA STATE UNIVERSITY	CATALYTIC ELECTRODE WITH GRADIENT POROSITY AND CATALYST DENSITY FOR FUEL CELLS
RE042434	2003	2011	GENERAL MOTORS CORPORATION	CORROSION RESISTANT PEM FUEL CELL
WO2011009124	2010	2011	FLORIDA STATE UNIVERSITY	CATALYTIC ELECTRODE WITH GRADIENT POROSITY AND CATALYST DENSITY FOR FUEL CELLS
WO2011029014	2010	2011	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	METHOD FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
WO2011029024	2010	2011	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	APPARATUS FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
WO2011031325	2010	2011	LOS ALAMOS NATIONAL SECURITY, LLC	ANION EXCHANGE POLYMER ELECTROLYTES
WO2011050314	2010	2011	ENERFUEL, INC.	INTEGRATED PEM FUEL CELL
WO2011087842	2010	2011	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTRODE WITH NANOSTRUCTURED CATALYST AND DISPERSED CATALYST SUBLAYER
WO2011122399	2011	2011	STC.UNM	FUEL CELL
WO2011129967	2011	2011	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
WO2011139678	2011	2011	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL WATER MANAGEMENT VIA REDUCED ANODE REACTANT PRESSURE
WO2011139693	2011	2011	3M INNOVATIVE PROPERTIES COMPANY	PLATINUM NICKEL CATALYST ALLOY
WO2011139705	2011	2011	3M INNOVATIVE PROPERTIES COMPANY	ANNEALED NANOSTRUCTURED THIN FILM CATALYST
WO2011146094	2010	2011	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL SUBASSEMBLIES INCORPORATING SUBGASKETED THRIFTED MEMBRANES
WO2011149732	2011	2011	3M INNOVATIVE PROPERTIES	REINFORCED ELECTROLYTE

			COMPANY	MEMBRANE
WO2011154811	2011	2011	RENSSELAER POLYTECHNIC INSTITUTE	METHOD FOR THE PRODUCTION OF AN ELECTROCHEMICAL CELL
WO2011160022	2011	2011	NORTHEASTERN UNIVERSITY	HIGHLY STABLE PLATINUM ALLOY CATALYST FOR METHANOL ELECTROOXIDATION
8088526	2008	2012	GENERAL MOTORS CORPORATION	ANODE REACTIVE BLEED AND INJECTOR SHIFT CONTROL STRATEGY
8092954	2009	2012	3M INNOVATIVE PROPERTIES COMPANY	METHOD OF MAKING A FUEL CELL POLYMER ELECTROLYTE MEMBRANE COMPRISING MANGANESE OXIDE
8101317	2004	2012	3M INNOVATIVE PROPERTIES COMPANY	DURABLE FUEL CELL HAVING POLYMER ELECTROLYTE MEMBRANE COMPRISING MANGANESE OXIDE
8110636	2009	2012	SANDIA CORPORATION	MULTI-BLOCK SULFONATED POLY(PHENYLENE) COPOLYMER PROTON EXCHANGE MEMBRANES
8114547	2011	2012	FORD GLOBAL TECHNOLOGIES, LLC	FUEL CELL STACK FLOW DIVERSION
8124261	2006	2012	BASF CORPORATION	PROCESS FOR RECYCLING COMPONENTS OF A PEM FUEL CELL MEMBRANE ELECTRODE ASSEMBLY
8124289	2008	2012	LG FUEL CELL SYSTEMS INC.	MULTISTAGE COMBUSTOR AND METHOD FOR STARTING A FUEL CELL SYSTEM
8129306	2009	2012	UCHICAGO ARGONNE, LLC	NON-PLATINUM BIMETALLIC POLYMER ELECTROLYTE FUEL CELL CATALYSTS
8137858	2010	2012	UCHICAGO ARGONNE, LLC	METHOD OF FABRICATING ELECTRODE CATALYST LAYERS WITH DIRECTIONALLY ORIENTED CARBON SUPPORT FOR PROTON EXCHANGE MEMBRANE FUEL CELL
8153324	2006	2012	NANOTEK INSTRUMENTS, INC.	CONTROLLED-RELEASE VAPOR FUEL CELL
8158909	2008	2012	DELPHI TECHNOLOGIES, INC.	HOT ZONE IGNITER
8163204	2009	2012	TDA RESEARCH	NANOPOROUS POLYMER

				ELECTROLYTE
8178463	2010	2012	UCHICAGO ARGONNE, LLC	HIGHLY DURABLE NANOSCALE ELECTROCATALYST BASED ON CORE SHELL PARTICLES
8197955	2008	2012	GENERAL ELECTRIC COMPANY	ELECTROLYTE MEMBRANE, METHODS OF MANUFACTURE THEREOF AND ARTICLES COMPRISING THE SAME
8206682	2009	2012	UNASSIGNED	METHOD FOR RECOVERING CATALYTIC ELEMENTS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
8206874	2008	2012	3M INNOVATIVE PROPERTIES COMPANY	POLYMER ELECTROLYTES INCLUDING HETEROPOLYACIDS
8211593	2005	2012	INTEMATIX CORPORATION	LOW PLATINUM FUEL CELLS, CATALYSTS, AND METHOD FOR PREPARING THE SAME
8227135	2006	2012	TOYOTA MOTOR CORP	ELECTROLYTES TO ENHANCE OXYGEN REDUCTION REACTION (ORR) IN THE CATHODE LAYER OF PEM FUEL CELL
8227140	2011	2012	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
8227147	2005	2012	LOS ALAMOS NATIONAL SECURITY, LLC	ADVANCED MEMBRANE ELECTRODE ASSEMBLIES FOR FUEL CELLS
8232017	2010	2012	DELPHI TECHNOLOGIES, INC.	FUEL CELL STACK INCLUDING NON-FUEL CELL CASSETTE
8236207	2010	2012	LOS ALAMOS NATIONAL SECURITY, LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS REFERENCE TO RELATED APPLICATION
8252711	2010	2012	STC.UNM	SELF SUPPORTING STRUCTURALLY ENGINEERED NON-PLATINUM ELECTROCATALYST FOR OXYGEN REDUCTION IN FUEL CELLS
8273495	2007	2012	GENERAL ELECTRIC COMPANY	ELECTROCHEMICAL CELL STRUCTURE AND METHOD OF MAKING THE SAME
8278011	2009	2012	NANOSYS, INC.	NANOSTRUCTURED CATALYST SUPPORTS
8283077	2008	2012	UNIVERSITY OF	STRUCTURES AND

			CALIFORNIA	FABRICATION TECHNIQUES FOR SOLID STATE ELECTROCHEMICAL DEVICES
8298719	2007	2012	UNIVERSITY OF NORTH FLORIDA	PASSIVE RECOVERY OF LIQUID WATER PRODUCED BY FUEL CELLS
8304122	2009	2012	PROTONEX TECHNOLOGY CORPORATION	SOLID OXIDE FUEL CELL SYSTEMS WITH HOT ZONES HAVING IMPROVED REACTANT DISTRIBUTION
8308984	2011	2012	NANOTEK INSTRUMENTS, INC.	METHOD OF PRODUCING NANO-SCALED INORGANIC PLATELETS
8308989	2011	2012	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCATALYST FOR OXYGEN REDUCTION WITH REDUCED PLATINUM OXIDATION AND DISSOLUTION RATES
8323809	2010	2012	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTROLYTE MEMBRANE WITH BASIC POLYMER
8326477	2010	2012	GENERAL MOTORS CORPORATION	HEEL AND TOE DRIVING ON FUEL CELL VEHICLE
8329006	2009	2012	FARADAY TECHNOLOGY, INC.	ELECTROPLATING CELL WITH HYDRODYNAMICS FACILITATING MORE UNIFORM DEPOSITION ACROSS A WORKPIECE DURING PLATING
8333941	2009	2012	STC.UNM	SPRAY PYROLYSIS SYNTHESIS OF MESOPOROUS NBRUYOZ AS ELECTROCATALYST SUPPORTS IN FUEL CELLS
8334014	2009	2012	STC.UNM	MICROPARTICLES WITH HIERARCHICAL POROSITY
EP2408048	2003	2012	NUVERA FUEL CELLS, INC.	HIGH-EFFICIENCY FUEL CELL POWER SYSTEM WITH POWER GENERATING EXPANDER
EP2408873	2010	2012	LOS ALAMOS NATIONAL SECURITY, LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
EP2430692	2010	2012	BASF CORPORATION	METHOD FOR RECOVERING CATALYTIC ELEMENTS FROM FUEL CELL MEMBRANE ELECTRODE ASSEMBLIES
EP2443195	2010	2012	ARKEMA INC.	ORGANIC/INORGANIC COMPOSITE BLEND MEMBRANE COMPOSITIONS OF POLYELECTROLYE

				BLENDS WITH NANOPARTICLES
EP2474065	2010	2012	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	METHOD FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
EP2474067	2010	2012	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	APPARATUS FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
EP2517290	2010	2012	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL MEMBRANE ELECTRODE ASSEMBLY WITH NANOSTRUCTURED CATALYST AND DISPERSED CATALYST SUBLAYER
EP2517292	2010	2012	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL SUBASSEMBLIES INCORPORATING SUBGASKETED THRIFTED MEMBRANES
WO2012006240	2011	2012	DIOXIDE MATERIALS INC	NOVEL CATALYST MIXTURES
WO2012009142	2011	2012	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTRODES WITH CONDUCTION NETWORKS
WO2012058425	2011	2012	VANDERBILT UNIVERSITY	NANOFIBER ELECTRODE AND METHOD OF FORMING SAME
WO2012058563	2011	2012	UNASSIGNED	PREVENTING MOBILIZATION OF TRACE METALS IN SUBSURFACE AQUIFERS DUE TO THE INTRODUCTION OF OXYGENATED WATER
WO2012064749	2011	2012	SIGNA CHEMISTRY, INC.	WATER REACTIVE HYDROGEN FUEL CELL POWER SYSTEM
WO2012068281	2011	2012	CERAMATEC, INC.	EFFICIENT REVERSIBLE ELECTRODES FOR SOLID OXIDE ELECTROLYZER CELLS
WO2012102724	2011	2012	UTC POWER CORPORATION	FUEL CELL SEAL
WO2012174335	2012	2012	STC.UNM	CATHODE CATALYSTS FOR FUEL CELL APPLICATION DERIVED FROM POLYMER PRECURSORS
WO2012174344	2012	2012	STC.UNM	NON-PGM CATHODE CATALYSTS FOR FUEL CELL APPLICATION DERIVED FROM HEAT TREATED HETEROATOMIC

				AMINES PRECURSORS
8342714	2010	2013	STRAY LIGHT OPTICAL TECHNOLOGIES	MOBILE LIGHTING APPARATUS
8349035	2009	2013	UCHICAGO ARGONNE, LLC	AUTOTHERMAL AND PARTIAL OXIDATION REFORMER-BASED FUEL PROCESSOR, METHOD FOR IMPROVING CATALYST FUNCTION IN AUTOTHERMAL AND PARTIAL OXIDATION REFORMER-BASED PROCESSORS
8354011	2010	2013	CERAMATEC, INC.	EFFICIENT REVERSIBLE ELECTRODES FOR SOLID OXIDE ELECTROLYZER CELLS
8367267	2005	2013	3M INNOVATIVE PROPERTIES COMPANY	HIGH DURABILITY FUEL CELL COMPONENTS WITH CERIUM OXIDE ADDITIVES
8372775	2007	2013	DE NORA ELETTRODI S.P.A.	CATALYST FOR OXYGEN REDUCTION
8383753	2011	2013	DOW GLOBAL TECHNOLOGIES INC.	POLYDENTATE HETEROATOM LIGAND CONTAINING METAL COMPLEXES, CATALYSTS AND METHODS OF MAKING AND USING THE SAME
8383763	2010	2013	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	ION-CONDUCTING SULFONATED POLYMERIC MATERIALS
8389180	2006	2013	BATTELLE ENERGY ALLIANCE, LLC	ELECTROLYTIC/FUEL CELL BUNDLES AND SYSTEMS INCLUDING A CURRENT COLLECTOR IN COMMUNICATION WITH AN ELECTRODE THEREOF
8394298	2011	2013	LOS ALAMOS NATIONAL SECURITY, LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
8394352	2009	2013	UNIVERSITY OF SOUTH CAROLINA	POROUS METAL OXIDE PARTICLES AND THEIR METHODS OF SYNTHESIS
8404613	2010	2013	BROOKHAVEN SCIENCE ASSOCIATES LLC	PLATINUM-BASED ELECTROCATALYSTS SYNTHESIZED BY DEPOSITING CONTIGUOUS ADLAYERS ON CARBON NANOSTRUCTURES
8415012	2009	2013	FLORIDA STATE UNIVERSITY	CARBON NANOTUBE AND NANOFIBER FILM-BASED MEMBRANE ELECTRODE ASSEMBLIES

8415070	2007	2013	E.I. DU PONT DE NEMOURS AND COMPANY	PARTIALLY FLUORINATED CYCLIC IONIC POLYMERS AND MEMBRANES
8420271	2009	2013	GENERAL MOTORS CORPORATION	METHOD TO IMPROVE RELIABILITY OF A FUEL CELL SYSTEM USING LOW PERFORMANCE CELL DETECTION AT LOW POWER OPERATION
8439534	2010	2013	UNASSIGNED	MOBILE LIGHTING APPARATUS
8455152	2009	2013	ENERFUEL, INC.	INTEGRATED PEM FUEL CELL
8465715	2010	2013	SANDIA CORPORATION	METHOD FOR SYNTHESIZING METAL BIS(BORANO) HYPOPHOSPHITE COMPLEXES
8465858	2005	2013	UNIVERSITY OF SOUTH CAROLINA	DEVELOPMENT OF A NOVEL METHOD FOR PREPARATION OF PEMFC ELECTRODES
8481227	2012	2013	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
8492049	2010	2013	LOS ALAMOS NATIONAL SECURITY, LLC	ANION EXCHANGE POLYMER ELECTROLYTES
8501307	2007	2013	NANOTEK INSTRUMENTS, INC.	RECOMPRESSED EXFOLIATED GRAPHITE ARTICLES
8518596	2012	2013	GENERAL MOTORS CORPORATION	LOW COST FUEL CELL DIFFUSION LAYER CONFIGURED FOR OPTIMIZED ANODE WATER MANAGEMENT
8518603	2005	2013	NANOTEK INSTRUMENTS, INC.	SHEET MOLDING COMPOUND FLOW FIELD PLATE, BIPOLAR PLATE AND FUEL CELL
8518608	2011	2013	LOS ALAMOS NATIONAL SECURITY, LLC	PREPARATION OF SUPPORTED ELECTROCATALYST COMPRISING MULTIWALLED CARBON NANOTUBES
8524388	2010	2013	UT-BATTELLE, LLC	SUPERBASE-DERIVED PROTIC IONIC LIQUIDS
8530109	2011	2013	LOS ALAMOS NATIONAL SECURITY, LLC	ANION EXCHANGE POLYMER ELECTROLYTES
8545657	2009	2013	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METHODS FOR TAPE FABRICATION OF CONTINUOUS FILAMENT COMPOSITE PARTS AND ARTICLES OF

				MANUFACTURE THEREOF
8557186	2010	2013	VELOCYS, INC.	INTEGRATED REACTORS, METHODS OF MAKING SAME, AND METHODS OF CONDUCTING SIMULTANEOUS EXOTHERMIC AND ENDOTHERMIC REACTIONS
8557458	2012	2013	LG FUEL CELL SYSTEMS, INC.	METHOD FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
8557480	2010	2013	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	HIGH POWER DENSITY FUEL CELL COMPRISING AN ARRAY OF MICROCHANNELS
8557484	2011	2013	3M INNOVATIVE PROPERTIES COMPANY	PLATINUM NICKEL CATALYST ALLOY
8574462	2007	2013	ARKEMA INC.	HIGH TEMPERATURE STABLE POLYELECTROLYTES HAVING BACKBONE AROMATIC GROUPS
8574664	2008	2013	GENERAL ELECTRIC COMPANY	ELECTROLYTE MEMBRANE, METHODS OF MANUFACTURE THEREOF AND ARTICLES COMPRISING THE SAME
8586252	2010	2013	ACUMENTRICS CORPORATION	INTEGRAL REACTOR SYSTEM AND METHOD FOR FUEL CELLS
8597841	2009	2013	LG FUEL CELL SYSTEMS INC.	METHOD FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
8614023	2012	2013	PROTONEX TECHNOLOGY CORPORATION	SOLID OXIDE FUEL CELL SYSTEMS WITH HOT ZONES HAVING IMPROVED REACTANT DISTRIBUTION
8617765	2006	2013	E.I. DU PONT DE NEMOURS AND COMPANY	CHEMICALLY STABILIZED IONOMERS CONTAINING INORGANIC FILLERS
EP2554579	2009	2013	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
EP2554580	2009	2013	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
EP2558442	2011	2013	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
EP2564455	2011	2013	3M INNOVATIVE	ANNEALED

			PROPERTIES COMPANY	NANOSTRUCTURED THIN FILM CATALYST
EP2564456	2011	2013	3M INNOVATIVE PROPERTIES COMPANY	PLATINUM NICKEL CATALYST ALLOY
EP2564458	2011	2013	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL WATER MANAGEMENT VIA REDUCED ANODE REACTANT PRESSURE
EP2577787	2011	2013	3M INNOVATIVE PROPERTIES COMPANY	REINFORCED ELECTROLYTE MEMBRANE
EP2580799	2011	2013	RENSSELAER POLYTECHNIC INSTITUTE	METHOD FOR THE PRODUCTION OF AN ELECTROCHEMICAL CELL
EP2593985	2011	2013	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTRODES WITH CONDUCTION NETWORKS
EP2632856	2011	2013	UNASSIGNED	PREVENTING MOBILIZATION OF TRACE METALS IN SUBSURFACE AQUIFERS DUE TO THE INTRODUCTION OF OXYGENATED WATER
EP2633581	2011	2013	VANDERBILT UNIVERSITY	NANOFIBER ELECTRODE AND METHOD OF FORMING SAME
EP2638593	2011	2013	SIGNA CHEMISTRY, INC.	WATER REACTIVE HYDROGEN FUEL CELL POWER SYSTEM
EP2640870	2011	2013	CERAMATEC, INC.	EFFICIENT REVERSIBLE ELECTRODES FOR SOLID OXIDE ELECTROLYZER CELLS
EP2668689	2011	2013	UTC POWER CORPORATION	FUEL CELL SEAL
EP2671918	2010	2013	ARKEMA INC.	ORGANIC/INORGANIC COMPOSITE BLEND MEMBRANE COMPOSITIONS OF POLYELECTROLYSE BLENDS WITH NANOPARTICLES
WO2013019614	2012	2013	3M INNOVATIVE PROPERTIES COMPANY	LOW EQUIVALENT WEIGHT POLYMERS
WO2013025216	2011	2013	UTC POWER CORPORATION	FUEL CELL AND MEMBRANE THEREFOR
WO2013028196	2011	2013	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	ON-LINE, CONTINUOUS MONITORING IN SOLAR CELL AND FUEL CELL MANUFACTURING USING SPECTRAL REFLECTANCE IMAGING
WO2013040452	2012	2013	STANFORD UNIVERSITY	MACRO-STRUCTURED HIGH SURFACE AREA

				TRANSPARENT CONDUCTIVE OXIDE ELECTRODES
WO2013116754	2013	2013	STC.UNM	CATHODE CATALYSTS FOR FUEL CELLS
WO2013126671	2013	2013	CALIFORNIA INSTITUTE OF TECHNOLOGY	METHOD AND SYSTEM FOR GRAPHENE FORMATION
WO2013141984	2013	2013	UNITED TECHNOLOGIES CORPORATION	CATALYTIC REACTION IN CONFINED FLOW CHANNEL
WO2013159115	2013	2013	BROOKHAVEN SCIENCE ASSOCIATES LLC	MOLYBDENUM AND TUNGSTEN NANOSTRUCTURES AND METHODS FOR MAKING AND USING SAME
WO2013169705	2013	2013	NORTHWESTERN UNIVERSITY	POROUS POLYMER NETWORKS AND ION-EXCHANGE MEDIA AND METAL-POLYMER COMPOSITES MADE THEREFROM
8623565	2010	2014	UNASSIGNED	ASSEMBLY OF BIFURCATION AND TRIFURCATION BIPOLAR PLATE TO DESIGN FUEL CELL STACK
8624105	2010	2014	SYNKERA TECHNOLOGIES, INC.	ENERGY CONVERSION DEVICE WITH SUPPORT MEMBER HAVING PORE CHANNELS
8628871	2005	2014	3M INNOVATIVE PROPERTIES COMPANY	HIGH DURABILITY FUEL CELL COMPONENTS WITH CERIUM SALT ADDITIVES
8628891	2006	2014	ACUMENTRICS CORPORATION	INTERCONNECTION OF BUNDLED SOLID OXIDE FUEL CELLS
8632928	2011	2014	INTELLIGENT ENERGY, INC.	WATER REACTIVE HYDROGEN FUEL CELL POWER SYSTEM
8637193	2009	2014	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL NANOCATALYST WITH VOLTAGE REVERSAL TOLERANCE
8637205	2010	2014	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL SUBASSEMBLIES INCORPORATING SUBGASKETED THRIFTED MEMBRANES
8642308	2011	2014	STC.UNM	BIOFUEL CELL ELECTROCATALYSTS UTILIZING ENZYME-CARBON NANOTUBE ADDUCTS
8647497	2012	2014	UNIVERSITY OF CENTRAL FLORIDA	METHOD AND SYSTEM FOR HYDROGEN SULFIDE

				REMOVAL
8652709	2009	2014	UCHICAGO ARGONNE, LLC	METHOD OF SEALING A BIPOLAR PLATE SUPPORTED SOLID OXIDE FUEL CELL WITH A SEALED ANODE COMPARTMENT
8658329	2012	2014	LOS ALAMOS NATIONAL SECURITY, LLC	ADVANCED MEMBRANE ELECTRODE ASSEMBLIES FOR FUEL CELLS
8663448	2008	2014	H2 PUMP, LLC	HYDROGEN FURNACE SYSTEM AND METHOD
8668752	2009	2014	LG FUEL CELL SYSTEMS INC.	APPARATUS FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
8678270	2012	2014	DELPHI TECHNOLOGIES, INC.	HOT ZONE IGNITER
8685878	2012	2014	UCHICAGO ARGONNE, LLC	HIGHLY DURABLE NANOSCALE ELECTROCATALYST BASED ON CORE SHELL PARTICLES
8690391	2012	2014	STRAY LIGHT OPTICAL TECHNOLOGIES	MULTI-EMITTER LIGHTING APPARATUS
8691129	2007	2014	NANOTEK INSTRUMENTS, INC.	METHOD OF PRODUCING EXFOLIATED GRAPHITE COMPOSITE COMPOSITIONS FOR FUEL CELL FLOW FIELD PLATES
8699207	2009	2014	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTRODES SYNTHESIZED FROM CARBON NANOSTRUCTURES COATED WITH A SMOOTH AND CONFORMAL METAL ADLAYER
8703355	2010	2014	FLORIDA STATE UNIVERSITY	CATALYTIC ELECTRODE WITH GRADIENT POROSITY AND CATALYST DENSITY FOR FUEL CELLS
8709229	2011	2014	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	METHOD TO PREVENT SULFUR ACCUMULATION IN MEMBRANE ELECTRODE ASSEMBLY
8709295	2011	2014	LOS ALAMOS NATIONAL SECURITY, LLC	NITROGEN-DOPED CARBON-SUPPORTED COBALT-IRON OXYGEN REDUCTION CATALYST
8728679	2007	2014	NANOTEK INSTRUMENTS, INC.	LAMINATED EXFOLIATED GRAPHITE COMPOSITE-METAL COMPOSITIONS FOR FUEL CELL FLOW

				FIELD PLATE OR BIPOLAR PLATE APPLICATIONS
8734632	2014	2014	H2 PUMP, LLC	HYDROGEN FURNACE SYSTEM AND METHOD
8741454	2007	2014	TOYOTA MOTOR CORP	PROTON EXCHANGE MEMBRANE FOR FUEL CELL
8748330	2011	2014	3M INNOVATIVE PROPERTIES COMPANY	ANNEALED NANOSTRUCTURED THIN FILM CATALYST
8765327	2010	2014	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTRODES WITH CONDUCTION NETWORKS
8771899	2010	2014	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	FUEL CELL COMPONENTS AND SYSTEMS HAVING CARBON-CONTAINING ELECTRICALLY-CONDUCTIVE HOLLOW FIBERS
8778560	2011	2014	UNIVERSITY OF SOUTH CAROLINA	MIXED IONIC AND ELECTRONIC CONDUCTOR BASED ON SR2FE2-XM0XO6 PEROVSKITE
8809483	2012	2014	SANDIA CORPORATION	FUNCTIONALIZATION OF POLY(PHENYLENE) BY THE ATTACHMENT OF SIDECHAINS
8814964	2012	2014	UCHICAGO ARGONNE, LLC	METHOD FOR IMPROVING CATALYST FUNCTION IN AUTO-THERMAL AND PARTIAL OXIDATION REFORMER-BASED PROCESSORS
8835003	2013	2014	UNIVERSITY OF SOUTH CAROLINA	POROUS METAL OXIDE PARTICLES AND THEIR METHODS OF SYNTHESIS
8835343	2010	2014	UCHICAGO ARGONNE, LLC	NON-PLATINUM GROUP METAL ELECTROCATALYSTS USING METAL ORGANIC FRAMEWORK MATERIALS AND METHOD OF PREPARATION
8865040	2011	2014	NANOTEK INSTRUMENTS, INC.	HIGHLY CONDUCTIVE COMPOSITES FOR FUEL CELL FLOW FIELD PLATES AND BIPOLAR PLATES
8865359	2010	2014	GENERAL MOTORS CORPORATION	FUEL CELL HAVING IMPROVED THERMAL CHARACTERISTICS
8865441	2011	2014	STANFORD UNIVERSITY	EFFICIENT CELL-FREE HYDROGEN PRODUCTION
8871483	2013	2014	STC.UNM	BIOFUEL CELL ELECTROCATALYSTS UTILIZING ENZYME-CARBON NANOTUBE

				ADDUCTS
8889316	2010	2014	ARKEMA INC.	ORGANIC/INORGANIC COMPOSITE BLEND MEMBRANE COMPOSITIONS OF POLYELECTROLYE BLENDS WITH NANOPARTICLES
8895204	2013	2014	INTELLIGENT ENERGY, INC.	WATER REACTIVE HYDROGEN FUEL CELL POWER SYSTEM
8895206	2009	2014	JOHNS HOPKINS UNIVERSITY	POROUS PLATINUM-BASED CATALYSTS FOR OXYGEN REDUCTION
8906270	2011	2014	COLORADO SCHOOL OF MINES	ACIDIC ION EXCHANGE MEMBRANE AND METHOD FOR MAKING AND USING THE SAME
8906575	2012	2014	LOS ALAMOS NATIONAL SECURITY, LLC	MINIMIZING ELECTRODE CONTAMINATION IN AN ELECTROCHEMICAL CELL
EP2712012	2013	2014	DELPHI TECHNOLOGIES, INC.	A METHOD OF MANUFACTURING A FUEL CELL STACK HAVING AN ELECTRICALLY CONDUCTIVE INTERCONNECT.
EP2720793	2012	2014	STC.UNM	NON-PGM CATHODE CATALYSTS FOR FUEL CELL APPLICATION DERIVED FROM HEAT TREATED HETEROATOMIC AMINES PRECURSORS
EP2733777	2012	2014	AIR PRODUCTS AND CHEMICALS, INC.	SEAL BETWEEN METAL AND CERAMIC CONDUITS
EP2739682	2012	2014	3M INNOVATIVE PROPERTIES COMPANY	LOW EQUIVALENT WEIGHT POLYMERS
EP2745343	2011	2014	UNITED TECHNOLOGIES CORPORATION	FUEL CELL AND MEMBRANE THEREFOR
EP2817261	2013	2014	CALIFORNIA INSTITUTE OF TECHNOLOGY	METHOD AND SYSTEM FOR GRAPHENE FORMATION
WO2014085563	2013	2014	STC.UNM	MECHANOCHEMICAL SYNTHESIS FOR PREPARATION OF NON-PGM ELECTROCATALYSTS
8927453	2013	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	MOLYBDENUM AND TUNGSTEN NANOSTRUCTURES AND METHODS FOR MAKING AND USING SAME
8944437	2012	2015	AIR PRODUCTS AND CHEMICALS, INC.	SEAL BETWEEN METAL AND CERAMIC CONDUITS
8945791	2011	2015	STC.UNM	OXYGEN SIDE ELECTRODE

				FOR A FUEL CELL
8962132	2010	2015	GINER ELECTROCHEMICAL SYSTEMS, LLC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING A POROUS SUPPORT AND A SOLID POLYMER ELECTROLYTE INCLUDING A DISPERSED REDUCED NOBLE METAL OR NOBLE METAL OXIDE
8974578	2013	2015	NORTHWESTERN UNIVERSITY	POROUS POLYMER NETWORKS AND ION-EXCHANGE MEDIA AND METAL-POLYMER COMPOSITES MADE THEREFROM
9005331	2010	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	PLATINUM-COATED NON-NOBLE METAL-NOBLE METAL CORE-SHELL ELECTROCATALYSTS
9005471	2011	2015	DYNALENE INC.	HEAT TRANSFER FLUID CONTAINING NANO-ADDITIVE
9012344	2011	2015	UCHICAGO ARGONNE, LLC	ELECTROCATALYSTS USING POROUS POLYMERS AND METHOD OF PREPARATION
9017530	2012	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	METHOD AND ELECTROCHEMICAL CELL FOR SYNTHESIS AND TREATMENT OF METAL MONOLAYER ELECTROCATALYSTS METAL, CARBON, AND OXIDE NANOPARTICLES IN BATCH, OR IN CONTINUOUS FASHION
9017900	2014	2015	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	FUEL CELL COMPONENTS AND SYSTEMS HAVING CARBON-CONTAINING ELECTRICALLY-CONDUCTIVE HOLLOW FIBERS
9023550	2011	2015	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	NANOCRYSTALLINE CERIUM OXIDE MATERIALS FOR SOLID FUEL CELL SYSTEMS
9023553	2008	2015	CHEMSULTANTS INTERNATIONAL, INC.	MULTILAYERED COMPOSITE PROTON EXCHANGE MEMBRANE AND A PROCESS FOR MANUFACTURING THE SAME
9034165	2009	2015	BROOKHAVEN SCIENCE ASSOCIATES, LLC	UNDERPOTENTIAL DEPOSITION-MEDIATED LAYER-BY-LAYER

				GROWTH OF THIN FILMS
9034538	2010	2015	3M INNOVATIVE PROPERTIES COMPANY	CASTING SOLUTION AND METHOD FOR MAKING A POLYMER ELECTROLYTE MEMBRANE
9045839	2008	2015	GENERAL ELECTRIC COMPANY	METHODS AND SYSTEMS FOR IN-SITU ELECTROPLATING OF ELECTRODES
9048480	2012	2015	LOS ALAMOS NATIONAL SECURITY, LLC	ANION EXCHANGE POLYMER ELECTROLYTES
9051431	2013	2015	LOS ALAMOS NATIONAL SECURITY, LLC	POLY(ARYLENE)-BASED ANION EXCHANGE POLYMER ELECTROLYTES
9065142	2012	2015	UCHICAGO ARGONNE, LLC	FUEL CELL ELECTRODES
9080242	2008	2015	GENERAL ELECTRIC COMPANY	PRESSURIZED ELECTROLYSIS STACK WITH THERMAL EXPANSION CAPABILITY
9093685	2009	2015	LOS ALAMOS NATIONAL SECURITY, LLC	METHODS OF MAKING MEMBRANE ELECTRODE ASSEMBLIES
9093715	2013	2015	BROWN UNIVERSITY	MULTIMETALLIC NANOPARTICLE CATALYSTS WITH ENHANCED ELECTROOXIDATION
9099253	2012	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTROCHEMICAL SYNTHESIS OF ELONGATED NOBLE METAL NANOPARTICLES, SUCH AS NANOWIRES AND NANORODS, ON HIGH-SURFACE AREA CARBON SUPPORTS
9105934	2011	2015	GEORGETOWN UNIVERSITY	PLATINUM ADLAYERED RUTHENIUM NANOPARTICLES, METHOD FOR PREPARING, AND USES THEREOF
9126830	2014	2015	BETTERGY CORP.	METAL DOPED ZEOLITE MEMBRANE FOR GAS SEPARATION
9150418	2013	2015	CALIFORNIA INSTITUTE OF TECHNOLOGY	METHOD AND SYSTEM FOR GRAPHENE FORMATION
9150968	2013	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	PLATINUM-BASED ELECTROCATALYSTS SYNTHESIZED BY DEPOSITING CONTIGUOUS ADLAYERS ON CARBON NANOSTRUCTURES
9153831	2010	2015	UNIVERSITY OF SOUTH CAROLINA	ELECTRODE DESIGN FOR LOW TEMPERATURE

				DIRECT-HYDROCARBON SOLID OXIDE FUEL CELLS
9160021	2013	2015	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
9169140	2011	2015	LOS ALAMOS NATIONAL SECURITY, LLC	NON-PRECIOUS METAL CATALYSTS PREPARED FROM PRECURSOR COMPRISING CYANAMIDE
9186653	2011	2015	NORTHEASTERN UNIVERSITY	HIGHLY STABLE PLATINUM ALLOY CATALYST FOR METHANOL ELECTROOXIDATION
9203094	2007	2015	UNIVERSITY OF AKRON	CATALYSTS COMPOSITIONS FOR USE IN FUEL CELLS
EP2828503	2013	2015	UNITED TECHNOLOGIES CORPORATION	CATALYTIC REACTION IN CONFINED FLOW CHANNEL
EP2854208	2014	2015	DELPHI TECHNOLOGIES, INC.	FUEL CELL ELECTRODE INTERCONNECT CONTACT MATERIAL ENCAPSULATION AND METHOD
EP2930775	2010	2015	LG FUEL CELL SYSTEMS, INC.	METHOD FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
RE045703	2014	2015	ONED MATERIAL LLC	NANOSTRUCTURED CATALYST SUPPORTS
WO2015021099	2014	2015	BETTERGY CORP.	METAL DOPED ZEOLITE MEMBRANE FOR GAS SEPARATION
WO2015164474	2015	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	SYNTHESIS OF AU-INDUCED STRUCTURALLY ORDERED AUPDCO INTERMETALLIC CORE-SHELL NANOPARTICLES AND THEIR USE AS OXYGEN REDUCTION CATALYSTS
9227224	2012	2016	STANFORD UNIVERSITY	METHOD OF FORMING MACRO-STRUCTURED HIGH SURFACE AREA TRANSPARENT CONDUCTIVE OXIDE ELECTRODES
9228954	2012	2016	UNIVERSITY OF CENTRAL FLORIDA	METHOD OF DETECTING DEFECTS IN ION EXCHANGE MEMBRANES OF ELECTROCHEMICAL CELLS BY CHEMOCHROMIC SENSORS
9234843	2011	2016	ALLIANCE FOR	ON-LINE, CONTINUOUS

			SUSTAINABLE ENERGY, LLC	MONITORING IN SOLAR CELL AND FUEL CELL MANUFACTURING USING SPECTRAL REFLECTANCE IMAGING
9246177	2012	2016	UCHICAGO ARGONNE, LLC	BIMETALLIC ALLOY ELECTROCATALYSTS WITH MULTILAYERED PLATINUM-SKIN SURFACES
9252445	2013	2016	VANDERBILT UNIVERSITY	NANOFIBER MEMBRANE-ELECTRODE-ASSEMBLY AND METHOD OF FABRICATING SAME
9255334	2012	2016	UCHICAGO ARGONNE, LLC	HYDROGEN EVOLUTION REACTION CATALYST
9276273	2011	2016	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL WATER MANAGEMENT VIA REDUCED ANODE REACTANT PRESSURE
9276284	2013	2016	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL SUBASSEMBLIES INCORPORATING SUBGASKETED THRIFTED MEMBRANES
9287568	2008	2016	3M INNOVATIVE PROPERTIES COMPANY	HIGH PERFORMANCE, HIGH DURABILITY NON-PRECIOUS METAL FUEL CELL CATALYSTS
9295960	2012	2016	UNITED TECHNOLOGIES CORPORATION	CATALYTIC REACTION IN CONFINED FLOW CHANNEL
9343758	2013	2016	PROTONEX TECHNOLOGY CORPORATION	SOLID OXIDE FUEL CELL SYSTEMS WITH HOT ZONES HAVING IMPROVED REACTANT DISTRIBUTION
9350026	2012	2016	UCHICAGO ARGONNE, LLC	NANOFIBROUS ELECTROCATALYSTS
9350036	2012	2016	VANDERBILT UNIVERSITY	COMPOSITE MEMBRANES, METHODS OF MAKING SAME, AND APPLICATIONS OF SAME
9356300	2013	2016	DELPHI TECHNOLOGIES, INC.	FUEL CELL ELECTRODE INTERCONNECT CONTACT MATERIAL ENCAPSULATION AND METHOD
9370773	2015	2016	DIOXIDE MATERIALS INC	ION-CONDUCTING MEMBRANES
9375894	2013	2016	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CONTINUOUS FILAMENT COMPOSITE PARTS AND ARTICLES OF MANUFACTURE THEREOF
9379393	2006	2016	NANOTEK INSTRUMENTS, INC.	CARBON CLADDED COMPOSITE FLOW FIELD PLATE, BIPOLAR PLATE

				AND FUEL CELL
9406943	2015	2016	UCHICAGO ARGONNE, LLC	ELECTROCATALYSTS USING POROUS POLYMERS AND METHOD OF PREPARATION
9413019	2011	2016	AUDI AG	FUEL CELL AND MEMBRANE THEREFORE
9419300	2011	2016	3M INNOVATIVE PROPERTIES COMPANY	PROTON CONDUCTING MATERIALS
9421521	2014	2016	UCHICAGO ARGONNE, LLC	NANOSEGREGATED BIMETALLIC OXIDE ANODE CATALYST FOR PROTON EXCHANGE MEMBRANE ELECTROLYZER
9425461	2014	2016	LOS ALAMOS NATIONAL SECURITY, LLC	REJUVENATION OF AUTOMOTIVE FUEL CELLS
9425462	2013	2016	GENERAL MOTORS CORPORATION	PREPARATION OF HOLLOW PT AND PT-ALLOY CATALYSTS
9431670	2013	2016	3M INNOVATIVE PROPERTIES COMPANY	HIGH DURABILITY FUEL CELL COMPONENTS WITH CERIUM SALT ADDITIVES
9437880	2012	2016	DELPHI TECHNOLOGIES, INC.	METHOD OF MANUFACTURING A FUEL CELL STACK HAVING AN ELECTRICALLY CONDUCTIVE INTERCONNECT
9437893	2014	2016	STEVENS INSTITUTE OF TECHNOLOGY	IN-MEMBRANE MICRO FUEL CELL
9452402	2013	2016	BATTELLE MEMORIAL INSTITUTE	INTEGRATED REACTORS, METHODS OF MAKING SAME, AND METHODS OF CONDUCTING SIMULTANEOUS EXOTHERMIC AND ENDOTHERMIC REACTIONS
9455451	2013	2016	UNIVERSITY OF CALIFORNIA	MEMBRANE-ELECTRODE STRUCTURES FOR MOLECULAR CATALYSTS FOR USE IN FUEL CELLS AND OTHER ELECTROCHEMICAL DEVICES
9468923	2015	2016	NORTHWESTERN UNIVERSITY	POROUS POLYMER NETWORKS AND ION-EXCHANGE MEDIA AND METAL-POLYMER COMPOSITES MADE THEREFROM
9481939	2015	2016	DIOXIDE	ELECTROCHEMICAL

			MATERIALS INC	DEVICE FOR CONVERTING CARBON DIOXIDE TO A REACTION PRODUCT
9490486	2013	2016	BROOKHAVEN SCIENCE ASSOCIATES LLC	METHOD FOR REMOVING STRONGLY ADSORBED SURFACTANTS AND CAPPING AGENTS FROM METAL TO FACILITATE THEIR CATALYTIC APPLICATIONS
9502719	2012	2016	STC.UNM	CATHODE CATALYSTS FOR FUEL CELL APPLICATION DERIVED FROM POLYMER PRECURSORS
9515323	2013	2016	STC.UNM	CATHODE CATALYSTS FOR FUEL CELLS
EP3012895	2008	2016	3M INNOVATIVE PROPERTIES COMPANY	POLYMER ELECTROLYTES INCLUDING HETEROPOLYACIDS
EP3091597	2010	2016	LG FUEL CELL SYSTEMS, INC.	APPARATUS FOR GENERATING A GAS WHICH MAY BE USED FOR STARTUP AND SHUTDOWN OF A FUEL CELL
WO2016064440	2015	2016	DIOXIDE MATERIALS INC	ELECTROLYZER AND MEMBRANES
WO2016064447	2015	2016	DIOXIDE MATERIALS INC	ELECTROLYZER AND MEMBRANES
9534097	2015	2017	SANDIA CORPORATION	POLY(PHENYLENE ALKYLENE)-BASED LONOMERS
9537166	2011	2017	RENSSELAER POLYTECHNIC INSTITUTE	METHOD FOR THE PRODUCTION OF AN ELECTROCHEMICAL CELL
9550170	2013	2017	BROOKHAVEN SCIENCE ASSOCIATES LLC	SYNTHESIS OF NANOPARTICLES USING ETHANOL
9553327	2014	2017	GENERAL MOTORS CORPORATION	GRAFTED FUNCTIONAL GROUPS ON EXPANDED TETRAFLUOROETHYLENE (EPTFE) SUPPORT FOR FUEL CELL AND WATER TRANSPORT MEMBRANES
9562005	2014	2017	NORTHWESTERN UNIVERSITY	METALLATED METAL-ORGANIC FRAMEWORKS
9566574	2011	2017	DIOXIDE MATERIALS INC	CATALYST MIXTURES
9570756	2010	2017	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTRODE WITH NANOSTRUCTURED CATALYST AND DISPERSED CATALYST SUBLAYER
9580824	2016	2017	DIOXIDE MATERIALS INC	ION-CONDUCTING MEMBRANES
9590260	2013	2017	ACUMENTRICS	INTEGRAL REACTOR

			CORPORATION	SYSTEM AND METHOD FOR FUEL CELLS
9597708	2007	2017	GENERAL ELECTRIC COMPANY	BOND LAYER FOR A SOLID OXIDE FUEL CELL, AND RELATED PROCESSES AND DEVICES
9634331	2012	2017	STC.UNM	NON-PGM CATHODE CATALYSTS FOR FUEL CELL APPLICATION DERIVED FROM HEAT TREATED HETEROATOMIC AMINES PRECURSORS
9640824	2014	2017	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL ELECTRODES WITH CONDUCTION NETWORKS
9689085	2015	2017	BROOKHAVEN SCIENCE ASSOCIATES LLC	UNDERPOTENTIAL DEPOSITION-MEDIATED LAYER-BY-LAYER GROWTH OF THIN FILMS
9711816	2012	2017	3M INNOVATIVE PROPERTIES COMPANY	LOW EQUIVALENT WEIGHT POLYMERS
9716279	2014	2017	BROOKHAVEN SCIENCE ASSOCIATES LLC	CORE-SHELL FUEL CELL ELECTRODES
9722256	2015	2017	STC.UNM	IMIDAZOLE-DERIVED MATERIALS
9728788	2013	2017	STC.UNM	MECHANOCHEMICAL SYNTHESIS FOR PREPARATION OF NON-PGM ELECTROCATALYSTS
9728802	2014	2017	GINER ELECTROCHEMICAL SYSTEMS, LLC	MICROMOLD METHODS FOR FABRICATING PERFORATED SUBSTRATES AND FOR PREPARING SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANES
9738665	2016	2017	NORTHWESTERN UNIVERSITY	METALLATED METAL-ORGANIC FRAMEWORKS
9825306	2014	2017	UNIVERSITY OF SOUTH CAROLINA	MIXED IONIC AND ELECTRONIC CONDUCTOR BASED ON SR2FE2-XMOXO6 PEROVSKITE
9825308	2016	2017	UCHICAGO ARGONNE, LLC	LOW PLATINUM CATALYST AND METHOD OF PREPARATION
9849445	2016	2017	UCHICAGO ARGONNE, LLC	SUBNANOMETER TO NANOMETER TRANSITION METAL CO OXIDATION CATALYSTS
9849450	2017	2017	DIOXIDE MATERIALS INC	ION-CONDUCTING MEMBRANES
9853255	2017	2017	BROOKHAVEN SCIENCE ASSOCIATES LLC	CORE-SHELL FUEL CELL ELECTRODES

EP3138875	2012	2017	3M INNOVATIVE PROPERTIES COMPANY	CROSSLINKED FLUORINATED POLYMERS WITH MANGANESE OR CERIUM AS ADDITIVES
EP3147982	2011	2017	3M INNOVATIVE PROPERTIES COMPANY	REINFORCED ELECTROLYTE MEMBRANE
EP3209816	2015	2017	DIOXIDE MATERIALS INC	ELECTROLYZER AND MEMBRANES
WO2017120249	2017	2017	SANDIA CORPORATION	POLY (PHENYLENE)-BASED ANION EXCHANGE POLYMERS AND METHODS THEREOF
WO2017120250	2017	2017	SANDIA CORPORATION	FUNCTIONALIZATION OF DIELS-ALDER POLYPHENYLENE POLYMERS
9865894	2015	2018	UNIVERSITY OF AKRON	SOLID OXIDE FUEL CELLS FUELED WITH REDUCIBLE OXIDES
9873102	2015	2018	UNIVERSITY OF CALIFORNIA	CATALYTIC DEVICES
9876246	2015	2018	VANDERBILT UNIVERSITY	NANOFIBER MEMBRANE-ELECTRODE-ASSEMBLY AND METHOD OF FABRICATING SAME
9882222	2014	2018	BROOKHAVEN SCIENCE ASSOCIATES LLC	NITRIDE STABILIZED CORE/SHELL NANOPARTICLES
9893373	2011	2018	3M INNOVATIVE PROPERTIES COMPANY	REINFORCED ELECTROLYTE MEMBRANE
9905870	2011	2018	VANDERBILT UNIVERSITY	NANOFIBER ELECTRODE AND METHOD OF FORMING SAME
9929453	2014	2018	UCHICAGO ARGONNE, LLC	BI-METALLIC NANOPARTICLES AS CATHODE ELECTROCATALYSTS
9959949	2014	2018	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	SOLID STATE ELECTROLYTE COMPOSITES BASED ON COMPLEX HYDRIDES AND METAL DOPED FULLERENES/FULLERANES FOR BATTERIES AND ELECTROCHEMICAL APPLICATIONS
9976199	2015	2018	BROOKHAVEN SCIENCE ASSOCIATES LLC	SYNTHESIS OF AU-INDUCED STRUCTURALLY ORDERED AUPDCO INTERMETALLIC CORE-SHELL NANOPARTICLES AND THEIR USE AS OXYGEN REDUCTION CATALYSTS

9979026	2013	2018	LOS ALAMOS NATIONAL SECURITY, LLC	NON-PRECIOUS METAL CATALYSTS PREPARED FROM PRECURSORS COMPRISING CYANAMIDE AND POLYANILINE
9997788	2014	2018	JOHNS HOPKINS UNIVERSITY	METHODS OF PRODUCING POROUS PLATINUM-BASED CATALYSTS FOR OXYGEN REDUCTION
10047446	2016	2018	DIOXIDE MATERIALS INC	METHOD AND SYSTEM FOR ELECTROCHEMICAL PRODUCTION OF FORMIC ACID FROM CARBON DIOXIDE
10053534	2017	2018	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	FUNCTIONALIZATION OF DIELS-ALDER POLYPHENYLENE POLYMERS
10053535	2017	2018	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	POLY(PHENYLENE)-BASED ANION EXCHANGE POLYMERS AND METHODS THEREOF
10099207	2015	2018	UCHICAGO ARGONNE, LLC	MULTIMETALLIC CORE/INTERLAYER/SHELL NANOPARTICLES
10103391	2011	2018	AUDI AG	FUEL CELL SEAL
10106903	2016	2018	UCHICAGO ARGONNE, LLC	CONSUMABLE ANODE AND ANODE ASSEMBLY FOR ELECTROLYTIC REDUCTION OF METAL OXIDES
10141593	2016	2018	VANDERBILT UNIVERSITY	COMPOSITE MEMBRANES, METHODS OF MAKING SAME, AND APPLICATIONS OF SAME
EP1997550	2008	2018	DELPHI TECHNOLOGIES, INC.	SYSTEM FOR CONTINUOUS REMOVAL OF A SPECIFIC GAS FROM A FLOWING MIXTURE OF GASES
EP3400252	2017	2018	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	FUNCTIONALIZATION OF DIELS-ALDER POLYPHENYLENE POLYMERS
RE046921	2015	2018	ONED MATERIAL LLC	NANOSTRUCTURED CATALYST SUPPORTS
10305114	2014	2019	UCHICAGO ARGONNE, LLC	NON-PLATINUM GROUP METAL ELECTROCATALYSTS USING METAL ORGANIC FRAMEWORK MATERIALS AND METHOD OF PREPARATION
10370483	2018	2019	NATIONAL	POLY(PHENYLENE)-BASED

			TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	ANION EXCHANGE POLYMERS AND METHODS THEREOF
10442887	2018	2019	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	FUNCTIONALIZATION OF DIELS-ALDER POLYPHENYLENE POLYMERS
10446868	2016	2019	3M INNOVATIVE PROPERTIES COMPANY	FUEL CELL SUBASSEMBLIES INCORPORATING SUBGASKETED THRIFTED MEMBRANES

Appendix FC-B. Fuel Cell Patents in Families Associated with Other DOE Funding

Patent #	Application Year	Issue / Publication Year	Original Assignee	Title
4115632	1977	1978	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF PREPARING ELECTROLYTE FOR USE IN FUEL CELLS
4169917	1978	1979	ENERGY RESEARCH CORPORATION	ELECTROCHEMICAL CELL AND SEPARATOR PLATE THEREOF
4192906	1978	1980	ENERGY RESEARCH CORPORATION	ELECTROCHEMICAL CELL OPERATION AND SYSTEM
4212929	1979	1980	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL MANIFOLD SEALING SYSTEM
4216278	1979	1980	GENERAL ELECTRIC COMPANY	PROCESS OF MAKING ELECTROLYTE STRUCTURE FOR MOLTEN CARBONATE FUEL CELLS
4232097	1979	1980	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL OXYGEN ELECTRODE
4242426	1979	1980	GENERAL ELECTRIC COMPANY	PROCESS FOR ELECTROLYTE STRUCTURE WITH STRONTIUM TITANATE MATRIX FOR MOLTEN CARBONATE FUEL CELLS
4246081	1979	1981	UNASSIGNED	ELECTROCHEMICAL SEPARATION AND CONCENTRATION OF SULFUR CONTAINING GASES FROM GAS MIXTURES
4251600	1979	1981	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF PREPARING A SINTERED LITHIUM ALUMINATE STRUCTURE FOR CONTAINING ELECTROLYTE
4276355	1980	1981	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL SYSTEM CONFIGURATIONS
4279971	1980	1981	GENERAL ELECTRIC COMPANY	ELECTROLYTE STRUCTURE WITH STRONTIUM TITANATE MATRIX FOR MOLTEN CARBONATE FUEL CELLS
4292378	1980	1981	UNITED STATES DEPARTMENT OF ENERGY	THERMAL REGENERATION OF AN ELECTROCHEMICAL CONCENTRATION CELL
4292379	1980	1981	WESTINGHOUSE ELECTRIC CORPORATION	VARIABLE AREA FUEL CELL PROCESS CHANNELS
EP0039235	1981	1981	WESTINGHOUSE ELECTRIC CORPORATION	POLYGONAL SHAPED FUEL CELL SYSTEM.
EP0039236	1981	1981	WESTINGHOUSE ELECTRIC	VARIABLE AREA FUEL CELL COOLING.

			CORPORATION	
EP0039237	1981	1981	WESTINGHOUSE ELECTRIC CORPORATION	VARIABLE AREA FUEL CELL PROCESS CHANNELS.
4310605	1980	1982	ENGELHARD CORPORATION	FUEL CELL SYSTEM
4324844	1980	1982	WESTINGHOUSE ELECTRIC CORPORATION	VARIABLE AREA FUEL CELL COOLING
4337571	1979	1982	UNITED STATES DEPARTMENT OF ENERGY	METHOD FOR PRODUCING A FUEL CELL MANIFOLD SEAL
4342816	1981	1982	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL STACK ARRANGEMENTS
4366211	1981	1982	WESTINGHOUSE ELECTRIC CORPORATION	CONTROL OF ELECTROLYTE FILL TO FUEL CELL STACK
4374906	1981	1983	UNITED TECHNOLOGIES CORPORATION	RIBBED ELECTRODE SUBSTRATES
4383008	1981	1983	ENERGY RESEARCH CORPORATION	FUEL CELL ASSEMBLY WITH ELECTROLYTE TRANSPORT
4383009	1981	1983	UNITED STATES DEPARTMENT OF ENERGY	LOW HYDROSTATIC HEAD ELECTROLYTE ADDITION TO FUEL CELL STACKS
4389466	1981	1983	UNITED STATES DEPARTMENT OF ENERGY	RAPIDLY REFUELABLE FUEL CELL
4389467	1980	1983	UNITED STATES DEPARTMENT OF ENERGY	POROUS ELECTROLYTE RETAINER FOR MOLTEN CARBONATE FUEL CELL
4395468	1981	1983	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL GENERATOR
4396689	1981	1983	EXXON RESEARCH AND ENGINEERING COMPANY	SEPARATOR-SPACER FOR ELECTROCHEMICAL SYSTEMS
4404267	1982	1983	GENERAL ELECTRIC COMPANY	ANODE COMPOSITE FOR MOLTEN CARBONATE FUEL CELL
4407906	1981	1983	UNASSIGNED	FUEL CELL WITH PT/PD ELECTROCATALYST ELECTRODE
4410606	1982	1983	UNASSIGNED	LOW TEMPERATURE THERMALLY REGENERATIVE ELECTROCHEMICAL SYSTEM
4410607	1981	1983	UNASSIGNED	POROUS ELECTRODE PREPARATION METHOD
4414294	1982	1983	UNITED STATES DEPARTMENT OF ENERGY	ELECTRICALLY INSULATING AND SEALING FRAME
4416955	1982	1983	ENERGY RESEARCH	FUEL CELL SUB-ASSEMBLY

			CORPORATION	
4423122	1982	1983	GENERAL ELECTRIC COMPANY	ELECTRODE FOR MOLTEN CARBONATE FUEL CELL
EP0063199	1981	1983	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL STACK ARRANGEMENTS
EP0074701	1982	1983	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL SYSTEM.
EP0075380	1982	1983	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL SYSTEM UTILIZING LIQUID ELECTROLYTE.
EP0077111	1982	1983	WESTINGHOUSE ELECTRIC CORPORATION	LOW HYDROSTATIC HEAD ELECTROLYTE ADDITION TO FUEL CELL STACKS.
EP0082389	1982	1983	ENERGY RESEARCH CORPORATION	FUEL CELL ASSEMBLY WITH ELECTROLYTE TRANSPORT.
EP0083938	1983	1983	ENERGY RESEARCH CORPORATION	FUEL CELL SUB-ASSEMBLY.
EP0089852	1983	1983	WESTINGHOUSE ELECTRIC CORPORATION	ELECTRICAL GENERATORS OF THE FUEL CELL TYPE.
EP0092765	1983	1983	GENERAL ELECTRIC COMPANY	ELECTRODE FOR MOLTEN CARBONATE FUEL CELL.
EP0092766	1983	1983	GENERAL ELECTRIC COMPANY	ANODE COMPOSITE FOR MOLTEN CARBONATE FUEL CELL.
4424491	1981	1984	UNITED STATES DEPARTMENT OF ENERGY	AUTOMATIC VOLTAGE IMBALANCE DETECTOR
4431714	1982	1984	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL DESIGN AND ASSEMBLY
4431715	1982	1984	WESTINGHOUSE ELECTRIC CORPORATION	ELECTRICAL CONTACT STRUCTURES FOR SOLID OXIDE ELECTROLYTE FUEL CELL
4448856	1983	1984	UNITED STATES DEPARTMENT OF ENERGY	BATTERY AND FUEL CELL ELECTRODES CONTAINING STAINLESS STEEL CHARGING ADDITIVE
4450212	1982	1984	ENGELHARD CORPORATION	EDGE SEAL FOR A POROUS GAS DISTRIBUTION PLATE OF A FUEL CELL
4454207	1983	1984	UNITED STATES DEPARTMENT OF ENERGY	STEAM REFORMING OF FUEL TO HYDROGEN IN FUEL CELLS
4459340	1982	1984	STANFORD UNIVERSITY	METHOD FOR PRODUCING ELECTRICITY FROM A FUEL CELL HAVING SOLID-OXIDE IONIC ELECTROLYTE
4459341	1983	1984	UNITED STATES	HIGH TEMPERATURE SOLID

			DEPARTMENT OF ENERGY	ELECTROLYTE FUEL CELL WITH CERAMIC ELECTRODES
4463066	1982	1984	ENGELHARD CORPORATION	FUEL CELL AND SYSTEM FOR SUPPLYING ELECTROLYTE THERETO
4463067	1982	1984	ENGELHARD CORPORATION	FUEL CELL AND SYSTEM FOR SUPPLYING ELECTROLYTE THERETO UTILIZING CASCADE FEED
4463068	1982	1984	ENGELHARD CORPORATION	FUEL CELL AND SYSTEM FOR SUPPLYING ELECTROLYTE THERETO WITH WICK FEED
4467019	1982	1984	ENGELHARD CORPORATION	FUEL CELL WITH ELECTROLYTE FEED SYSTEM
4476196	1983	1984	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELL HAVING MONOLITHIC CROSS FLOW CORE AND MANIFOLDING
4476197	1983	1984	UNITED STATES DEPARTMENT OF ENERGY	INTEGRAL MANIFOLDING STRUCTURE FOR FUEL CELL CORE HAVING PARALLEL GAS FLOW
4476198	1983	1984	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELL HAVING MONOLITHIC CORE
4477541	1982	1984	UNITED STATES DEPARTMENT OF ENERGY	SOLID ELECTROLYTE STRUCTURE
4478776	1981	1984	UNASSIGNED	METHOD OF MAKING MOLTEN CARBONATE FUEL CELL CERAMIC MATRIX TAPE
4490442	1983	1984	ENERGY RESEARCH CORPORATION	FUEL CELL SYSTEM AND METHOD
4490444	1981	1984	WESTINGHOUSE ELECTRIC CORPORATION	HIGH TEMPERATURE SOLID ELECTROLYTE FUEL CELL CONFIGURATIONS AND INTERCONNECTIONS
EP0098676	1983	1984	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL DESIGN AND ASSEMBLY AND COOLING PLATE THEREFOR.
EP0107397	1983	1984	ENGELHARD CORPORATION	EDGE SEAL FOR A POROUS GAS DISTRIBUTION PLATE OF A FUEL CELL.
4499663	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF FABRICATING A MONOLITHIC CORE FOR A SOLID OXIDE FUEL CELL
4505992	1983	1985	ENGELHARD CORPORATION	INTEGRAL GAS SEAL FOR FUEL CELL GAS DISTRIBUTION ASSEMBLIES AND METHOD OF FABRICATION
4510212	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELL HAVING COMPOUND CROSS FLOW GAS PATTERNS
4510213	1983	1985	UNITED STATES	FUEL CELL STACK WITH

			DEPARTMENT OF ENERGY	INTERNAL MANIFOLDS FOR REACTANT GASES
4511636	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	MOLTEN CARBONATE FUEL CELL MATRICES
4514475	1984	1985	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL SEPARATOR WITH COMPRESSIBLE SEALING FLANGES
4520082	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL GENERATOR
4522894	1984	1985	ENGELHARD CORPORATION	FUEL CELL ELECTRIC POWER PRODUCTION
4526812	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	COATED POWDER FOR ELECTROLYTE MATRIX FOR CARBONATE FUEL CELL
4526843	1984	1985	ENGELHARD CORPORATION	FILM BONDED FUEL CELL INTERFACE CONFIGURATION
4529670	1984	1985	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL HAVING DUAL ELECTRODE ANODE OR CATHODE
4540640	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	COATED POWDER FOR ELECTROLYTE MATRIX FOR CARBONATE FUEL CELL
4547437	1984	1985	WESTINGHOUSE ELECTRIC CORPORATION	PROTECTIVE INTERLAYER FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
4548874	1984	1985	UNITED STATES DEPARTMENT OF ENERGY	SHORT PROTECTION DEVICE FOR STACK OF ELECTROLYTIC CELLS
4548875	1984	1985	WESTINGHOUSE ELECTRIC CORPORATION	HEATED TRANSPORTABLE FUEL CELL CARTRIDGES
4548876	1984	1985	UNITED STATES DEPARTMENT OF ENERGY	INTEGRATED CURRENT COLLECTOR AND CATALYST SUPPORT
4548877	1984	1985	UNITED STATES DEPARTMENT OF ENERGY	ELECTROLYTE RESERVOIR FOR CARBONATE FUEL CELLS
4560626	1982	1985	UNITED STATES DEPARTMENT OF ENERGY	RAPIDLY REFUELABLE FUEL CELL
4562124	1985	1985	WESTINGHOUSE ELECTRIC CORPORATION	AIR ELECTRODE MATERIAL FOR HIGH TEMPERATURE ELECTROCHEMICAL CELLS
EP0122150	1984	1985	ENGELHARD CORPORATION	INTEGRAL GAS SEAL FOR FUEL CELL GAS DISTRIBUTION ASSEMBLIES AND METHOD OF FABRICATION
EP0133747	1984	1985	WESTINGHOUSE ELECTRIC CORPORATION	IMPROVED FUEL CELL GENERATORS.
4564567	1983	1986	UNITED STATES DEPARTMENT OF	ELECTRONICALLY CONDUCTIVE CERAMICS FOR

			ENERGY	HIGH TEMPERATURE OXIDIZING ENVIRONMENTS
4581303	1985	1986	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR MAKING STRUCTURE FOR A MCFC
4582765	1981	1986	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL SYSTEM WITH COOLANT FLOW REVERSAL
4582766	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	HIGH PERFORMANCE CERMET ELECTRODES
4583583	1983	1986	ENGELHARD CORPORATION	FUEL CELL CRIMP-RESISTANT COOLING DEVICE WITH INTERNAL COIL
4588661	1984	1986	ENGELHARD CORPORATION	FABRICATION OF GAS IMPERVIOUS EDGE SEAL FOR A BIPOLAR GAS DISTRIBUTION ASSEMBLY FOR USE IN A FUEL CELL
4596750	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	SUPPORT TUBE FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELL
4597170	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF MAKING AN ELECTRODE
4598028	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	HIGH STRENGTH POROUS SUPPORT TUBES FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
4598467	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	PROTECTIVE INTERLAYER FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
4604331	1984	1986	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL SEPARATOR PLATE WITH BELLOWS-TYPE SEALING FLANGES
4605602	1984	1986	ENGELHARD CORPORATION	CORROSION PROTECTED, MULTI-LAYER FUEL CELL INTERFACE
4609562	1984	1986	WESTINGHOUSE ELECTRIC CORPORATION	APPARATUS AND METHOD FOR DEPOSITING COATING ONTO POROUS SUBSTRATE
4609595	1984	1986	UNITED STATES DEPARTMENT OF ENERGY	MOLTEN CARBONATE FUEL CELL SEPARATOR
4631238	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	COBALT DOPED LANTHANUM CHROMITE MATERIAL SUITABLE FOR HIGH TEMPERATURE USE
4631239	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL PLATES WITH IMPROVED ARRANGEMENT OF PROCESS CHANNELS FOR ENHANCED PRESSURE DROP ACROSS THE PLATES

EP0174762	1985	1986	ENGELHARD CORPORATION	FABRICATION OF GAS IMPERVIOUS EDGE SEAL FOR A BIPOLAR GAS DISTRIBUTION ASSEMBLY FOR USE IN A FUEL CELL.
EP0176247	1985	1986	ENGELHARD CORPORATION	CORROSION PROTECTED, MULTI-LAYER FUEL CELL INTERFACE.
EP0180289	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS.
EP0181680	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL ARRANGEMENTS.
EP0188056	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS.
EP0188868	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	CERAMIC COMPOUND AND AIR ELECTRODE MATERIALS FOR HIGH-TEMPERATURE ELECTROCHEMICAL CELLS.
EP0191229	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL GENERATORS.
EP0194374	1985	1986	WESTINGHOUSE ELECTRIC CORPORATION	HIGH TEMPERATURE ELECTROCHEMICAL CELLS.
EP0196465	1986	1986	INSTITUTE OF GAS TECHNOLOGY	SULFUR TOLERANT MOLTEN CARBONATE FUEL CELL ANODE AND PROCESS.
EP0198466	1986	1986	ENERGY RESEARCH CORPORATION	NICKEL ANODE ELECTRODE.
4639401	1986	1987	UNITED STATES DEPARTMENT OF ENERGY	SURFACTANT ADDITION TO PHOSPHORIC ACID ELECTROLYTE
4640875	1985	1987	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL GENERATOR CONTAINING A GAS SEALING MEANS
4643954	1985	1987	UNITED STATES DEPARTMENT OF ENERGY	DEVICE FOR EQUALIZING MOLTEN ELECTROLYTE CONTENT IN A FUEL CELL STACK
4643955	1985	1987	UNITED STATES DEPARTMENT OF ENERGY	MOLTEN CARBONATE FUEL CELL REDUCTION OF NICKEL DEPOSITS
4648945	1985	1987	WESTINGHOUSE ELECTRIC CORPORATION	BIPOLAR PLATING OF METAL CONTACTS ONTO OXIDE INTERCONNECTION FOR SOLID OXIDE ELECTROCHEMICAL CELL
4652411	1984	1987	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF PREPARING THIN POROUS SHEETS OF CERAMIC MATERIAL
4659379	1985	1987	ENERGY RESEARCH	NICKEL ANODE ELECTRODE

			CORPORATION	
4659635	1986	1987	UNITED STATES DEPARTMENT OF ENERGY	ELECTROLYTE MATRIX IN A MOLTEN CARBONATE FUEL CELL STACK
4664987	1984	1987	WESTINGHOUSE ELECTRIC CORPORATION	FUEL CELL ARRANGEMENT
4666798	1985	1987	UNITED STATES DEPARTMENT OF ENERGY	SERIALLY CONNECTED SOLID OXIDE FUEL CELLS HAVING MONOLITHIC CORES
4670359	1985	1987	ENGELHARD CORPORATION	FUEL CELL INTEGRATED WITH STEAM REFORMER
4692274	1986	1987	WESTINGHOUSE ELECTRIC CORPORATION	PROTECTIVE INTERLAYER FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
4702971	1986	1987	WESTINGHOUSE ELECTRIC CORPORATION	SULFUR TOLERANT COMPOSITE CERMET ELECTRODES FOR SOLID OXIDE ELECTROCHEMICAL CELLS
4714586	1986	1987	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF PREPARING A DIMENSIONALLY STABLE ELECTRODE FOR USE IN A MCFC
4714661	1986	1987	UNITED STATES DEPARTMENT OF ENERGY	MOLTEN CARBONATE FUEL CELL
EP0194380	1985	1987	WESTINGHOUSE ELECTRIC CORPORATION	SUPPORT TUBES FOR ELECTROCHEMICAL CELLS
EP0198978	1985	1987	WESTINGHOUSE ELECTRIC CORPORATION	FORMATION OF AN ADHERENT METAL DEPOSIT ON AN EXPOSED SURFACE OF AN ELECTRICALLY-CONDUCTING CERAMIC
EP0220787	1983	1987	ENGELHARD CORPORATION	PROCESS FOR MAKING PASTE FOR SEALING POROUS LAYERS
EP0225769	1986	1987	WESTINGHOUSE ELECTRIC CORPORATION	IMPROVEMENTS IN OR RELATING TO FUEL CELL PLATES.
EP0231576	1986	1987	WESTINGHOUSE ELECTRIC CORPORATION	IMPROVEMENTS IN OR RELATING TO ELECTROCHEMICAL FUEL CELLS.
4718997	1986	1988	EXXON RESEARCH AND ENGINEERING COMPANY	ELECTROCHEMICAL DEVICE
4721513	1982	1988	UNITED STATES DEPARTMENT OF ENERGY	CATHODE PREPARATION METHOD FOR MOLTEN CARBONATE FUEL CELL
4729931	1986	1988	WESTINGHOUSE ELECTRIC CORPORATION	REFORMING OF FUEL INSIDE FUEL CELL GENERATOR

4732637	1986	1988	ENGELHARD CORPORATION	METHOD OF FABRICATING AN INTEGRAL GAS SEAL FOR FUEL CELL GAS DISTRIBUTION ASSEMBLIES
4732822	1986	1988	UNITED STATES DEPARTMENT OF ENERGY	INTERNAL ELECTROLYTE SUPPLY SYSTEM FOR RELIABLE TRANSPORT THROUGHOUT FUEL CELL STACKS
4749632	1986	1988	UNITED STATES DEPARTMENT OF ENERGY	SINTERING AID FOR LANTHANUM CHROMITE REFRACTORIES
4751062	1986	1988	ENGELHARD CORPORATION	FUEL CELL WITH ELECTROLYTE MATRIX ASSEMBLY
4761348	1987	1988	UNITED STATES DEPARTMENT OF ENERGY	ELECTROLYTIC CELL STACK WITH MOLTEN ELECTROLYTE MIGRATION CONTROL
4761349	1987	1988	UNIVERSITY OF CHICAGO	SOLID OXIDE FUEL CELL WITH MONOLITHIC CORE
4780437	1987	1988	UNITED STATES DEPARTMENT OF ENERGY	FABRICATION OF CATALYTIC ELECTRODES FOR MOLTEN CARBONATE FUEL CELLS
4781241	1987	1988	INTERNATIONAL FUEL CELLS CORPORATION	HEAT EXCHANGER FOR FUEL CELL POWER PLANT REFORMER
4791035	1987	1988	WESTINGHOUSE ELECTRIC CORPORATION	CELL AND CURRENT COLLECTOR FELT ARRANGEMENT FOR SOLID OXIDE ELECTROCHEMICAL CELL COMBINATIONS
EP0194373	1985	1988	WESTINGHOUSE ELECTRIC CORPORATION	IMPROVEMENTS IN OR RELATING TO THE DEPOSITION OF A COATING ON A POROUS SUBSTRATE
EP0196387	1985	1988	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF INCREASING THE CELL VOLTAGE OF ELECTROCHEMICAL CELLS
EP0196388	1985	1988	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF MAKING ELECTRODES METHOD OF MAKING ELECTRODES
EP0253459	1987	1988	WESTINGHOUSE ELECTRIC CORPORATION	ELECTRODES FOR SOLID OXIDE ELECTROLYTE ELECTROCHEMICAL CELLS
EP0262961	1987	1988	ENGELHARD CORPORATION	FUEL CELL WITH ELECTROLYTE MATRIX ASSEMBLY.
EP0266861	1987	1988	WESTINGHOUSE ELECTRIC CORPORATION	IMPROVEMENTS IN OR RELATING TO REFORMING A GASEOUS REFORMABLE FUEL WITHIN A SOLID OXIDE FUEL CELL GENERATOR.
WO1988003332	1987	1988	UNIVERSITY OF CHICAGO	SINTERING AID FOR LANTHANUM CHROMITE REFRACTORIES
WO1988007265	1988	1988	UNIVERSITY OF	SOLID OXIDE FUEL CELL

			CHICAGO	WITH MONOLITHIC CORE
WO1988008045	1988	1988	UNIVERSITY OF CHICAGO	MONOLITHIC SOLID ELECTROLYTE OXYGEN PUMP
4804592	1987	1989	UNITED STATES DEPARTMENT OF ENERGY	COMPOSITE ELECTRODE FOR USE IN ELECTROCHEMICAL CELLS
4808491	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	CORNER HEATING IN RECTANGULAR SOLID OXIDE ELECTROCHEMICAL CELL GENERATORS
4810596	1985	1989	HUGHES AIRCRAFT COMPANY	SULFURIC ACID THERMOELECTROCHEMICAL SYSTEM AND METHOD
4812329	1987	1989	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF MAKING SULFUR TOLERANT COMPOSITE CERMET ELECTRODES FOR SOLID OXIDE ELECTROCHEMICAL CELLS
4824742	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	MANIFOLD, BUS SUPPORT AND COUPLING ARRANGEMENT FOR SOLID OXIDE FUEL CELLS
4826716	1987	1989	ENGELHARD CORPORATION	FILM BONDED FUEL CELL INTERFACE CONFIGURATION
4827606	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	METHOD AND APPARATUS FOR ASSEMBLING SOLID OXIDE FUEL CELLS
4831965	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	FABRICATION OF SOLID OXIDE FUEL CELL BY ELECTROCHEMICAL VAPOR DEPOSITION
4833045	1987	1989	WESTINGHOUSE ELECTRIC CORPORATION	POROUS ELECTRONIC CURRENT COLLECTOR BODIES FOR ELECTROCHEMICAL CELL CONFIGURATIONS
4847172	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	LOW RESISTANCE FUEL ELECTRODES
4849308	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	MANIFOLD SEAL FOR FUEL CELL STACK ASSEMBLY
4853301	1985	1989	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL PLATES WITH SKEWED PROCESS CHANNELS FOR UNIFORM DISTRIBUTION OF STACK COMPRESSION LOAD
4855194	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL HAVING ELECTROLYTE INVENTORY CONTROL VOLUME
4861345	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF BONDING A CONDUCTIVE LAYER ON AN ELECTRODE OF AN ELECTROCHEMICAL CELL
4865925	1988	1989	HUGHES	GAS PERMEABLE ELECTRODE

			AIRCRAFT COMPANY	FOR ELECTROCHEMICAL SYSTEM
4874678	1987	1989	WESTINGHOUSE ELECTRIC CORPORATION	ELONGATED SOLID ELECTROLYTE CELL CONFIGURATIONS AND FLEXIBLE CONNECTIONS THEREFOR
4876115	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	ELECTRODE ASSEMBLY FOR USE IN A SOLID POLYMER ELECTROLYTE FUEL CELL
4876163	1987	1989	WESTINGHOUSE ELECTRIC CORPORATION	GENERATOR CONFIGURATION FOR SOLID OXIDE FUEL CELLS
4877506	1987	1989	UNASSIGNED	MONOLITHIC SOLID ELECTROLYTE OXYGEN PUMP
4883497	1988	1989	ARCH DEVELOPMENT CORPORATION	FORMATION OF THIN WALLED CERAMIC SOLID OXIDE FUEL CELLS
4885078	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	DEVICES CAPABLE OF REMOVING SILICON AND ALUMINUM FROM GASEOUS ATMOSPHERES
4888254	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	LOW CIRCUMFERENTIAL VOLTAGE GRADIENT SELF SUPPORTING ELECTRODE FOR SOLID OXIDE FUEL CELLS
EP0274003	1987	1989	WESTINGHOUSE ELECTRIC CORPORATION	IMPROVED INTERNAL ELECTROLYTE SUPPLY SYSTEM FOR RELIABLE TRANSPORT THROUGHOUT FUEL CELL STACK
EP0289580	1987	1989	UNIVERSITY OF CHICAGO	SINTERING AID FOR LANTHANUM CHROMITE REFRACTORIES.
EP0304877	1988	1989	INTERNATIONAL FUEL CELLS CORPORATION	HEAT EXCHANGER FOR FUEL CELL POWER PLANT REFORMER.
EP0307462	1988	1989	UNIVERSITY OF CHICAGO	SOLID OXIDE FUEL CELL WITH MONOLITHIC CORE.
EP0309553	1988	1989	UNIVERSITY OF CHICAGO	MONOLITHIC SOLID ELECTROLYTE OXYGEN PUMP.
EP0320087	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	ELONGATED ELECTROCHEMICAL CELL COMBINATIONS.
EP0321069	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR HAVING A SPIRAL, CIRCULAR OR FOLDED ROW CONFIGURATION.
EP0328812	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL GENERATORS OF RECTANGULAR DESIGN HAVING CORNER HEATING.

EP0329894	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	LOW RESISTANCE FUEL ELECTRODES
EP0337036	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	A METHOD FOR BONDING A CONDUCTIVE LAYER ON AN ELECTRODE STRUCTURE.
EP0341365	1988	1989	WESTINGHOUSE ELECTRIC CORPORATION	A METHOD OF BONDING A CONDUCTIVE LAYER ON AN ELECTRODE STRUCTURE.
4891280	1986	1990	UNITED STATES DEPARTMENT OF ENERGY	CATHODE FOR MOLTEN CARBONATE FUEL CELL
4895576	1988	1990	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF DOPING INTERCONNECTIONS FOR ELECTROCHEMICAL CELLS
4921765	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	COMBINED GOAL GASIFIER AND FUEL CELL SYSTEM AND METHOD
4925745	1985	1990	INSTITUTE OF GAS TECHNOLOGY	SULFUR TOLERANT MOLTEN CARBONATE FUEL CELL ANODE AND PROCESS
4938833	1989	1990	ENGELHARD CORPORATION	PROCESS FOR MAKING FILM-BONDED FUEL CELL INTERFACES
4939111	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	CATHODE FOR MOLTEN CARBONATE FUEL CELL
4943494	1988	1990	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELL MATRIX AND MODULES
4945010	1986	1990	ENGELHARD CORPORATION	COOLING ASSEMBLY FOR FUEL CELLS
4971830	1990	1990	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF ELECTRODE FABRICATION FOR SOLID OXIDE ELECTROCHEMICAL CELLS
4973530	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL WATER TRANSPORT
4978590	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	DRY COMPLIANT SEAL FOR PHOSPHORIC ACID FUEL CELL
4978591	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	CORROSION FREE PHOSPHORIC ACID FUEL CELL
WO1990004859	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	FABRICATION OF DUAL POROSITY ELECTRODE STRUCTURE
4983471	1989	1991	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL APPARATUS HAVING AXIALLY DISTRIBUTED ENTRY OF A FUEL-SPENT FUEL MIXTURE TRANSVERSE TO THE CELL LENGTHS
4992341	1988	1991	UNITED STATES DEPARTMENT OF	FABRICATION OF DUAL POROSITY ELECTRODE

			ENERGY	STRUCTURE
5008163	1989	1991	UNITED STATES DEPARTMENT OF ENERGY	CONDUCTIVE CERAMIC COMPOSITION AND METHOD OF PREPARATION
5009968	1989	1991	INTERNATIONAL FUEL CELLS CORPORATION	FUEL CELL END PLATE STRUCTURE
5021304	1989	1991	WESTINGHOUSE ELECTRIC CORPORATION	MODIFIED CERMET FUEL ELECTRODES FOR SOLID OXIDE ELECTROCHEMICAL CELLS
5041197	1989	1991	PHYSICAL SCIENCES, INC.	H2/C12 FUEL CELLS FOR POWER AND HCL PRODUCTION - CHEMICAL COGENERATION
5045414	1989	1991	INTERNATIONAL FUEL CELLS CORPORATION	REACTANT GAS COMPOSITION FOR FUEL CELL POTENTIAL CONTROL
5047299	1990	1991	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL APPARATUS HAVING AN INTEGRATED REFORMER-MIXER NOZZLE-MIXER DIFFUSER
5073405	1991	1991	WESTINGHOUSE ELECTRIC CORPORATION	APPLYING A TAPERED ELECTRODE ON A POROUS CERAMIC SUPPORT TUBE BY MASKING A BAND INSIDE THE TUBE AND DRAWING IN ELECTRODE MATERIAL FROM THE OUTSIDE OF THE TUBE BY SUCTION
EP0373745	1989	1991	WESTINGHOUSE ELECTRIC CORPORATION	AN ELECTROCHEMICAL DEVICE CONTAINING A DEPOSIT OF METAL OXIDE OR METAL SALT
EP0439938	1990	1991	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF ELECTRODE FABRICATION FOR SOLID OXIDE ELECTROCHEMICAL CELLS.
EP0443241	1990	1991	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL APPARATUS HAVING AXIALLY DISTRIBUTED ENTRIES SUPPLYING A FUEL-SPENT FUEL MIXTURE TRANSVERSE TO THE CELL LENGTHS.
EP0447717	1990	1991	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF MAKING HIGHLY SINTERABLE LANTHANUM CHROMITE POWDER.
EP0454924	1990	1991	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF FORMING A THIN LAYER OF DOPED LANTHANUM CHROMITE PARTICLES IN A TAPE.
EP0454925	1990	1991	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF BONDING AN INTERCONNECTION LAYER ON AN ELECTRODE.

EP0461248	1990	1991	INTERNATIONAL FUEL CELLS CORPORATION	USE AND COMPOSITION OF A REACTANT GAS TO CONTROL FUEL CELL POTENTIAL.
WO1991010266	1990	1991	INTERNATIONAL FUEL CELLS CORPORATION	USE AND COMPOSITION OF A REACTANT GAS TO CONTROL FUEL CELL POTENTIAL
5079104	1991	1992	INTERNATIONAL FUEL CELLS CORPORATION	INTEGRATED FUEL CELL STACK SHUNT CURRENT PREVENTION ARRANGEMENT
5080689	1990	1992	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF BONDING AN INTERCONNECTION LAYER ON AN ELECTRODE OF AN ELECTROCHEMICAL CELL
5096786	1989	1992	WESTINGHOUSE ELECTRIC CORPORATION	INTEGRAL EDGE SEALS FOR PHOSPHORIC ACID FUEL CELLS
5106654	1990	1992	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF FORMING A DENSE, HIGH TEMPERATURE ELECTRONICALLY CONDUCTIVE COMPOSITE LAYER ON A POROUS CERAMIC SUBSTRATE
5132352	1990	1992	WESTINGHOUSE ELECTRIC CORPORATION	TAPE METHOD OF FORMING A THIN LAYER OF DOPED LANTHANUM CHROMITE PARTICLES AND OF BONDING SUCH ON AN ELECTRODE
5139896	1991	1992	UNITED STATES DEPARTMENT OF ENERGY	ALL CERAMIC STRUCTURE FOR MOLTEN CARBONATE FUEL CELL
5143751	1990	1992	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF MAKING HIGHLY SINTERABLE LANTHANUM CHROMITE POWDER
5143801	1990	1992	BATTELLE MEMORIAL INSTITUTE	SOLID OXIDE FUEL CELLS, AND AIR ELECTRODE AND ELECTRICAL INTERCONNECTION MATERIALS THEREFOR
5169730	1990	1992	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL APPARATUS HAVING AN EXTERIOR FUEL MIXER NOZZLE
EP0467692	1991	1992	WESTINGHOUSE ELECTRIC CORPORATION	A METHOD OF FORMING AN ELECTRONICALLY CONDUCTIVE COMPOSITE LAYER ON A SUBSTRATE IN A DEVICE CONTAINING SOLID ELECTROLYTE.
EP0468698	1991	1992	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL APPARATUS HAVING AN EXTERIOR FUEL MIXER NOZZLE.
EP0468699	1991	1992	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL CELL APPARATUS HAVING AN INTEGRATED REFORMER-MIXER NOZZLE-MIXER

				DIFFUSER.
EP0495583	1992	1992	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF DEPOSITING A TAPERED ELECTRODE BY INTERNAL MASKING.
WO1992007393	1991	1992	BATTELLE MEMORIAL INSTITUTE	SOLID OXIDE FUEL CELLS, AND AIR ELECTRODE AND ELECTRICAL INTERCONNECTION MATERIALS THEREFOR
5200279	1991	1993	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR
5206095	1990	1993	INSTITUTE OF GAS TECHNOLOGY	CARBONATE FUEL CELL ANODES
5213911	1991	1993	UNITED STATES DEPARTMENT OF ENERGY	SOLID-OXIDE FUEL CELL ELECTROLYTE
5219673	1991	1993	UNASSIGNED	CELL STRUCTURE FOR ELECTROCHEMICAL DEVICES AND METHOD OF MAKING SAME
5232794	1991	1993	UNITED STATES DEPARTMENT OF ENERGY	IONIC CONDUCTORS FOR SOLID OXIDE FUEL CELLS
5242873	1988	1993	ARCH DEVELOPMENT CORPORATION	ELECTRICALLY CONDUCTIVE MATERIAL
5244752	1991	1993	WESTINGHOUSE ELECTRIC CORPORATION	APPARATUS TUBE CONFIGURATION AND MOUNTING FOR SOLID OXIDE FUEL CELLS
5258240	1993	1993	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR
5273838	1992	1993	WESTINGHOUSE ELECTRIC CORPORATION	DOUBLE INTERCONNECTION FUEL CELL ARRAY
EP0396685	1989	1993	UNITED STATES DEPARTMENT OF ENERGY	FABRICATION OF DUAL POROSITY ELECTRODE STRUCTURE
EP0448517	1991	1993	INSTITUTE OF GAS TECHNOLOGY	CARBONATE FUEL CELL ANODES
EP0536910	1992	1993	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR.
EP0567640	1992	1993	UNITED STATES DEPARTMENT OF ENERGY	IONIC CONDUCTORS FOR SOLID OXIDE FUEL CELLS.
EP0568281	1993	1993	WESTINGHOUSE ELECTRIC CORPORATION	AIR ELECTRODE MATERIAL HAVING CONTROLLED SINTERABILITY.
EP0571659	1992	1993	HUGHES AIRCRAFT COMPANY	DUAL POROSITY GAS-EVOLVING ELECTRODE.

WO1993008613	1992	1993	UNITED STATES DEPARTMENT OF ENERGY	IONIC CONDUCTORS FOR SOLID OXIDE FUEL CELLS
5277995	1993	1994	WESTINGHOUSE ELECTRIC CORPORATION	ELECTRODE AND METHOD OF INTERCONNECTION SINTERING ON AN ELECTRODE OF AN ELECTROCHEMICAL CELL
5290642	1990	1994	ALLIEDSIGNAL INC.	METHOD OF FABRICATING A MONOLITHIC SOLID OXIDE FUEL CELL
5306574	1992	1994	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF LOW TEMPERATURE OPERATION OF AN ELECTROCHEMICAL CELL ARRAY
5330859	1992	1994	UNIVERSITY OF CHICAGO	SOLID OXIDE FUEL CELL WITH SINGLE MATERIAL FOR ELECTRODES AND INTERCONNECT
5336274	1993	1994	UNIVERSITY OF CALIFORNIA	METHOD FOR FORMING A CELL SEPARATOR FOR USE IN BIPOLAR-STACK ENERGY STORAGE DEVICES
5340665	1992	1994	CERAMATEC, INC.	CREEP RESISTANT, METAL-COATED LIFEO2 ANODES FOR MOLTEN CARBONATED FUEL CELLS
5342704	1993	1994	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF MAKING AN AIR ELECTRODE MATERIAL HAVING CONTROLLED SINTERABILITY
5346661	1992	1994	UNITED STATES DEPARTMENT OF ENERGY	HOT COMPRESSION PROCESS FOR MAKING EDGE SEALS FOR FUEL CELLS
5347816	1992	1994	UNIVERSITY OF CHICAGO	VARIABLE PRESSURE THERMAL INSULATING JACKET
5356728	1993	1994	AMOCO CORPORATION	CROSS-FLOW ELECTROCHEMICAL REACTOR CELLS, CROSS-FLOW REACTORS, AND USE OF CROSS-FLOW REACTORS FOR OXIDATION REACTIONS
5362578	1992	1994	INSTITUTE OF GAS TECHNOLOGY	INTEGRATED MAIN RAIL, FEED RAIL, AND CURRENT COLLECTOR
5364712	1993	1994	HUGHES AIRCRAFT COMPANY	DUAL POROSITY GAS EVOLVING ELECTRODE
EP0588536	1993	1994	CERAMATEC, INC.	CREEP RESISTANT METAL-COATED LIFEO2 ANODES FOR MOLTEN CARBONATE AND SOLID OXIDE FUEL CELLS.
EP0617475	1994	1994	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF FORMING AN INTERCONNECTION LAYER BY SINTERING ON AN

				ELECTRODE OF AN ELECTROCHEMICAL CELL.
WO1994020997	1994	1994	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	SOLID ELECTROLYTE-ELECTRODE SYSTEM FOR AN ELECTROCHEMICAL CELL
WO1994024065	1994	1994	AMOCO CORPORATION	OXYGEN ION-CONDUCTING DENSE CERAMIC
5378550	1993	1995	UNITED STATES DEPARTMENT OF ENERGY	ELECTROLYTES FOR POWER SOURCES
5389456	1994	1995	WESTINGHOUSE ELECTRIC CORPORATION	METHOD AND CLOSING PORES IN A THERMALLY SPRAYED DOPED LANTHANUM CHROMITE INTERCONNECTION LAYER
5391440	1994	1995	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF FORMING A LEAK PROOF PLASMA SPRAYED INTERCONNECTION LAYER ON AN ELECTRODE OF AN ELECTROCHEMICAL CELL
5393619	1994	1995	UNIVERSITY OF CALIFORNIA	CELL SEPARATOR FOR USE IN BIPOLAR-STACK ENERGY STORAGE DEVICES
5401460	1993	1995	M-C POWER CORPORATION	METHOD FOR SINTERING FUEL CELL ELECTRODES USING A CARRIER
5403461	1993	1995	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	SOLID ELECTROLYTE-ELECTRODE SYSTEM FOR AN ELECTROCHEMICAL CELL
5413878	1993	1995	UNITED STATES DEPARTMENT OF ENERGY	SYSTEM AND METHOD FOR NETWORKING ELECTROCHEMICAL DEVICES
5426003	1994	1995	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF FORMING A PLASMA SPRAYED INTERCONNECTION LAYER ON AN ELECTRODE OF AN ELECTROCHEMICAL CELL
5434020	1993	1995	UNIVERSITY OF CALIFORNIA	CONTINUOUS-FEED ELECTROCHEMICAL CELL WITH NONPACKING PARTICULATE ELECTRODE
5449568	1993	1995	UNITED STATES DEPARTMENT OF ENERGY	INDIRECT-FIRED GAS TURBINE BOTTOMED WITH FUEL CELL
5453331	1994	1995	UNIVERSITY OF CHICAGO	COMPLIANT SEALANTS FOR SOLID OXIDE FUEL CELLS AND OTHER CERAMICS
5470669	1989	1995	HUGHES AIRCRAFT COMPANY	THERMOELECTROCHEMICAL SYSTEM AND METHOD
5470674	1994	1995	UNASSIGNED	ELECTROLYTE SALTS FOR POWER SOURCES
EP0677327	1995	1995	WESTINGHOUSE ELECTRIC CORPORATION	HYDROCARBON REFORMING CATALYST MATERIAL AND CONFIGURATION OF THE SAME.

5496655	1994	1996	LOCKHEED MARTIN IDAHO TECHNOLOGIES COMPANY	CATALYTIC BIPOLAR INTERCONNECTION PLATE FOR USE IN A FUEL CELL
5498487	1994	1996	WESTINGHOUSE ELECTRIC CORPORATION	OXYGEN SENSOR FOR MONITORING GAS MIXTURES CONTAINING HYDROCARBONS
5503945	1994	1996	INSTITUTE OF GAS TECHNOLOGY	SEPARATOR PLATE FOR A FUEL CELL
5509189	1994	1996	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	METHOD FOR MAKING AN ELECTROCHEMICAL CELL
5516597	1994	1996	WESTINGHOUSE ELECTRIC CORPORATION	PROTECTIVE INTERLAYER FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
5527631	1995	1996	WESTINGHOUSE ELECTRIC CORPORATION	HYDROCARBON REFORMING CATALYST MATERIAL AND CONFIGURATION OF THE SAME
5541014	1995	1996	UNITED STATES DEPARTMENT OF ENERGY	INDIRECT-FIRED GAS TURBINE DUAL FUEL CELL POWER CYCLE
5554453	1995	1996	ENERGY RESEARCH CORPORATION	CARBONATE FUEL CELL SYSTEM WITH THERMALLY INTEGRATED GASIFICATION
5573867	1996	1996	WESTINGHOUSE ELECTRIC CORPORATION	PURGE GAS PROTECTED TRANSPORTABLE PRESSURIZED FUEL CELL MODULES AND THEIR OPERATION IN A POWER PLANT
5580497	1994	1996	AMOCO CORPORATION	OXYGEN ION-CONDUCTING DENSE CERAMIC
5580673	1994	1996	ENERGY RESEARCH CORPORATION	CARBONATE FUEL CELL MATRIX
EP0709909	1995	1996	ENERGY RESEARCH CORPORATION	CARBONATE FUEL CELL MATRIX
EP0727836	1995	1996	WESTINGHOUSE ELECTRIC CORPORATION	METHOD OF FORMING A PLASMA SPRAYED INTERCONNECTION LAYER ON AN ELECTRODE OF AN ELECTROCHEMICAL CELL
WO1996005626	1995	1996	UNIVERSITY OF CHICAGO	COMPLIANT SEALANTS FOR SOLID OXIDE FUEL CELLS AND OTHER CERAMICS
WO1996014668	1995	1996	WESTINGHOUSE ELECTRIC CORPORATION	PROTECTIVE INTERLAYER FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
WO1996028343	1996	1996	AEROVIRONMENT INC.	SOLAR POWERED FLYING WING SURVEILLANCE

				AIRCRAFT
WO1996029751	1996	1996	LOCKHEED MARTIN IDAHO TECHNOLOGIES COMPANY	MINIATURE CERAMIC FUEL CELL
5626977	1995	1997	UNIVERSITY OF CALIFORNIA	COMPOSITE CARBON FOAM ELECTRODE
5639437	1996	1997	AMOCO CORPORATION	OXYGEN ION-CONDUCTING DENSE CERAMIC
5641585	1995	1997	LOCKHEED MARTIN IDAHO TECHNOLOGIES COMPANY	MINIATURE CERAMIC FUEL CELL
5656388	1995	1997	CALIFORNIA INSTITUTE OF TECHNOLOGY	METAL HYDRIDES AS ELECTRODE/CATALYST MATERIALS FOR OXYGEN EVOLUTION/REDUCTION IN ELECTROCHEMICAL DEVICES
5686198	1996	1997	WESTINGHOUSE ELECTRIC CORPORATION	LOW COST STABLE AIR ELECTRODE MATERIAL FOR HIGH TEMPERATURE SOLID OXIDE ELECTROLYTE ELECTROCHEMICAL CELLS
EP0791231	1995	1997	WESTINGHOUSE ELECTRIC CORPORATION	PROTECTIVE INTERLAYER FOR HIGH TEMPERATURE SOLID ELECTROLYTE ELECTROCHEMICAL CELLS
WO1997028573	1997	1997	WESTINGHOUSE ELECTRIC CORPORATION	PURGE GAS PROTECTED TRANSPORTABLE PRESSURIZED FUEL CELL MODULES AND THEIR OPERATION IN A POWER PLANT
WO1997032349	1997	1997	WESTINGHOUSE ELECTRIC CORPORATION	LOW COST STABLE AIR ELECTRODE MATERIAL FOR HIGH TEMPERATURE SOLID OXIDE ELECTROLYTE ELECTROCHEMICAL CELLS
WO1997033333	1997	1997	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR WITH REMOVABLE MODULAR FUEL CELL STACK CONFIGURATIONS
5723074	1996	1998	AMOCO CORPORATION	OXYGEN ION-CONDUCTING DENSE CERAMIC
5733675	1995	1998	WESTINGHOUSE ELECTRIC CORPORATION	ELECTROCHEMICAL FUEL CELL GENERATOR HAVING AN INTERNAL AND LEAK TIGHT HYDROCARBON FUEL REFORMER
5741605	1996	1998	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR WITH REMOVABLE MODULAR FUEL CELL STACK CONFIGURATIONS
5750278	1995	1998	WESTINGHOUSE	SELF-COOLING MONO-

			ELECTRIC CORPORATION	CONTAINER FUEL CELL GENERATORS AND POWER PLANTS USING AN ARRAY OF SUCH GENERATORS
5753385	1995	1998	UNIVERSITY OF CALIFORNIA	HYBRID DEPOSITION OF THIN FILM SOLID OXIDE FUEL CELLS AND ELECTROLYZERS
5805657	1997	1998	UNITED STATES DEPARTMENT OF ENERGY	NUCLEAR FUEL ELEMENTS MADE FROM NANOPHASE MATERIALS
5810284	1995	1998	UNASSIGNED	AIRCRAFT
5833452	1996	1998	M-C POWER CORPORATION	COATED METAL SINTERING CARRIERS FOR FUEL CELL ELECTRODES
EP0885466	1997	1998	WESTINGHOUSE ELECTRIC CORPORATION	LOW COST STABLE AIR ELECTRODE MATERIAL FOR HIGH TEMPERATURE SOLID OXIDE ELECTROLYTE ELECTROCHEMICAL CELLS
WO1998012764	1996	1998	WESTINGHOUSE ELECTRIC CORPORATION	AN ELECTROCHEMICAL FUEL CELL GENERATOR HAVING AN INTERNAL AND LEAK TIGHT HYDROCARBON FUEL REFORMER
WO1998026465	1997	1998	ENERGY RESEARCH CORPORATION	ELECTROLYTE MATRIX FOR MOLTEN CARBONATE FUEL CELLS
WO1998045891	1998	1998	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL OPERABLE OVER WIDE TEMPERATURE RANGE
5869203	1996	1999	ENERGY RESEARCH CORPORATION	ELECTROLYTE MATRIX FOR MOLTEN CARBONATE FUEL CELLS
5882809	1997	1999	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELL WITH MULTI-UNIT CONSTRUCTION AND PRISMATIC DESIGN
5888665	1996	1999	CALIFORNIA INSTITUTE OF TECHNOLOGY	LANI5IS-BASED METAL HYDRIDE ELECTRODE IN NI-MH RECHARGEABLE CELLS
5898564	1996	1999	UNIVERSITY OF CALIFORNIA	CAPACITOR WITH A COMPOSITE CARBON FOAM ELECTRODE
5908713	1997	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	SINTERED ELECTRODE FOR SOLID OXIDE FUEL CELLS
5916700	1998	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	LANTHANUM MANGANITE-BASED AIR ELECTRODE FOR SOLID OXIDE FUEL CELLS
5928805	1997	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	COVER AND STARTUP GAS SUPPLY SYSTEM FOR SOLID OXIDE FUEL CELL GENERATOR
5932146	1997	1999	SIEMENS	AIR ELECTRODE

			WESTINGHOUSE POWER CORPORATION	COMPOSITION FOR SOLID OXIDE FUEL CELL
5942345	1997	1999	UNIVERSITY OF CHICAGO	HIGH PERFORMANCE ELECTROLYTES FOR MCFC
5993985	1998	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL CELL TUBES AND METHOD OF MAKING SAME
5993989	1997	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	INTERFACIAL MATERIAL FOR SOLID OXIDE FUEL CELL
6001501	1998	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	CONNECTIONS FOR SOLID OXIDE FUEL CELLS
6007683	1997	1999	UNIVERSITY OF CALIFORNIA	HYBRID DEPOSITION OF THIN FILM SOLID OXIDE FUEL CELLS AND ELECTROLYZERS
EP0914687	1997	1999	WESTINGHOUSE ELECTRIC CORPORATION	SOLID OXIDE FUEL CELL GENERATOR WITH REMOVABLE MODULAR FUEL CELL STACK CONFIGURATIONS
WO1999016140	1998	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	SINTERED ELECTRODE FOR SOLID OXIDE FUEL CELLS
WO1999021649	1998	1999	ELTRON RESEARCH, INC.	CATALYTIC MEMBRANE REACTOR WITH TWO COMPONENT THREE-DIMENSIONAL CATALYSIS
WO1999027598	1998	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	COVER AND STARTUP GAS SUPPLY SYSTEM FOR SOLID OXIDE FUEL CELL GENERATOR
WO1999033134	1998	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	AIR ELECTRODE COMPOSITION FOR SOLID OXIDE FUEL CELL
WO1999039396	1999	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	CONNECTIONS FOR SOLID OXIDE FUEL CELLS
WO1999040641	1999	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	METHOD OF MAKING STRAIGHT FUEL CELL TUBES
WO1999041793	1999	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	IMPROVED LANTHANUM MANGANITE-BASED AIR ELECTRODE FOR SOLID OXIDE FUEL CELLS
WO1999044251	1999	1999	SIEMENS WESTINGHOUSE POWER	FUEL CELL GENERATOR ENERGY DISSIPATOR

			CORPORATION	
WO1999054947	1999	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL CELL TUBES AND METHOD OF MAKING SAME
WO1999054949	1999	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	METHOD OF MAKING CLOSED END CERAMIC FUEL CELL TUBES
WO1999062129	1999	1999	SIEMENS WESTINGHOUSE POWER CORPORATION	IRON ALUMINIDE ALLOY CONTAINER FOR SOLID OXIDE FUEL CELLS
6025083	1998	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL CELL GENERATOR ENERGY DISSIPATOR
6033794	1997	2000	UNITED STATES DEPARTMENT OF ENERGY	MULTI-STAGE FUEL CELL SYSTEM METHOD AND APPARATUS
6083641	1998	2000	UNITED STATES DEPARTMENT OF ENERGY	TITANIUM CARBIDE BIPOLAR PLATE FOR ELECTROCHEMICAL DEVICES
6114058	1998	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	IRON ALUMINIDE ALLOY CONTAINER FOR SOLID OXIDE FUEL CELLS
6136704	1999	2000	UT-BATTELLE, LLC	METHOD FOR FORMING POROUS PLATINUM FILMS
6139985	1998	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	ELECTRODE ELECTROLYTE INTERLAYERS CONTAINING CERIUM OXIDE FOR ELECTROCHEMICAL FUEL CELLS
6165431	1999	2000	ELTRON RESEARCH, INC.	METHODS FOR SEPARATING OXYGEN FROM OXYGEN-CONTAINING GASES
EP1016154	1996	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	AN ELECTROCHEMICAL FUEL CELL GENERATOR HAVING AN INTERNAL AND LEAK TIGHT HYDROCARBON FUEL REFORMER
EP1016155	1997	2000	ENERGY RESEARCH CORPORATION	ELECTROLYTE MATRIX FOR MOLTEN CARBONATE FUEL CELLS
EP1027149	1998	2000	ELTRON RESEARCH, INC.	CATALYTIC MEMBRANE REACTOR WITH A THREE DIMENSIONAL CATALYST IN THE OXIDATION ZONE
EP1032952	1998	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	COVER AND STARTUP GAS SUPPLY SYSTEM FOR SOLID OXIDE FUEL CELL GENERATOR
EP1032953	1998	2000	SIEMENS WESTINGHOUSE POWER	SINTERED ELECTRODE FOR SOLID OXIDE FUEL CELLS

			CORPORATION	
EP1040530	1998	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	AIR ELECTRODE COMPOSITION FOR SOLID OXIDE FUEL CELL
EP1050085	1999	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	IMPROVED LANTHANUM MANGANITE-BASED AIR ELECTRODE FOR SOLID OXIDE FUEL CELLS
EP1051765	1999	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	CONNECTIONS FOR SOLID OXIDE FUEL CELLS
EP1055261	1999	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	METHOD OF MAKING STRAIGHT FUEL CELL TUBES
EP1060531	1999	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL CELL GENERATOR ENERGY DISSIPATOR
WO2000003447	1999	2000	MICHIGAN BIOTECHNOLOGY INSTITUTE	ELECTROCHEMICAL METHODS FOR GENERATION OF A BIOLOGICAL PROTON MOTIVE FORCE AND PYRIDINE NUCLEOTIDE COFACTOR REGENERATION
WO2000004362	1999	2000	PENN STATE UNIVERSITY	METHOD OF SCREENING COMPOSITIONS FOR ELECTROCATALYTIC ACTIVITY
WO2000039864	1999	2000	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL ELECTRODE FORMATION FOR A SOLID OXIDE FUEL CELL
WO2000045457	2000	2000	UNIVERSITY OF CALIFORNIA	MEMS-BASED THIN-FILM FUEL CELLS
WO2000049672	1999	2000	ENERGY RESEARCH CORPORATION	INTERNAL REFORMING FUEL CELL ASSEMBLY WITH SIMPLIFIED FUEL FEED
WO2000059613	2000	2000	ELTRON RESEARCH, INC.	CATALYTIC MEMBRANE REACTOR MATERIALS FOR THE SEPARATION OF OXYGEN FROM AIR
WO2000069007	2000	2000	SANDIA CORPORATION	FUEL CELL AND MEMBRANE
6200696	1999	2001	ENERGY RESEARCH CORPORATION	INTERNAL REFORMING FUEL CELL ASSEMBLY WITH SIMPLIFIED FUEL FEED
6207311	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	SOLID OXIDE FUEL CELL OPERABLE OVER WIDE TEMPERATURE RANGE
6217822	1998	2001	SIEMENS WESTINGHOUSE POWER	METHOD OF MAKING STRAIGHT FUEL CELL TUBES

			CORPORATION	
6221522	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	OPEN END PROTECTION FOR SOLID OXIDE FUEL CELLS
6248468	1998	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL ELECTRODE CONTAINING PRE-SINTERED NICKEL/ZIRCONIA FOR A SOLID OXIDE FUEL CELL
6255010	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	SINGLE MODULE PRESSURIZED FUEL CELL TURBINE GENERATOR SYSTEM
6270649	1999	2001	MICHIGAN STATE UNIVERSITY	ELECTROCHEMICAL METHODS FOR GENERATION OF A BIOLOGICAL PROTON MOTIVE FORCE AND PYRIDINE NUCLEOTIDE COFACTOR REGENERATION
6284402	1999	2001	PENN STATE UNIVERSITY	ELECTROCATALYST COMPOSITIONS
6332990	1999	2001	UNIVERSITY OF CALIFORNIA	METHOD FOR FABRICATING COMPOSITE CARBON FOAM
EP1070360	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL CELL TUBES AND METHOD OF MAKING SAME
EP1070363	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	METHOD OF MAKING CLOSED END CERAMIC FUEL CELL TUBES
EP1099271	1999	2001	MICHIGAN STATE UNIVERSITY	ELECTROCHEMICAL METHODS FOR GENERATION OF A BIOLOGICAL PROTON MOTIVE FORCE AND PYRIDINE NUCLEOTIDE COFACTOR REGENERATION
EP1145340	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	IRON ALUMINIDE ALLOY CONTAINER FOR SOLID OXIDE FUEL CELLS
EP1145345	1999	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL ELECTRODE FORMATION FOR A SOLID OXIDE FUEL CELL
EP1157437	1999	2001	ENERGY RESEARCH CORPORATION	INTERNAL REFORMING FUEL CELL ASSEMBLY WITH SIMPLIFIED FUEL FEED
WO2001006589	2000	2001	SIEMENS WESTINGHOUSE POWER CORPORATION	SINGLE MODULE PRESSURIZED FUEL CELL TURBINE GENERATOR SYSTEM
WO2001012312	2000	2001	BATTELLE MEMORIAL INSTITUTE	A CHEMICAL REACTOR AND METHOD FOR GAS PHASE REACTANT CATALYTIC REACTIONS

WO2001039311	2000	2001	UNITED STATES DEPARTMENT OF ENERGY	PLANAR FUEL CELL UTILIZING NAIL CURRENT COLLECTORS FOR INCREASED ACTIVE SURFACE AREA
6355093	1997	2002	ELTRON RESEARCH, INC.	TWO COMPONENT-THREE DIMENSIONAL CATALYSIS
6361893	1999	2002	UNITED STATES DEPARTMENT OF ENERGY	PLANAR FUEL CELL UTILIZING NAIL CURRENT COLLECTORS FOR INCREASED ACTIVE SURFACE AREA
6379485	1998	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	METHOD OF MAKING CLOSED END CERAMIC FUEL CELL TUBES
6379831	2000	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	EXPANDED NICKEL SCREEN ELECTRICAL CONNECTION SUPPORTS FOR SOLID OXIDE FUEL CELLS
6410161	1999	2002	FUELCELL ENERGY, INC.	METAL-CERAMIC JOINT ASSEMBLY
6416897	2000	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	TUBULAR SCREEN ELECTRICAL CONNECTION SUPPORT FOR SOLID OXIDE FUEL CELLS
6430966	1999	2002	BATTELLE MEMORIAL INSTITUTE	GLASS-CERAMIC MATERIAL AND METHOD OF MAKING
6444342	2000	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	AIR FEED TUBE SUPPORT SYSTEM FOR A SOLID OXIDE FUEL CELL GENERATOR
6495023	2001	2002	MICHIGAN STATE UNIVERSITY	ELECTROCHEMICAL METHODS FOR GENERATION OF A BIOLOGICAL PROTON MOTIVE FORCE AND PYRIDINE NUCLEOTIDE COFACTOR REGENERATION
EP1183092	2000	2002	ELTRON RESEARCH, INC.	CATALYTIC MEMBRANE REACTOR MATERIALS FOR THE SEPARATION OF OXYGEN FROM AIR
EP1190460	2000	2002	SANDIA CORPORATION	FUEL CELL AND MEMBRANE
EP1206316	2000	2002	BATTELLE MEMORIAL INSTITUTE	CHEMICAL REACTOR AND METHOD FOR CATALYTIC GAS PHASE REACTIONS
WO2002011223	2001	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	EXPANDED NICKEL SCREEN ELECTRICAL CONNECTION SUPPORTS FOR SOLID OXIDE FUEL CELLS
WO2002015295	2001	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	A SEGREGATED EXHAUST SOFC GENERATOR WITH HIGH FUEL UTILIZATION CAPABILITY

WO2002017418	2001	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	AIR FEED TUBE SUPPORT SYSTEM FOR A SOLID OXIDE FUEL CELL GENERATOR
WO2002021621	2001	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	TUBULAR SCREEN ELECTRICAL CONNECTION SUPPORTS FOR SOLID OXIDE FUEL CELLS
WO2002059906	2001	2002	FUELCELL ENERGY, INC.	ELECTROLYTE CREEPAGE BARRIER FOR LIQUID ELECTROLYTE FUEL CELLS
WO2002059994	2002	2002	UNIVERSITY OF CALIFORNIA	CO-FLOW PLANAR SOFC FUEL CELL STACK
WO2002067352	2001	2002	SIEMENS WESTINGHOUSE POWER CORPORATION	ENERGY DISSIPATER FOR PRESSURIZED FUEL CELL GENERATORS
WO2002072281	2002	2002	UNIVERSITY OF CALIFORNIA	A METHOD FOR MAKING THICK AND/OR THIN FILM
WO2002073726	2002	2002	UNIVERSITY OF CALIFORNIA	FLEXIBLE INTERCONNECTS FOR FUEL CELL STACKS
WO2002075022	2002	2002	MICHIGAN BIOTECHNOLOGY INSTITUTE	ELECTROCHEMICAL METHODS FOR GENERATION OF BIOLOGICAL PROTON MOTIVE FORCE AND PYRIDINE NUCLEOTIDE COFACTOR REGENERATION
WO2002078109	2002	2002	UT-BATTELLE, LLC	FOSSIL FUEL COMBINED CYCLE POWER SYSTEM
WO2002087730	2002	2002	BATTELLE MEMORIAL INSTITUTE	METHOD AND APPARATUS FOR THERMAL SWING ADSORPTION AND THERMALLY-ENHANCED PRESSURE SWING ADSORPTION
WO2002103828	2002	2002	UNIVERSITY OF CALIFORNIA	METHOD OF FABRICATION OF ELECTRODES AND ELECTROLYTES
6508925	2001	2003	SIEMENS WESTINGHOUSE POWER CORPORATION	AUTOMATED BRUSH PLATING PROCESS FOR SOLID OXIDE FUEL CELLS
6532769	2000	2003	BATTELLE MEMORIAL INSTITUTE	GLASS-CERAMIC JOINT AND METHOD OF JOINING
6592782	2000	2003	ELTRON RESEARCH, INC.	MATERIALS AND METHODS FOR THE SEPARATION OF OXYGEN FROM AIR
6610434	2000	2003	SIEMENS WESTINGHOUSE POWER CORPORATION	SEGREGATED EXHAUST SOFC GENERATOR WITH HIGH FUEL UTILIZATION CAPABILITY
6623880	2001	2003	UNITED STATES DEPARTMENT OF ENERGY	FUEL CELL-FUEL CELL HYBRID SYSTEM
6630012	2001	2003	BATTELLE	METHOD FOR THERMAL

			MEMORIAL INSTITUTE	SWING ADSORPTION AND THERMALLY-ENHANCED PRESSURE SWING ADSORPTION
6635375	2001	2003	UNITED STATES DEPARTMENT OF ENERGY	PLANAR SOLID OXIDE FUEL CELL WITH STAGED INDIRECT-INTERNAL AIR AND FUEL PREHEATING AND REFORMATION
6638654	1999	2003	UNIVERSITY OF CALIFORNIA	MEMS-BASED THIN-FILM FUEL CELLS
6641946	2001	2003	SIEMENS WESTINGHOUSE POWER CORPORATION	FUEL DISSIPATER FOR PRESSURIZED FUEL CELL GENERATORS
EP1325527	2001	2003	SIEMENS WESTINGHOUSE POWER CORPORATION	AIR FEED TUBE SUPPORT SYSTEM FOR A SOLID OXIDE FUEL CELL GENERATOR
EP1350278	2001	2003	FUELCELL ENERGY, INC.	ELECTROLYTE CREEPAGE BARRIER FOR LIQUID ELECTROLYTE FUEL CELLS
WO2003004140	2002	2003	NEXTECH MATERIALS, LTD.	CERAMIC ELECTROLYTE COATING METHODS
WO2003032412	2002	2003	UNIVERSITY OF CALIFORNIA	METHOD OF FORMING A PACKAGE FOR MEMS-BASED FUEL CELL
WO2003051529	2002	2003	UNIVERSITY OF CALIFORNIA	A PROCESS FOR MAKING DENSE THIN FILMS
WO2003052858	2002	2003	UNIVERSITY OF CALIFORNIA	METAL CURRENT COLLECT PROTECTED BY OXIDE FILM
WO2003056646	2002	2003	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
WO2003059813	2002	2003	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING STRUCTURES, METHODS OF MAKING, AND PROCESSES USING SAME
WO2003068892	2003	2003	PENN STATE UNIVERSITY	DEEP DESULFURIZATION OF HYDROCARBON FUELS
WO2003083978	2002	2003	UNIVERSITY OF CALIFORNIA	TILTED FUEL CELL APPARATUS
WO2003092046	2003	2003	UNIVERSITY OF CALIFORNIA	PLANAR ELECTROCHEMICAL DEVICE ASSEMBLY
WO2003092106	2003	2003	BATTELLE MEMORIAL INSTITUTE	MULTI-LAYER SEAL FOR ELECTROCHEMICAL DEVICES
WO2003094268	2003	2003	BATTELLE MEMORIAL INSTITUTE	CERIUM-MODIFIED DOPED STRONTIUM TITANATE COMPOSITION FOR SOLID OXIDE FUEL CELL ANODES AND ELECTRODES FOR OTHER ELECTROCHEMICAL DEVICES
WO2003096470	2003	2003	UNIVERSITY OF CALIFORNIA	ELECTROCHEMICAL CELL STACK ASSEMBLY

WO2004001885	2003	2003	DELPHI TECHNOLOGIES, INC.	OXYGEN GETTERS FOR ANODE PROTECTION IN A SOLID-OXIDE FUEL CELL STACK
6673130	2001	2004	UNIVERSITY OF CALIFORNIA	METHOD OF FABRICATION OF ELECTRODES AND ELECTROLYTES
6682842	2000	2004	UNIVERSITY OF CALIFORNIA	COMPOSITE ELECTRODE/ELECTROLYTE STRUCTURE
6689499	2001	2004	SIEMENS WESTINGHOUSE POWER CORPORATION	PRESSURIZED SOLID OXIDE FUEL CELL INTEGRAL AIR ACCUMULAR CONTAINMENT
6713519	2001	2004	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING CATALYSTS, METHODS OF MAKING, AND REACTIONS CATALYZED OVER NANOTUBE CATALYSTS
6740441	2002	2004	UNIVERSITY OF CALIFORNIA	METAL CURRENT COLLECT PROTECTED BY OXIDE FILM
6746515	2002	2004	BATTELLE MEMORIAL INSTITUTE	METHOD AND APPARATUS FOR THERMAL SWING ADSORPTION AND THERMALLY-ENHANCED PRESSURE SWING ADSORPTION
6753036	2001	2004	UNIVERSITY OF CALIFORNIA	METHOD FOR FABRICATION OF ELECTRODES
6767662	2001	2004	UNIVERSITY OF CALIFORNIA	ELECTROCHEMICAL DEVICE AND PROCESS OF MAKING
6803138	2001	2004	NEXTECH MATERIALS, LTD.	CERAMIC ELECTROLYTE COATING METHODS
6811741	2001	2004	UNIVERSITY OF CALIFORNIA	METHOD FOR MAKING THICK AND/OR THIN FILM
6815102	2002	2004	GENERAL ELECTRIC COMPANY	ENERGY MANAGEMENT SYSTEM FOR A ROTARY MACHINE AND METHOD THEREFOR
6815105	2001	2004	UNIVERSITY OF CALIFORNIA	FUEL CELL APPARATUS AND METHOD THEREOF
6815116	2001	2004	UNIVERSITY OF CALIFORNIA	FLEXIBLE INTERCONNECTS FOR FUEL CELL STACKS
6821666	2001	2004	UNIVERSITY OF CALIFORNIA	METHOD OF FORMING A PACKAGE FOR MEMS-BASED FUEL CELL
6824689	2001	2004	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING STRUCTURES, METHODS OF MAKING, AND PROCESSES USING SAME
6824910	2001	2004	UNIVERSITY OF CALIFORNIA	CO-FLOW PLANAR SOFC FUEL CELL STACK
EP1376726	2003	2004	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING A FUEL COMBUSTOR TO PRE-HEAT A

				FUEL REFORMER ON START-UP
EP1378954	2003	2004	DELPHI TECHNOLOGIES, INC.	CO-FLOW ANODE/CATHODE SUPPLY HEAT EXCHANGER FOR A SOLID-OXIDE FUEL CELL ASSEMBLY
EP1383590	2002	2004	BATTELLE MEMORIAL INSTITUTE	METHOD AND APPARATUS FOR THERMAL SWING ADSORPTION AND THERMALLY-ENHANCED PRESSURE SWING ADSORPTION
EP1386366	2002	2004	UNIVERSITY OF CALIFORNIA	FLEXIBLE INTERCONNECTS FOR FUEL CELL STACKS
EP1387427	2003	2004	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING A HEAT EXCHANGER REGULATING THE TEMPERATURE OF THE CATHODE AIR FEED
EP1401042	2003	2004	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING MEANS FOR CONTROLLING TAIL GAS COMBUSTION TEMPERATURE
EP1414557	2002	2004	NEXTECH MATERIALS, LTD.	CERAMIC ELECTROLYTE COATING METHODS
EP1429869	2002	2004	UNIVERSITY OF CALIFORNIA	A METHOD FOR MAKING THICK AND/OR THIN FILM
EP1454371	2002	2004	UNIVERSITY OF CALIFORNIA	METHOD OF FORMING A PACKAGE FOR MEMS-BASED FUEL CELL
EP1455952	2002	2004	UNIVERSITY OF CALIFORNIA	A PROCESS FOR MAKING DENSE THIN FILMS
EP1456895	2002	2004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
EP1456900	2002	2004	UNIVERSITY OF CALIFORNIA	METAL CURRENT COLLECT PROTECTED BY OXIDE FILM
EP1465836	2002	2004	BATTELLE MEMORIAL INSTITUTE	STRUCTURES CONTAINING CARBON NANOTUBES AND A POROUS SUPPORT, METHODS OF MAKING THE SAME, AND RELATED USES
EP1492190	2004	2004	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR GASKETING A FUEL CELL
WO2004004052	2003	2004	UNIVERSITY OF CALIFORNIA	MEMS-BASED FUEL CELLS WITH INTEGRATED CATALYTIC FUEL PROCESSOR AND METHOD THEREOF
WO2004030805	2002	2004	UNIVERSITY OF CALIFORNIA	A CHEMICAL MICROREACTOR AND METHOD THEREOF
WO2004033061	2003	2004	UNIVERSITY OF CALIFORNIA	FLUORINE SEPARATION AND GENERATION DEVICE
WO2004034485	2003	2004	FUELCELL ENERGY, INC.	FLEXIBLE FUEL CELL GAS MANIFOLD SYSTEM
WO2004047207	2003	2004	BATTELLE	COPPER-SUBSTITUTED

			MEMORIAL INSTITUTE	PEROVSKITE COMPOSITIONS FOR SOLID OXIDE FUEL CELL CATHODES AND OXYGEN REDUCTION ELECTROCHEMICAL DEVICES
WO2004097957	2004	2004	NEXTECH MATERIALS, LTD.	PEROVSKITE ELECTRODES AND METHOD OF MAKING THE SAME
WO2004100284	2004	2004	NORTHWESTERN UNIVERSITY	DIRECT HYDROCARBON FUEL CELLS
WO2004114445	2004	2004	ARIZONA STATE UNIVERSITY	IONIC LIQUIDS AND IONIC LIQUID ACIDS WITH HIGH TEMPERATURE STABILITY FOR FUEL CELL AND OTHER HIGH TEMPERATURE APPLICATIONS, METHOD OF MAKING AND CELL EMPLOYING SAME
6841290	2001	2005	SANDIA CORPORATION	FUEL CELL AND MEMBRANE
6846511	2003	2005	UNIVERSITY OF CALIFORNIA	METHOD OF MAKING A LAYERED COMPOSITE ELECTRODE/ELECTROLYTE
6878479	2002	2005	UNIVERSITY OF CALIFORNIA	TILTED FUEL CELL APPARATUS
6884290	2003	2005	MICHIGAN STATE UNIVERSITY	ELECTRICALLY CONDUCTIVE POLYCRYSTALLINE DIAMOND AND PARTICULATE METAL BASED ELECTRODES
6887611	2002	2005	UNASSIGNED	FLEXIBLE FUEL CELL GAS MANIFOLD SYSTEM
6890677	2002	2005	SANDIA CORPORATION	FUEL CELL AND MEMBRANE
6921557	2002	2005	UNIVERSITY OF CALIFORNIA	PROCESS FOR MAKING DENSE THIN FILMS
6921603	2002	2005	UNIVERSITY OF CALIFORNIA	MICROFLUIDIC FUEL CELL SYSTEMS WITH EMBEDDED MATERIALS AND STRUCTURES AND METHOD THEREOF
6936237	2001	2005	BATTELLE MEMORIAL INSTITUTE	REFORMING CATALYSTS AND METHODS OF ALCOHOL STEAM REFORMING
6946213	2003	2005	NEXTECH MATERIALS, LTD.	PEROVSKITE ELECTRODES AND METHOD OF MAKING THE SAME
6949230	2001	2005	ELTRON RESEARCH, INC.	SOLID STATE OXYGEN ANION AND ELECTRON MEDIATING MEMBRANE AND CATALYTIC MEMBRANE REACTORS CONTAINING THEM
6960235	2001	2005	UNIVERSITY OF CALIFORNIA	CHEMICAL MICROREACTOR AND METHOD THEREOF
6960403	2002	2005	UNIVERSITY OF CALIFORNIA	BONDED POLYIMIDE FUEL CELL PACKAGE AND METHOD THEREOF

6967064	2002	2005	DELPHI TECHNOLOGIES, INC.	CO-FLOW ANODE/CATHODE SUPPLY HEAT EXCHANGER FOR A SOLID-OXIDE FUEL CELL ASSEMBLY
6974496	2003	2005	BATTELLE MEMORIAL INSTITUTE	APPARATUS FOR THERMAL SWING ADSORPTION AND THERMALLY-ENHANCED PRESSURE SWING ADSORPTION
EP1500157	2003	2005	BATTELLE MEMORIAL INSTITUTE	MULTI-LAYER SEAL FOR ELECTROCHEMICAL DEVICES
EP1504477	2003	2005	UNIVERSITY OF CALIFORNIA	ELECTROCHEMICAL CELL STACK ASSEMBLY
EP1507302	2004	2005	DELPHI TECHNOLOGIES, INC.	CASCADED FUEL CELL STACKS FOR FAST START-UP AND ANODE COKING CONTROL
EP1520317	2003	2005	UNIVERSITY OF CALIFORNIA	MEMS-BASED FUEL CELLS WITH INTEGRATED CATALYTIC FUEL PROCESSOR AND METHOD THEREOF
EP1531513	2004	2005	SIEMENS POWER GENERATION, INC.	COMBINATION NICKEL FOAM EXPANDED NICKEL SCREEN ELECTRICAL CONNECTION SUPPORTS FOR SOLID OXIDE FUEL CELLS
EP1554767	2003	2005	FUELCELL ENERGY, INC.	FLEXIBLE FUEL CELL GAS MANIFOLD SYSTEM
EP1559163	2003	2005	UNIVERSITY OF CALIFORNIA	FLUORINE SEPARATION AND GENERATION DEVICE
EP1567257	2002	2005	UNIVERSITY OF CALIFORNIA	A CHEMICAL MICROREACTOR AND METHOD THEREOF
EP1571727	2005	2005	DELPHI TECHNOLOGIES, INC.	APPARATUS AND METHOD FOR OPERATION OF A HIGH TEMPERATURE FUEL CELL SYSTEM USING RECYCLED ANODE EXHAUST
WO2005024280	2004	2005	BATTELLE MEMORIAL INSTITUTE	ADVANCED MICA BASED SEAL AND METHOD FOR MAKING AND USING
WO2005029609	2004	2005	UNIVERSITY OF ILLINOIS	ORGANIC FUEL CELLS AND FUEL CELL CONDUCTING SHEETS
WO2005048379	2004	2005	UNIVERSITY OF ILLINOIS	IMPROVED PALLADIUM-BASED ELECTROCATALYSTS AND FUEL CELLS EMPLOYING SUCH ELECTROCATALYSTS
WO2005069768	2004	2005	FUELCELL ENERGY, INC.	MOLTEN CARBONATE FUEL CELL CATHODE WITH MIXED OXIDE COATING
WO2005088759	2005	2005	UNIVERSITY OF ILLINOIS	MICROFLUIDIC ELECTROCHEMICAL REACTORS
WO2005101553	2005	2005	UNIVERSITY OF CALIFORNIA	AEROGEL AND XEROGEL COMPOSITES FOR USE AS

				CARBON ANODES
6984467	2002	2006	SIEMENS WESTINGHOUSE POWER CORPORATION	PLASMA SPRAYED CERIA-CONTAINING INTERLAYER
6994930	2002	2006	UNITED STATES DEPARTMENT OF ENERGY	DIRECT FIRED RECIPROCATING ENGINE AND BOTTOMING HIGH TEMPERATURE FUEL CELL HYBRID
7001682	2002	2006	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING MEANS FOR CONTROLLING TAIL GAS COMBUSTION TEMPERATURE
7008969	2004	2006	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING CATALYSTS, METHODS OF MAKING, AND REACTIONS CATALYZED OVER NANOTUBE CATALYSTS
7011760	2004	2006	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING STRUCTURES, METHODS OF MAKING, AND PROCESSES USING SAME
7056487	2003	2006	SIEMENS POWER GENERATION, INC.	GAS CLEANING SYSTEM AND METHOD
7056611	2002	2006	SIEMENS POWER GENERATION, INC.	SYSTEM FOR CONTROLLING THE OPERATING TEMPERATURE OF A FUEL CELL
7090752	2003	2006	UNIVERSITY OF CALIFORNIA	FLUORINE SEPARATION AND GENERATION DEVICE
7118606	2001	2006	UT-BATTELLE, LLC	FOSSIL FUEL COMBINED CYCLE POWER SYSTEM
7122261	2003	2006	UNIVERSITY OF CALIFORNIA	METAL HYDRIDE FUEL STORAGE AND METHOD THEREOF
7132188	2003	2006	UNIVERSITY OF ILLINOIS	FUEL CELLS AND FUEL CELL CATALYSTS
7144753	2004	2006	MICHIGAN STATE UNIVERSITY	BORON-DOPED NANOCRYSTALLINE DIAMOND
EP1618618	2004	2006	ARIZONA STATE UNIVERSITY	IONIC LIQUIDS AND IONIC LIQUID ACIDS WITH HIGH TEMPERATURE STABILITY FOR FUEL CELL AND OTHER HIGH TEMPERATURE APPLICATIONS, METHOD OF MAKING AND CELL EMPLOYING SAME
EP1632000	2004	2006	NEXTECH MATERIALS, LTD.	PEROVSKITE ELECTRODES AND METHOD OF MAKING THE SAME
EP1659654	2005	2006	SIEMENS POWER GENERATION,	RECUPERATED ATMOSPHERIC SOFC/GAS

			INC.	TURBINE HYBRID CYCLE
EP1677377	2005	2006	DELPHI TECHNOLOGIES, INC.	CERAMIC COATINGS FOR INSULATING MODULAR FUEL CELL CASSETTES IN A SOLID-OXIDE FUEL CELL STACK
EP1677380	2005	2006	DELPHI TECHNOLOGIES, INC.	MODULAR FUEL CELL CASSETTE FOR FORMING A SOLID-OXIDE FUEL CELL STACK
EP1686643	2006	2006	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR THERMAL, MECHANICAL, AND ELECTRICAL OPTIMIZATION OF A SOLID-OXIDE FUEL CELL STACK
EP1730803	2005	2006	UNIVERSITY OF CALIFORNIA	AEROGEL AND XEROGEL COMPOSITES FOR USE AS CARBON ANODES
EP1732157	2006	2006	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR FORMING ELECTRODE INTERCONNECT CONTACTS FOR A SOLID-OXIDE FUEL CELL STACK
EP1733449	2005	2006	UNIVERSITY OF ILLINOIS	MICROFLUIDIC ELECTROCHEMICAL REACTORS
WO2006014190	2005	2006	UNIVERSITY OF CALIFORNIA	COMPACT FUEL CELL
WO2006020572	2005	2006	FUELCELL ENERGY, INC.	MODULAR FUEL-CELL STACK ASSEMBLY
WO2006055262	2005	2006	BATTELLE ENERGY ALLIANCE, LLC	METHOD FOR PRODUCING A BOROHYDRIDE
WO2006062625	2005	2006	FUELCELL ENERGY, INC.	HIGH PERFORMANCE INTERNAL REFORMING UNIT FOR HIGH TEMPERATURE FUEL CELLS
WO2006071360	2005	2006	FUELCELL ENERGY, INC.	MANIFOLD GASKET ACCOMMODATING DIFFERENTIAL MOVEMENT OF FUEL CELL STACK
WO2006071841	2005	2006	FUELCELL ENERGY, INC.	FUEL CELL SYSTEM INCLUDING A UNIT FOR ELECTRICAL ISOLATION OF A FUEL CELL STACK FROM A MANIFOLD ASSEMBLY AND METHOD THEREFOR
WO2006076459	2006	2006	SANDIA CORPORATION	PHOTOCATALYTIC METHODS FOR PREPARATION OF ELECTROCATALYST MATERIALS
WO2006091250	2005	2006	UNIVERSITY OF CALIFORNIA	JOINING OF DISSIMILAR MATERIALS
WO2006099593	2006	2006	UNIVERSITY OF CALIFORNIA	CARBON BASED ELECTROCATALYSTS FOR FUEL CELLS
WO2006127045	2005	2006	UNIVERSITY OF	SEALED JOINT STRUCTURE

			CALIFORNIA	FOR ELECTROCHEMICAL DEVICE
7157165	2003	2007	UCHICAGO ARGONNE, LLC	IRON-BASED PEROVSKITE CATHODES FOR SOLID OXIDE FUEL CELLS
7157172	2003	2007	SIEMENS POWER GENERATION, INC.	COMBINATION NICKEL FOAM EXPANDED NICKEL SCREEN ELECTRICAL CONNECTION SUPPORTS FOR SOLID OXIDE FUEL CELLS
7159841	2003	2007	UNITED STATES DEPARTMENT OF ENERGY	PIEZOELECTRIC AXIAL FLOW MICROVALVE
7163713	2002	2007	UNIVERSITY OF CALIFORNIA	METHOD FOR MAKING DENSE CRACK FREE THIN FILMS
7186352	2004	2007	UNIVERSITY OF CALIFORNIA	MICROFLUIDIC SYSTEMS WITH EMBEDDED MATERIALS AND STRUCTURES AND METHOD THEREOF
7189471	2003	2007	UNIVERSITY OF CALIFORNIA	SOLID OXIDE MEMS-BASED FUEL CELLS
7201985	2003	2007	FUELCELL ENERGY, INC.	INACTIVE END CELL ASSEMBLY FOR FUEL CELLS FOR IMPROVED ELECTROLYTE MANAGEMENT AND ELECTRICAL CONTACT
7217300	2003	2007	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR GASKETING A FUEL CELL
7222406	2002	2007	BATTELLE MEMORIAL INSTITUTE	METHODS FOR MAKING A MULTI-LAYER SEAL FOR ELECTROCHEMICAL DEVICES
7232626	2003	2007	UNIVERSITY OF CALIFORNIA	PLANAR ELECTROCHEMICAL DEVICE ASSEMBLY
7252901	2004	2007	UNIVERSITY OF CALIFORNIA	CONVERSION OF RAW CARBONACEOUS FUELS
7258942	2003	2007	BATTELLE MEMORIAL INSTITUTE	MULTILAYER COMPRESSIVE SEAL FOR SEALING IN HIGH TEMPERATURE DEVICES
7261804	2003	2007	UNIVERSITY OF CALIFORNIA	GRAPHITIZED-CARBON FIBER/CARBON CHAR FUEL
7261833	2004	2007	NEXTECH MATERIALS, LTD.	CERAMIC ELECTROLYTE COATING AND METHODS
7276304	2004	2007	FUELCELL ENERGY, INC.	FUEL CELL SYSTEM INCLUDING A UNIT FOR ELECTRICAL ISOLATION OF A FUEL CELL STACK FROM A MANIFOLD ASSEMBLY AND METHOD THEREFOR
7282282	2003	2007	UNIVERSITY OF ILLINOIS	ORGANIC FUEL CELLS AND FUEL CELL CONDUCTING SHEETS
7288231	2003	2007	BATTELLE MEMORIAL INSTITUTE	CHEMICAL REACTOR AND METHOD FOR GAS PHASE REACTANT CATALYTIC

				REACTIONS
7288576	2005	2007	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING CATALYSTS, METHODS OF MAKING, AND REACTIONS CATALYZED OVER NANOTUBE CATALYSTS
7294427	2004	2007	FUELCELL ENERGY, INC.	MANIFOLD GASKET ACCOMMODATING DIFFERENTIAL MOVEMENT OF FUEL CELL STACK
7306872	2004	2007	DELPHI TECHNOLOGIES, INC.	MODULAR FUEL CELL CASSETTE FOR FORMING A SOLID-OXIDE FUEL CELL STACK
EP1766707	2004	2007	FUELCELL ENERGY, INC.	MOLTEN CARBONATE FUEL CELL CATHODE WITH MIXED OXIDE COATING
EP1770812	2006	2007	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR LIGHT INTERNAL REFORMING IN A SOLID OXIDE FUEL CELL SYSTEM
EP1775790	2006	2007	DELPHI TECHNOLOGIES, INC.	SOFC ASSEMBLY JOINT SPACING
EP1787351	2005	2007	FUELCELL ENERGY, INC.	MODULAR FUEL-CELL STACK ASSEMBLY
EP1801907	2006	2007	DELAVAN INC	FUEL INJECTION AND MIXING SYSTEMS AND METHODS OF USING THE SAME
EP1825541	2005	2007	UNIVERSITY OF CALIFORNIA	SEALED JOINT STRUCTURE FOR ELECTROCHEMICAL DEVICE
EP1829112	2005	2007	UNIVERSITY OF CALIFORNIA	JOINING OF DISSIMILAR MATERIALS
EP1836126	2005	2007	FUELCELL ENERGY, INC.	HIGH PERFORMANCE INTERNAL REFORMING UNIT FOR HIGH TEMPERATURE FUEL CELLS
EP1836739	2005	2007	FUELCELL ENERGY, INC.	MANIFOLD GASKET ACCOMMODATING DIFFERENTIAL MOVEMENT OF FUEL CELL STACK
EP1839355	2005	2007	FUELCELL ENERGY, INC.	FUEL CELL SYSTEM INCLUDING A UNIT FOR ELECTRICAL ISOLATION OF A FUEL CELL STACK FROM A MANIFOLD ASSEMBLY AND METHOD THEREFOR
EP1839744	2007	2007	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	GOLD-BASED CATALYST WITH A POROUS STRUCTURE
EP1845252	2007	2007	DELAVAN INC.	FUEL INJECTION AND MIXING SYSTEMS HAVING PIEZOELECTRIC ELEMENTS

				AND METHODS OF USING THE SAME
WO2007021871	2006	2007	FUELCELL ENERGY, INC.	CONTROL ASSEMBLY FOR CONTROLLING A FUEL CELL SYSTEM DURING SHUTDOWN AND RESTART
WO2007050577	2006	2007	UNIVERSITY OF ILLINOIS	FUEL-CELL BASED POWER GENERATING SYSTEM HAVING POWER CONDITIONING APPARATUS
WO2007067242	2006	2007	SIEMENS POWER GENERATION, INC.	STEPPED GRADIENT FUEL ELECTRODE AND METHOD FOR MAKING THE SAME
WO2007087218	2007	2007	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	OXIDATION CATALYST
WO2007117276	2006	2007	CERAMATEC, INC.	PROCESS FOR MAKING CERAMIC INSULATION
WO2007139583	2006	2007	SIEMENS POWER GENERATION, INC.	ANODE GAS STACK START-UP HEATER AND PURGE GAS GENERATOR
7320838	2003	2008	FUELCELL ENERGY, INC.	ELECTROLYTE CREEPAGE BARRIER FOR LIQUID ELECTROLYTE FUEL CELLS
7323270	2004	2008	FUELCELL ENERGY, INC.	MODULAR FUEL-CELL STACK ASSEMBLY
7326482	2004	2008	DELPHI TECHNOLOGIES, INC.	APPARATUS AND METHOD FOR OPERATION OF A HIGH TEMPERATURE FUEL CELL SYSTEM USING RECYCLED ANODE EXHAUST
7338734	2002	2008	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
7351491	2003	2008	BATTELLE MEMORIAL INSTITUTE	SUPPORTING ELECTRODES FOR SOLID OXIDE FUEL CELLS AND OTHER ELECTROCHEMICAL DEVICES
7361424	2003	2008	UNIVERSITY OF CALIFORNIA	SOLID POLYMER MEMS-BASED FUEL CELLS
7410016	2002	2008	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING A FUEL COMBUSTOR TO PRE-HEAT REFORMER ON START-UP
7410718	2004	2008	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	AEROGEL AND XEROGEL COMPOSITES FOR USE AS CARBON ANODES
7420027	2004	2008	BATTELLE ENERGY ALLIANCE, LLC	METHOD FOR PRODUCING A BOROHYDRIDE
7422812	2002	2008	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING A THERMALLY-REGULATED CATHODE AIR HEAT EXCHANGER

7422819	2005	2008	DELPHI TECHNOLOGIES, INC.	CERAMIC COATINGS FOR INSULATING MODULAR FUEL CELL CASSETTES IN A SOLID-OXIDE FUEL CELL STACK
7431746	2004	2008	FUELCELL ENERGY, INC.	HIGH PERFORMANCE INTERNAL REFORMING UNIT FOR HIGH TEMPERATURE FUEL CELLS
7435490	2006	2008	DELPHI TECHNOLOGIES, INC.	OXYGEN GETTERS FOR ANODE PROTECTION IN A SOLID-OXIDE FUEL CELL STACK
7438733	2006	2008	UT-BATTELLE, LLC	FOSSIL FUEL COMBINED CYCLE POWER GENERATION METHOD
7438987	2004	2008	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CARBON FUEL PARTICLES USED IN DIRECT CARBON CONVERSION FUEL CELLS
7459223	2005	2008	MICHIGAN STATE UNIVERSITY	ELECTROCHEMICAL METHODS FOR GENERATION OF A BIOLOGICAL PROTON MOTIVE FORCE AND PYRIDINE NUCLEOTIDE COFACTOR REGENERATION
7468120	2005	2008	UNIVERSITY OF CALIFORNIA	FLUORINE SEPARATION AND GENERATION DEVICE
7468218	2004	2008	BATTELLE MEMORIAL INSTITUTE	COMPOSITE SOLID OXIDE FUEL CELL ANODE BASED ON CERIA AND STRONTIUM TITANATE
7470477	2003	2008	DELPHI TECHNOLOGIES, INC.	CASCADED FUEL CELL STACKS FOR FAST START-UP AND ANODE COKING CONTROL
EP1920487	2006	2008	FUELCELL ENERGY, INC.	CONTROL ASSEMBLY FOR CONTROLLING A FUEL CELL SYSTEM DURING SHUTDOWN AND RESTART
EP1948411	2006	2008	CERAMATEC, INC.	PROCESS FOR MAKING CERAMIC INSULATION
EP1951638	2006	2008	UNIVERSITY OF HOUSTON	NOVEL CATHODE AND ELECTROLYTE MATERIALS FOR SOLID OXIDE FUEL CELLS AND ION TRANSPORT MEMBRANES
EP1964195	2006	2008	SIEMENS ENERGY, INC.	METHOD FOR DEPOSITING A STEPPED-GRADIENT FUEL ELECTRODE ONTO A FUEL CELL SUPPORT
WO2008016345	2006	2008	UNIVERSITY OF CALIFORNIA	JOINED CONCENTRIC TUBES
WO2008039260	2007	2008	DELPHI TECHNOLOGIES, INC.	MODULAR FUEL CELL CASSETTE SPACERS FOR FORMING A SOLID-OXIDE FUEL CELL STACK

WO2008048225	2006	2008	UNIVERSITY OF HOUSTON	NOVEL CATHODE AND ELECTROLYTE MATERIALS FOR SOLID OXIDE FUEL CELLS AND ION TRANSPORT MEMBRANES
WO2008082693	2007	2008	BATTELLE MEMORIAL INSTITUTE	BIOMOLECULAR HYBRID MATERIAL AND PROCESS FOR PREPARING SAME AND USES FOR SAME
WO2008109652	2008	2008	ATI PROPERTIES, INC.	METHOD FOR REDUCING FORMATION OF ELECTRICALLY RESISTIVE LAYER ON FERRITIC STAINLESS STEELS
7485386	2004	2009	SIEMENS ENERGY, INC.	FLEXIBLE CERAMIC GASKET FOR SOFC GENERATOR
7518886	2005	2009	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	MULTIPHASE SOFT SWITCHED DC/DC CONVERTER AND ACTIVE CONTROL TECHNIQUE FOR FUEL CELL RIPPLE CURRENT ELIMINATION
7527659	2006	2009	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METAL HYDRIDE FUEL STORAGE AND METHOD THEREOF
7534296	2006	2009	MICHIGAN STATE UNIVERSITY	ELECTRICALLY CONDUCTIVE DIAMOND ELECTRODES
7534402	2005	2009	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METHOD FOR FORMING A CHEMICAL MICROREACTOR
7553517	2005	2009	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF APPLYING A CERIUM DIFFUSION COATING TO A METALLIC ALLOY
7553573	2005	2009	UNIVERSITY OF CALIFORNIA	SOLID STATE ELECTROCHEMICAL COMPOSITE
7569297	2005	2009	UNIVERSITY OF ILLINOIS	FUEL CELL MEMBRANES AND CROSSOVER PREVENTION
7582375	2005	2009	DELPHI TECHNOLOGIES, INC.	METHOD FOR CUTTING SOLID OXIDE FUEL CELL ELEMENTS
7592090	2005	2009	NEXTECH MATERIALS, LTD.	PEROVSKITE ELECTRODES AND METHOD OF MAKING THE SAME
7595085	2004	2009	DELPHI TECHNOLOGIES, INC.	CERAMIC ASSEMBLY WITH A STABILIZER LAYER
7597986	2007	2009	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR GASKETING A FUEL CELL
7601450	2005	2009	DELPHI TECHNOLOGIES, INC.	HYBRID INTERCONNECT FOR A SOLID-OXIDE FUEL CELL STACK
7611835	2005	2009	BATTELLE	PROCESS FOR PREPARING

			MEMORIAL INSTITUTE	MULTILAYER ENZYME COATING ON A FIBER
7611878	2005	2009	BATTELLE MEMORIAL INSTITUTE	BIOCATALYTIC MATERIAL COMPRISING MULTILAYER ENZYME COATED FIBER
7615299	2005	2009	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR THERMAL, MECHANICAL, AND ELECTRICAL OPTIMIZATION OF A SOLID-OXIDE FUEL CELL STACK
7618725	2005	2009	UNIVERSITY OF ILLINOIS	LOW CONTAMINANT FORMIC ACID FUEL FOR DIRECT LIQUID FUEL CELL
7628951	2006	2009	CERAMATEC, INC.	PROCESS FOR MAKING CERAMIC INSULATION
7637967	2005	2009	SIEMENS ENERGY, INC.	STEPPED GRADIENT FUEL ELECTRODE AND METHOD FOR MAKING THE SAME
EP2019443	2008	2009	DELPHI TECHNOLOGIES, INC.	SOLID BONDED INTERCONNECT SYSTEM IN A SOLID OXIDE FUEL CELL STACK
EP2027624	2006	2009	SIEMENS ENERGY, INC.	ANODE GAS STACK START-UP HEATER AND PURGE GAS GENERATOR
EP2041279	2007	2009	BATTELLE MEMORIAL INSTITUTE	BIOMOLECULAR HYBRID MATERIAL AND PROCESS FOR PREPARING SAME AND USES FOR SAME
EP2056985	2006	2009	UNIVERSITY OF CALIFORNIA	JOINED CONCENTRIC TUBES
EP2074671	2007	2009	DELPHI TECHNOLOGIES, INC.	MODULAR FUEL CELL CASSETTE SPACERS FOR FORMING A SOLID-OXIDE FUEL CELL STACK
EP2107629	2009	2009	DELPHI TECHNOLOGIES, INC.	FLEXIBLE, HIGH-EFFICIENCY FUEL REFORMING IN A SOLID OXIDE FUEL CELL SYSTEM
EP2109174	2009	2009	DELPHI TECHNOLOGIES, INC.	APPARATUS FOR SOLID-OXIDE FUEL CELL SHUTDOWN
EP2134878	2008	2009	ATI PROPERTIES, INC.	METHOD FOR REDUCING FORMATION OF ELECTRICALLY RESISTIVE LAYER ON FERRITIC STAINLESS STEELS
WO2008154535	2008	2009	BATTELLE MEMORIAL INSTITUTE	DIFFUSION BARRIERS IN MODIFIED AIR BRAZES
WO2009009214	2008	2009	UNIVERSITY OF SOUTHERN CALIFORNIA	MICROBIAL FUEL CELLS
WO2009011753	2008	2009	UNIVERSITY OF CALIFORNIA	NANOSTRUCTURED POLYMER MEMBRANES FOR PROTON CONDUCTION
WO2009040516	2008	2009	INTELLIGENT	FUEL CELL SYSTEM

			ENERGY, INC.	
WO2009043818	2008	2009	SIEMENS AKTIENGESELLSCHAFT	AID FOR ELECTRICAL CONTACTING OF HIGH-TEMPERATURE FUEL CELLS AND METHOD FOR PRODUCTION THEREOF
WO2009048663	2008	2009	UNIVERSITY OF MINNESOTA	NANO-STRUCTURED POLYMER COMPOSITES AND PROCESS FOR PREPARING SAME
WO2009076644	2008	2009	UNIVERSITY OF FLORIDA	ELECTRIC-FIELD ENHANCED PERFORMANCE IN CATALYSIS AND SOLID-STATE DEVICES INVOLVING GASES
WO2009094289	2009	2009	BATTELLE MEMORIAL INSTITUTE	A NOVEL APPROACH FOR IMPROVED STABILITY AND PERFORMANCE OF SOFC METALLIC INTERCONNECTS
WO2009128849	2008	2009	UNIVERSITY OF CALIFORNIA	INTEGRATED SEAL FOR HIGH-TEMPERATURE ELECTROCHEMICAL DEVICE
WO2009131942	2009	2009	BATTELLE MEMORIAL INSTITUTE	SULFUR-TOLERANT CATALYST SYSTEMS
WO2009134297	2009	2009	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF SYNTHESIS OF PROTON CONDUCTING MATERIALS
WO2009136992	2009	2009	SIEMENS ENERGY, INC.	FUEL CELL GENERATOR WITH FUEL ELECTRODES THAT CONTROL ON-CELL FUEL REFORMATION
7641997	2004	2010	UT-BATTELLE, LLC	DESIGN AND SYNTHESIS OF GUEST-HOST NANOSTRUCTURES TO ENHANCE IONIC CONDUCTIVITY ACROSS NANOCOMPOSITE MEMBRANES
7645532	2004	2010	DELPHI TECHNOLOGIES, INC.	SOLID-OXIDE FUEL CELL SYSTEM HAVING AN UPSTREAM REFORMATE COMBUSTOR
7670475	2008	2010	UNIVERSITY OF CALIFORNIA	FLUORINE SEPARATION AND GENERATION DEVICE
7670711	2003	2010	BATTELLE MEMORIAL INSTITUTE	CERIUM-MODIFIED DOPED STRONTIUM TITANATE COMPOSITIONS FOR SOLID OXIDE FUEL CELL ANODES AND ELECTRODES FOR OTHER ELECTROCHEMICAL DEVICES
7691488	2007	2010	BATTELLE MEMORIAL INSTITUTE	DIFFUSION BARRIERS IN MODIFIED AIR BRAZES
7695834	2008	2010	UT-BATTELLE,	MICROBIAL FUEL CELL WITH

			LLC	IMPROVED ANODE
7700215	2006	2010	DELPHI TECHNOLOGIES, INC.	CLAD CURRENT CARRIER FOR A SOLID OXIDE FUEL CELL STACK
7709118	2004	2010	SIEMENS ENERGY, INC.	RECUPERATED ATMOSPHERIC SOFC/GAS TURBINE HYBRID CYCLE
7709124	2003	2010	NORTHWESTERN UNIVERSITY	DIRECT HYDROCARBON FUEL CELLS
7732080	2005	2010	UCHICAGO ARGONNE, LLC	CATALYTIC MEMBRANES FOR CO OXIDATION IN FUEL CELLS
7732086	2005	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	BONDED POLYIMIDE FUEL CELL PACKAGE
7736547	2008	2010	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD OF SYNTHESIS OF PROTON CONDUCTING MATERIALS
7736777	2005	2010	FUELCELL ENERGY, INC.	CONTROL ASSEMBLY FOR CONTROLLING A FUEL CELL SYSTEM DURING SHUTDOWN AND RESTART
7740966	2006	2010	UNIVERSITY OF CALIFORNIA	ELECTROCHEMICAL CELL STACK ASSEMBLY
7740974	2004	2010	UNIVERSITY OF ILLINOIS	FORMIC ACID FUEL CELLS AND CATALYSTS
7741428	2008	2010	BATTELLE ENERGY ALLIANCE, LLC	METHOD FOR PRODUCING A BOROHYDRIDE
7744830	2005	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CATALYST FOR MICROELECTROMECHANICAL SYSTEMS MICROREACTORS
7754367	2007	2010	DELPHI TECHNOLOGIES, INC.	SOLID BONDED INTERCONNECT SYSTEM IN A LIGHTWEIGHT SOLID OXIDE FUEL CELL STACK
7754393	2008	2010	FUELCELL ENERGY, INC.	MODULAR FUEL-CELL STACK ASSEMBLY
7758989	2006	2010	DELPHI TECHNOLOGIES, INC.	MODULAR FUEL CELL CASSETTE SPACERS FOR FORMING A SOLID-OXIDE FUEL CELL STACK
7758992	2003	2010	BATTELLE MEMORIAL INSTITUTE	COPPER-SUBSTITUTED PEROVSKITE COMPOSITIONS FOR SOLID OXIDE FUEL CELL CATHODES AND OXYGEN REDUCTION ELECTRODES IN OTHER ELECTROCHEMICAL DEVICES
7763702	2007	2010	PENN STATE UNIVERSITY	SYNTHESIS OF POLYPHOSPHAZENES WITH SULFONIMIDE SIDE GROUPS
7766251	2005	2010	DELAVAN INC	FUEL INJECTION AND MIXING SYSTEMS AND METHODS OF

				USING THE SAME
7771884	2006	2010	DELPHI TECHNOLOGIES, INC.	SOLID OXIDE FUEL CELL STACK HAVING AN INTEGRAL GAS DISTRIBUTION MANIFOLD
7771887	2009	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METAL HYDRIDE FUEL STORAGE AND METHOD THEREOF
7776479	2005	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	MICRO-ELECTRO-MECHANICAL SYSTEMS PHOSPHORIC ACID FUEL CELL
7781115	2010	2010	SIEMENS ENERGY, INC.	RECUPERATED ATMOSPHERE SOFC/GAS TURBINE HYBRID CYCLE
7781123	2005	2010	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR FORMING ELECTRODE INTERCONNECT CONTACTS FOR A SOLID-OXIDE FUEL CELL STACK
7785728	2004	2010	UNIVERSITY OF ILLINOIS	PALLADIUM-BASED ELECTROCATALYSTS AND FUEL CELLS EMPLOYING SUCH ELECTROCATALYSTS
7794894	2007	2010	BATTELLE MEMORIAL INSTITUTE	MULTI-LAYER SEAL FOR ELECTROCHEMICAL DEVICES
7808129	2006	2010	UNIVERSITY OF ILLINOIS	FUEL-CELL BASED POWER GENERATING SYSTEM HAVING POWER CONDITIONING APPARATUS
7811711	2008	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	AEROGEL AND XEROGEL COMPOSITES FOR USE AS CARBON ANODES
7816055	2005	2010	UNIVERSITY OF CALIFORNIA	COMPACT FUEL CELL
7816482	2009	2010	SANDIA CORPORATION	EPOXY-CROSSLINKED SULFONATED POLY (PHENYLENE) COPOLYMER PROTON EXCHANGE MEMBRANES
7829035	2006	2010	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	OXIDATION CATALYST
7829213	2007	2010	UNIVERSITY OF CALIFORNIA	PLANAR ELECTROCHEMICAL DEVICE ASSEMBLY
7832737	2005	2010	BATTELLE MEMORIAL INSTITUTE	MULTI-LAYER SEAL FOR ELECTROCHEMICAL DEVICES
7833674	2009	2010	DELPHI TECHNOLOGIES, INC.	METHOD FOR IMPROVING ROBUSTNESS OF SOLID OXIDE FUEL CELL STACKS
7838141	2009	2010	BATTELLE MEMORIAL	CERIUM-MODIFIED DOPED STRONTIUM TITANATE

			INSTITUTE	COMPOSITIONS FOR SOLID OXIDE FUEL CELL ANODES AND ELECTRODES FOR OTHER ELECTROCHEMICAL DEVICES
7838273	2008	2010	BATTELLE MEMORIAL INSTITUTE	BIOMOLECULAR HYBRID MATERIAL AND PROCESS FOR PREPARING SAME AND USES FOR SAME
7842634	2006	2010	UMICORE AG & CO. KG	BLENDED CATALYST WITH IMPROVED PERFORMANCE
7855018	2010	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	MICRO-ELECTRO-MECHANICAL SYSTEMS PHOSPHORIC ACID FUEL CELL
7855030	2009	2010	DELPHI TECHNOLOGIES, INC.	INHIBITOR FOR PREVENTION OF BRAZE MIGRATION IN SOLID OXIDE FUEL CELLS
7858214	2005	2010	DELPHI TECHNOLOGIES, INC.	METHOD AND APPARATUS FOR LIGHT INTERNAL REFORMING IN A SOLID OXIDE FUEL CELL SYSTEM
7858243	2008	2010	UNIVERSITY OF WYOMING	INFLUENTIAL FUEL CELL SYSTEMS INCLUDING EFFECTIVE CATHODES AND USE WITH REMEDIATION EFFORTS
EP2155627	2008	2010	BATTELLE MEMORIAL INSTITUTE	DIFFUSION BARRIERS IN MODIFIED AIR BRAZES
EP2156501	2008	2010	UNIVERSITY OF SOUTHERN CALIFORNIA	MICROBIAL FUEL CELLS
EP2158962	2009	2010	DELPHI TECHNOLOGIES, INC.	METHOD FOR FORMING A FUEL CELL REFORMER
EP2166601	2009	2010	DELPHI TECHNOLOGIES, INC.	LOW-TEMPERATURE BONDING OF REFRACTORY CERAMIC LAYERS
EP2173799	2008	2010	UNIVERSITY OF MINNESOTA	NANO-STRUCTURED POLYMER COMPOSITES AND PROCESS FOR PREPARING SAME
EP2193566	2008	2010	SIEMENS ENERGY, INC.	AID FOR ELECTRICAL CONTACTING OF HIGH-TEMPERATURE FUEL CELLS AND METHOD FOR PRODUCTION THEREOF
EP2206185	2008	2010	INTELLIGENT ENERGY, INC.	FUEL CELL SYSTEM
EP2240976	2008	2010	UNIVERSITY OF FLORIDA	ELECTRIC-FIELD ENHANCED PERFORMANCE IN SOLID ELECTROLYTE DEVICES INVOLVING GASES
EP2246925	2010	2010	DELPHI TECHNOLOGIES,	INHIBITOR FOR PREVENTION OF BRAZE MIGRATION IN

			INC.	SOLID OXIDE FUEL CELLS
WO2010005781	2009	2010	SIEMENS ENERGY, INC.	SOLID OXIDE FUEL CELL WITH TRANSITIONED CROSS-SECTION FOR IMPROVED ANODE GAS MANAGEMENT AT THE OPEN END
WO2010017540	2009	2010	UNIVERSITY OF MASSACHUSETTS	GEOBACTER STRAINS THAT USE ALTERNATE ORGANIC COMPOUNDS, METHODS OF MAKING, AND METHODS OF USE THEREOF
WO2010039434	2009	2010	BATTELLE MEMORIAL INSTITUTE	CASSETTES FOR SOLID-OXIDE FUEL CELL STACKS AND METHODS OF MAKING THE SAME
WO2010039436	2009	2010	BATTELLE MEMORIAL INSTITUTE	OPTIMIZED CELL CONFIGURATIONS FOR STABLE LSCF-BASED SOLID OXIDE FUEL CELLS
WO2010044983	2009	2010	UT-BATTELLE, LLC	MICROBIAL FUEL CELL WITH IMPROVED ANODE
WO2010045329	2009	2010	UNIVERSITY OF FLORIDA	ADVANCED MATERIALS AND DESIGN FOR LOW TEMPERATURE SOFCS
WO2010051441	2009	2010	GEORGIA TECH RESEARCH CORPORATION	CHEMICAL COMPOSITIONS, METHODS OF MAKING THE CHEMICAL COMPOSITIONS, AND STRUCTURES MADE FROM THE CHEMICAL COMPOSITIONS
WO2010071820	2009	2010	BATTELLE MEMORIAL INSTITUTE	CASSETTE LESS SOFC STACK AND METHOD OF ASSEMBLY
WO2010135509	2010	2010	BATTELLE MEMORIAL INSTITUTE	IMMOBILIZED FLUID MEMBRANES FOR GAS SEPARATION
WO2010135576	2010	2010	CORNELL RESEARCH FOUNDATION, INC.	CONDUCTING METAL OXIDE AND METAL NITRIDE NANOPARTICLES
WO2010138958	2010	2010	CORNELL RESEARCH FOUNDATION, INC.	IONOMERS AND METHODS OF MAKING SAME AND USES THEREOF
WO2010151502	2010	2010	SIEMENS ENERGY, INC.	TUBULAR SOLID OXIDE FUEL CELLS WITH POROUS METAL SUPPORTS AND CERAMIC INTERCONNECTIONS
7867658	2004	2011	ARIZONA STATE UNIVERSITY	IONIC LIQUIDS AND IONIC LIQUID ACIDS WITH HIGH TEMPERATURE STABILITY FOR FUEL CELL AND OTHER HIGH TEMPERATURE APPLICATIONS, METHOD OF MAKING AND CELL EMPLOYING SAME

7875101	2008	2011	SANDIA CORPORATION	HYBRID MEMBRANE—PSA SYSTEM FOR SEPARATING OXYGEN FROM AIR
7879754	2008	2011	BATTELLE MEMORIAL INSTITUTE	SULFUR-TOLERANT CATALYST SYSTEMS
7901820	2008	2011	DELPHI TECHNOLOGIES, INC.	SOLID OXIDE FUEL CELL STACK ASSEMBLY AND METHOD FOR FUELING
7901837	2006	2011	UNIVERSITY OF CALIFORNIA	STRUCTURES FOR DENSE, CRACK FREE THIN FILMS
7909971	2005	2011	UNIVERSITY OF ILLINOIS	MICROFLUIDIC ELECTROCHEMICAL REACTORS
7914946	2004	2011	FUELCELL ENERGY, INC.	CATHODE SIDE HARDWARE FOR CARBONATE FUEL CELLS
7919214	2005	2011	FUELCELL ENERGY, INC.	CATHODE SIDE HARDWARE FOR CARBONATE FUEL CELLS
7931707	2005	2011	DELPHI TECHNOLOGIES, INC.	REGENERABLE METHOD AND SYSTEM FOR DESULFURIZING REFORMATE
7931993	2005	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METHOD OF PREPARATION OF BONDED POLYIMIDE FUEL CELL PACKAGE
7943269	2009	2011	UNIVERSITY OF ROCHESTER	ION-/PROTON-CONDUCTING APPARATUS AND METHOD
7951500	2006	2011	SIEMENS ENERGY, INC.	ANODE GAS STACK START-UP HEATER AND PURGE GAS GENERATOR
7964324	2009	2011	DELPHI TECHNOLOGIES, INC.	METHOD FOR IMPREGNATING A SOLID OXIDE FUEL CELL CATHODE WITH SILVER TO REDUCE ELECTRICAL RESISTANCE
7976787	2008	2011	DELPHI TECHNOLOGIES, INC.	FUEL CELL REFORMER
7993534	2009	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CHEMICAL MICROREACTOR AND METHOD THEREOF
7993785	2003	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	MEMS-BASED FUEL CELLS WITH INTEGRATED CATALYTIC FUEL PROCESSOR AND METHOD THEREOF
7994089	2008	2011	UNIVERSITY OF HOUSTON	DE-ALLOYED PLATINUM NANOPARTICLES
7998627	2008	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CARBON FUEL PARTICLES USED IN DIRECT CARBON CONVERSION FUEL CELLS
8038763	2006	2011	UNIVERSITY OF MARYLAND	AU-PT HETEROAGGREGATE DENDRITIC NANOSTRUCTURES AND AU-PT ALLOY NANOPARTICLES

				AND THEIR USE AS CATALYSTS
8043752	2008	2011	SIEMENS ENERGY, INC.	FUEL CELL GENERATOR WITH FUEL ELECTRODES THAT CONTROL ON-CELL FUEL REFORMATION
8053128	2008	2011	DELPHI TECHNOLOGIES, INC.	APPARATUS FOR SOLID-OXIDE FUEL CELL SHUTDOWN HAVING A TIMING CIRCUIT AND A RESERVOIR
8057988	2010	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CATALYST FOR MICROELECTROMECHANICAL SYSTEMS MICROREACTORS
8074895	2007	2011	DELAVAN INC	FUEL INJECTION AND MIXING SYSTEMS HAVING PIEZOELECTRIC ELEMENTS AND METHODS OF USING THE SAME
EP2276564	2009	2011	BATTELLE MEMORIAL INSTITUTE	SULFUR-TOLERANT CATALYST SYSTEMS
EP2277228	2008	2011	UNIVERSITY OF CALIFORNIA	INTEGRATED SEAL FOR HIGH-TEMPERATURE ELECTROCHEMICAL DEVICE
EP2278643	2002	2011	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
EP2295376	2002	2011	BATTELLE MEMORIAL INSTITUTE	CARBON NANOTUBE-CONTAINING STRUCTURES, METHODS OF MAKING, AND PROCESSES USING SAME
EP2309574	2010	2011	DELPHI TECHNOLOGIES, INC.	METHOD FOR IMPROVING ROBUSTNESS OF SOLID OXIDE FUEL CELL STACKS
EP2319118	2009	2011	SIEMENS ENERGY, INC.	SOLID OXIDE FUEL CELL WITH TRANSITIONED CROSS-SECTION FOR IMPROVED ANODE GAS MANAGEMENT AT THE OPEN END
EP2329550	2009	2011	BATTELLE MEMORIAL INSTITUTE	OPTIMIZED CELL CONFIGURATIONS FOR STABLE LSCF-BASED SOLID OXIDE FUEL CELLS
EP2329554	2009	2011	BATTELLE MEMORIAL INSTITUTE	CASSETTES FOR SOLID-OXIDE FUEL CELL STACKS AND METHODS OF MAKING THE SAME
EP2333882	2010	2011	DELPHI TECHNOLOGIES, INC.	PEROVSKITE MATERIALS FOR SOLID OXIDE FUEL CELL CATHODES
EP2338201	2009	2011	UNIVERSITY OF FLORIDA	ADVANCED MATERIALS AND DESIGN FOR LOW TEMPERATURE SOFCS
EP2368287	2009	2011	BATTELLE	CASSETTE LESS SOFC STACK

			MEMORIAL INSTITUTE	AND METHOD OF ASSEMBLY
EP2390950	2011	2011	DELPHI TECHNOLOGIES, INC.	MULTIPLE STACK FUEL CELL SYSTEM
WO2011038233	2010	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	HIGH-PERFORMANCE RECHARGEABLE BATTERIES WITH FAST SOLID-STATE ION CONDUCTORS
WO2011079377	2010	2011	ANGSTROM POWER INCORPORATED	FUEL CELLS AND FUEL CELL COMPONENTS HAVING ASYMMETRIC ARCHITECTURE AND METHODS THEREOF
WO2011087821	2010	2011	UNIVERSITY OF MASSACHUSETTS	MICROBIAL PRODUCTION OF MULTI-CARBON CHEMICALS AND FUELS FROM WATER AND CARBON DIOXIDE USING ELECTRIC CURRENT
WO2011109020	2010	2011	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	ELECTROCHEMICAL NITRIDATION OF METAL SURFACES
WO2011119243	2011	2011	BATTELLE MEMORIAL INSTITUTE	GLASS COMPOSITION AND PROCESS FOR SEALING VOID SPACES IN ELECTROCHEMICAL DEVICES
WO2011143368	2011	2011	ARIZONA STATE UNIVERSITY	METAL-AIR CELL WITH PERFORMANCE ENHANCING ADDITIVE
8097384	2008	2012	SIEMENS ENERGY, INC.	SOLID OXIDE FUEL CELL WITH TRANSITIONED CROSS-SECTION FOR IMPROVED ANODE GAS MANAGEMENT AT THE OPEN END
8101305	2011	2012	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CARBON FUEL PARTICLES USED IN DIRECT CARBON CONVERSION FUEL CELLS
8110948	2009	2012	UT-BATTELLE, LLC	POWER CONVERSION APPARATUS AND METHOD
8124037	2009	2012	DELPHI TECHNOLOGIES, INC.	PEROVSKITE MATERIALS FOR SOLID OXIDE FUEL CELL CATHODES
8129054	2011	2012	DELPHI TECHNOLOGIES, INC.	SYSTEM FOR ADDING SULFUR TO A FUEL CELL STACK SYSTEM FOR IMPROVED FUEL CELL STABILITY
8129072	2011	2012	UNIVERSITY OF ROCHESTER	ION-CONDUCTING CERAMIC APPARATUS, METHOD, FABRICATION, AND APPLICATIONS
8148013	2007	2012	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
8153328	2007	2012	LAWRENCE LIVERMORE	CARBON FUEL CELLS WITH CARBON CORROSION

			NATIONAL SECURITY, LLC	SUPPRESSION
8158843	2003	2012	PENN STATE UNIVERSITY	DEEP DESULFURIZATION OF HYDROCARBON FUELS
8163353	2008	2012	SIEMENS ENERGY, INC.	FABRICATION OF COPPER-BASED ANODES VIA ATMOSPHORIC PLASMA SPRAYING TECHNIQUES
8163433	2009	2012	SIEMENS ENERGY, INC.	FUEL CELL INTEGRAL BUNDLE ASSEMBLY INCLUDING CERAMIC OPEN END SEAL AND VERTICAL AND HORIZONTAL THERMAL EXPANSION CONTROL
8166777	2010	2012	BATTELLE MEMORIAL INSTITUTE	GLASS COMPOSITION AND PROCESS FOR SEALING VOID SPACES IN ELECTROCHEMICAL DEVICES
8168347	2005	2012	DELPHI TECHNOLOGIES, INC.	SOFC ASSEMBLY JOINT SPACING
8173322	2009	2012	SIEMENS ENERGY, INC.	TUBULAR SOLID OXIDE FUEL CELLS WITH POROUS METAL SUPPORTS AND CERAMIC INTERCONNECTIONS
8182965	2008	2012	BATTELLE MEMORIAL INSTITUTE	OPTIMIZED CELL CONFIGURATIONS FOR STABLE LSCF-BASED SOLID OXIDE FUEL CELLS
8192854	2009	2012	UT-BATTELLE, LLC	MICROBIAL FUEL CELL TREATMENT OF ETHANOL FERMENTATION PROCESS WATER
8193761	2007	2012	HONEYWELL INTERNATIONAL INC.	HYBRID POWER SOURCE
8197982	2011	2012	DELPHI TECHNOLOGIES, INC.	FUEL CELL WITH INTERNAL FLOW CONTROL
8211587	2003	2012	SIEMENS ENERGY, INC.	PLASMA SPRAYED CERAMIC-METAL FUEL ELECTRODE
8241817	2009	2012	BATTELLE MEMORIAL INSTITUTE	APPROACH FOR IMPROVED STABILITY AND PERFORMANCE OF SOFC METALLIC INTERCONNECTS
8247135	2005	2012	CASE WESTERN RESERVE UNIVERSITY	LIGHT-WEIGHT, FLEXIBLE EDGE COLLECTED FUEL CELLS
8247136	2006	2012	UNIVERSITY OF CALIFORNIA	CARBON BASED ELECTROCATALYSTS FOR FUEL CELLS
8283078	2011	2012	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CARBON FUEL PARTICLES USED IN DIRECT CARBON CONVERSION FUEL CELLS
8287673	2005	2012	UNIVERSITY OF	JOINING OF DISSIMILAR

			CALIFORNIA	MATERIALS
8293426	2008	2012	BATTELLE MEMORIAL INSTITUTE	CASSETTES FOR SOLID-OXIDE FUEL CELL STACKS AND METHODS OF MAKING THE SAME
8310235	2007	2012	UNITED STATES DEPARTMENT OF ENERGY	NMR APPARATUS FOR IN SITU ANALYSIS OF FUEL CELLS
EP2446493	2010	2012	SIEMENS ENERGY, INC.	TUBULAR SOLID OXIDE FUEL CELLS WITH POROUS METAL SUPPORTS AND CERAMIC INTERCONNECTIONS
EP2472658	2011	2012	DELPHI TECHNOLOGIES, INC.	A SOLID OXIDE FUEL CELL HAVING A GLASS COMPOSITE SEAL
EP2506356	2012	2012	DELPHI TECHNOLOGIES, INC.	SYSTEM FOR ADDING SULFUR TO A FUEL CELL STACK SYSTEM FOR IMPROVED FUEL CELL STABILITY
EP2519988	2010	2012	SOCIETE BIC	FUEL CELLS AND FUEL CELL COMPONENTS HAVING ASYMMETRIC ARCHITECTURE AND METHODS THEREOF
WO2012047869	2011	2012	NORTHERN ILLINOIS UNIVERSITY	SENSORS AND DEVICES CONTAINING ULTRA-SMALL NANOWIRE ARRAYS
WO2012083233	2011	2012	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
WO2012093991	2011	2012	UTC POWER CORPORATION	THERMAL ENERGY RECYCLING FUEL CELL ARRANGEMENT
WO2012106564	2012	2012	UNIVERSITY OF DELAWARE	DEVICES, SYSTEMS, AND METHODS FOR VARIABLE FLOW RATE FUEL EJECTION
WO2012142537	2012	2012	NEXTECH MATERIALS, LTD.	PROTECTIVE COATINGS FOR METAL ALLOYS AND METHODS INCORPORATING THE SAME
WO2012173990	2012	2012	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	FUEL CELL SYSTEM WITH INTERCONNECT
WO2012173997	2012	2012	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	FUEL CELL SYSTEM WITH INTERCONNECT
WO2012174000	2012	2012	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	FUEL CELL SYSTEM WITH INTERCONNECT
WO2012174558	2012	2012	FLUIDIC, INC.	METAL-AIR CELL WITH ION EXCHANGE MATERIAL
WO2012177652	2012	2012	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	PROTECTION OF POROUS CARBON FUEL PARTICLES FROM BOUDOUARD CORROSION
8343686	2006	2013	UNIVERSITY OF	JOINED CONCENTRIC TUBES

			CALIFORNIA	
8349547	2010	2013	SANDIA CORPORATION	LITHOGRAPHICALLY DEFINED MICROPOROUS CARBON STRUCTURES
8389178	2010	2013	UNITED STATES DEPARTMENT OF ENERGY	ELECTROCHEMICAL ENERGY STORAGE DEVICE BASED ON CARBON DIOXIDE AS ELECTROACTIVE SPECIES
8394544	2008	2013	BATTELLE MEMORIAL INSTITUTE	SOLID OXIDE FUEL CELL STEAM REFORMING POWER SYSTEM
8415037	2008	2013	UNIVERSITY OF SOUTHERN CALIFORNIA	MICROBIAL FUEL CELLS
8420278	2010	2013	DELPHI TECHNOLOGIES, INC.	SOLID OXIDE FUEL CELL HAVING A GLASS COMPOSITE SEAL
8420704	2008	2013	UNIVERSITY OF MINNESOTA	NANO-STRUCTURED POLYMER COMPOSITES AND PROCESS FOR PREPARING SAME
8424747	2010	2013	BATTELLE MEMORIAL INSTITUTE	DIFFUSION BARRIERS IN MODIFIED AIR BRAZES
8435694	2004	2013	FUELCELL ENERGY, INC.	MOLTEN CARBONATE FUEL CELL CATHODE WITH MIXED OXIDE COATING
8436057	2010	2013	UNITED STATES DEPARTMENT OF ENERGY	ANION EXCHANGE MEMBRANE
8445148	2004	2013	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METHOD OF FORMING A PACKAGE FOR MEMS-BASED FUEL CELL
8445159	2005	2013	UNIVERSITY OF CALIFORNIA	SEALED JOINT STRUCTURE FOR ELECTROCHEMICAL DEVICE
8460823	2010	2013	SANDIA CORPORATION	ELECTROCHEMICAL COMPONENTS EMPLOYING POLYSILOXANE-DERIVED BINDERS
8460838	2009	2013	SIEMENS ENERGY, INC.	GENERATOR MODULE ARCHITECTURE FOR A LARGE SOLID OXIDE FUEL CELL POWER PLANT
8465797	2011	2013	UNIVERSITY OF SOUTH CAROLINA	METHOD TO FABRICATE HIGH PERFORMANCE TUBULAR SOLID OXIDE FUEL CELLS
8465883	2008	2013	UNIVERSITY OF CALIFORNIA	NANOSTRUCTURED POLYMER MEMBRANES FOR PROTON CONDUCTION
8486580	2008	2013	UNIVERSITY OF CALIFORNIA	INTEGRATED SEAL FOR HIGH-TEMPERATURE ELECTROCHEMICAL DEVICE
8486582	2012	2013	BATTELLE MEMORIAL	SURFACE MODIFICATION TO PREVENT OXIDE SCALE

			INSTITUTE	SPALLATION
8501366	2009	2013	SANDIA CORPORATION	NANOENGINEERED MEMBRANE ELECTRODE ASSEMBLY INTERFACE
8507131	2012	2013	DELPHI TECHNOLOGIES, INC.	SYSTEM FOR ADDING SULFUR TO A FUEL CELL STACK SYSTEM FOR IMPROVED FUEL CELL STABILITY
8529709	2008	2013	ATI PROPERTIES, INC.	METHOD FOR REDUCING FORMATION OF ELECTRICALLY RESISTIVE LAYER ON FERRITIC STAINLESS STEELS
8541146	2006	2013	TOYOTA MOTOR CORP	PHOTOCATALYTIC METHODS FOR PREPARATION OF ELECTROCATALYST MATERIALS
8574782	2010	2013	YAMUTC POWER CORPORATION	FUEL CELL REPEATER UNIT INCLUDING FRAME AND SEPARATOR PLATE
8585807	2011	2013	UCHICAGO ARGONNE, LLC	LOW-COST METHOD FOR FABRICATING PALLADIUM AND PALLADIUM-ALLOY THIN FILMS ON POROUS SUPPORTS
8597513	2009	2013	UT-BATTELLE, LLC	MICROBIAL FUEL CELL TREATMENT OF FUEL PROCESS WASTEWATER
8597930	2011	2013	UNIVERSITY OF MASSACHUSETTS	GEOBACTER STRAINS THAT USE ALTERNATE ORGANIC COMPOUNDS, METHODS OF MAKING, AND METHODS OF USE THEREOF
8609573	2008	2013	TOYOTA MOTOR CORP	PHOTOCATALYTIC METHODS FOR PREPARATION OF ELECTROCATALYST MATERIALS
EP2058918	2008	2013	HONEYWELL INTERNATIONAL INC.	HYBRID POWER SOURCE
EP2569819	2011	2013	ARIZONA STATE UNIVERSITY	METAL-AIR CELL WITH PERFORMANCE ENHANCING ADDITIVE
EP2595227	2012	2013	DELPHI TECHNOLOGIES, INC.	FUEL CELL WITH INTERNAL FLOW CONTROL
EP2652819	2011	2013	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
EP2670984	2012	2013	UNIVERSITY OF DELAWARE	DEVICES, SYSTEMS, AND METHODS FOR VARIABLE FLOW RATE FUEL EJECTION
WO2013003341	2012	2013	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	REDUCING GAS GENERATORS AND METHODS FOR GENERATING A REDUCING GAS

WO2013003363	2012	2013	ROLLS-ROYCE FUEL CELL SYSTEMS INC.	ENGINE SYSTEMS AND METHODS OF OPERATING AN ENGINE
WO2013019958	2012	2013	UNASSIGNED	DIRECT CARBON FUEL CELL SYSTEM WITH CIRCULATING ELECTROLYTE SLURRY AND METHODS OF USING SAME
WO2013096156	2012	2013	3M INNOVATIVE PROPERTIES COMPANY	CATALYSTS SYSTEMS
WO2013130145	2012	2013	UNIVERSITY OF CALIFORNIA	PRINTED BIOFUEL CELLS
WO2013147930	2012	2013	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE SYSTEMS HAVING AN ELECTRODE COMPRISING LIXSY
8637209	2006	2014	UNASSIGNED	CATHODE AND ELECTROLYTE MATERIALS FOR SOLID OXIDE FUEL CELLS AND ION TRANSPORT MEMBRANES
8673067	2009	2014	BATTELLE MEMORIAL INSTITUTE	IMMOBILIZED FLUID MEMBRANES FOR GAS SEPARATION
8673519	2008	2014	SIEMENS AKTIENGESELLSCHAFT	AID FOR ELECTRICAL CONTACTING OF HIGH-TEMPERATURE FUEL CELLS AND METHOD FOR PRODUCTION THEREOF
8715882	2010	2014	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	HIGH POWER DENSITY FUEL CELL COMPRISING AN ARRAY OF MICROCHANNELS
8722226	2010	2014	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
8722227	2013	2014	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	HIGH ENERGY DENSITY REDOX FLOW DEVICE
8741800	2010	2014	UCHICAGO ARGONNE, LLC	HYDROTHERMAL PERFORMANCE OF CATALYST SUPPORTS
8785346	2009	2014	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	METHOD FOR FORMING GOLD-CONTAINING CATALYST WITH POROUS STRUCTURE
8802316	2010	2014	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELLS HAVING POROUS CATHODES INFILTRATED WITH OXYGEN-REDUCING CATALYSTS
8839659	2011	2014	NORTHERN ILLINOIS UNIVERSITY	SENSORS AND DEVICES CONTAINING ULTRA-SMALL NANOWIRE ARRAYS
8852807	2012	2014	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
8889303	2009	2014	BATTELLE	CASSETTE LESS SOFC STACK

			MEMORIAL INSTITUTE	AND METHOD OF ASSEMBLY
8906572	2012	2014	GENERAL ELECTRIC COMPANY	POLYMER-ELECTROLYTE MEMBRANE, ELECTROCHEMICAL FUEL CELL, AND RELATED METHOD
8916311	2011	2014	UNIVERSITY OF ROCHESTER	ION/PROTON-CONDUCTING APPARATUS AND METHOD
8920993	2012	2014	DELPHI TECHNOLOGIES, INC.	ANODE PROTECTION SYSTEM FOR SHUTDOWN OF SOLID OXIDE FUEL CELL SYSTEM
EP2721668	2012	2014	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
EP2721669	2012	2014	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
EP2721680	2012	2014	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
EP2721687	2012	2014	FLUIDIC, INC.	METAL-AIR CELL WITH ION EXCHANGE MATERIAL
EP2726188	2012	2014	LG FUEL CELL SYSTEMS, INC.	ENGINE SYSTEMS AND METHODS OF OPERATING AN ENGINE
EP2726190	2012	2014	LG FUEL CELL SYSTEMS, INC.	REDUCING GAS GENERATORS AND METHODS FOR GENERATING A REDUCING GAS
EP2743245	2013	2014	DELPHI TECHNOLOGIES, INC.	MATERIAL FOR SOLID STATE SINTERED MATERIAL.
EP2794105	2012	2014	3M INNOVATIVE PROPERTIES COMPANY	CATALYSTS SYSTEMS
WO2014018536	2013	2014	MO-SCI CORPORATION	VISCOUS SEALING GLASS COMPOSITIONS FOR SOLID OXIDE FUELS CELLS
WO2014028576	2013	2014	BATTELLE MEMORIAL INSTITUTE	SYSTEM AND PROCESS FOR ALUMINIZATION OF METAL-CONTAINING SUBSTRATES
WO2014046763	2013	2014	BATTELLE MEMORIAL INSTITUTE	SURFACE MODIFICATION TO PREVENT OXIDE SCALE SPALLATION
WO2014078411	2013	2014	CITY UNIVERSITY OF NEW YORK	A MAGNETIC DEVICE FOR PRODUCING ELECTROLYTE FLOW IN BATTERY SYSTEMS
WO2014093876	2013	2014	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
WO2014100376	2013	2014	PRAXAIR TECHNOLOGY, INC.	METHOD FOR SEALING AN OXYGEN TRANSPORT MEMBRANE ASSEMBLY
WO2014121276	2014	2014	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	METAL SULFIDE ELECTRODES AND ENERGY STORAGE DEVICES THEREOF
WO2014143957	2014	2014	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM CONFIGURED TO CAPTURE

				CHROMIUM
WO2014144612	2014	2014	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM INCLUDING SACRIFICIAL NICKEL SOURCE
WO2014175976	2014	2014	UNIVERSITY OF PHILADELPHIA	DIRECT CARBON FUEL CELL AND STACK DESIGNS
WO2014179098	2014	2014	UNITED TECHNOLOGIES CORPORATION	FUEL CELL SYSTEM BLOWER CONFIGURATION
8932781	2009	2015	GEORGIA TECH RESEARCH CORPORATION	CHEMICAL COMPOSITIONS, METHODS OF MAKING THE CHEMICAL COMPOSITIONS, AND STRUCTURES MADE FROM THE CHEMICAL COMPOSITIONS
8956777	2013	2015	BALLARD POWER SYSTEMS INC.	SOLID OXIDE FUEL CELL POWER PLANT HAVING A FIXED CONTACT OXIDATION CATALYZED SECTION OF A MULTI-SECTION CATHODE AIR HEAT EXCHANGER
8974981	2011	2015	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
8993159	2013	2015	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
9005490	2012	2015	DELPHI TECHNOLOGIES, INC.	MATERIAL FOR SOLID STATE SINTERED MATERIAL
9017897	2012	2015	DELPHI TECHNOLOGIES, INC.	METAL COMPOSITE MATERIAL FOR ATTACHMENT TO CERAMIC
9034170	2008	2015	UNIVERSITY OF FLORIDA	ELECTRIC-FIELD ENHANCED PERFORMANCE IN CATALYSIS AND SOLID-STATE DEVICES INVOLVING GASES
9040205	2012	2015	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	PROTECTION OF POROUS CARBON FUEL PARTICLES FROM BOUDOUARD CORROSION
9054348	2012	2015	NEXTECH MATERIALS, LTD.	PROTECTIVE COATINGS FOR METAL ALLOYS AND METHODS INCORPORATING THE SAME
9068271	2010	2015	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	ELECTROCHEMICAL NITRIDATION OF METAL SURFACES
9074198	2010	2015	UNIVERSITY OF MASSACHUSETTS	GEOBACTERACEAE STRAINS AND METHODS
9083016	2012	2015	BALLARD POWER SYSTEMS INC.	SOLID OXIDE FUEL CELL POWER PLANT WITH AN ANODE RECYCLE LOOP TURBOCHARGER
9105880	2011	2015	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT

9112219	2010	2015	DELPHI TECHNOLOGIES, INC.	MULTIPLE STACK FUEL CELL SYSTEM WITH SHARED PLENUM
9118048	2011	2015	LG FUEL CELL SYSTEMS INC.	ENGINE SYSTEMS AND METHODS OF OPERATING AN ENGINE
9118089	2012	2015	FLUIDIC, INC.	METAL-AIR CELL WITH ION EXCHANGE MATERIAL
9136542	2012	2015	OHIO STATE UNIVERSITY	CATALYSTS FOR USE IN ELECTROCHEMICAL APPLICATIONS AND ELECTRODES AND DEVICES USING SAME
9147888	2011	2015	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
9153833	2014	2015	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
9175408	2010	2015	UNIVERSITY OF MASSACHUSETTS	MICROBIAL PRODUCTION OF MULTI-CARBON CHEMICALS AND FUELS FROM WATER AND CARBON DIOXIDE USING ELECTRIC CURRENT
9178235	2011	2015	LG FUEL CELL SYSTEMS INC.	REDUCING GAS GENERATORS AND METHODS FOR GENERATING A REDUCING GAS
9178240	2013	2015	BATTELLE MEMORIAL INSTITUTE	SYSTEM AND PROCESS FOR ALUMINIZATION OF METAL-CONTAINING SUBSTRATES
9178244	2010	2015	INTELLIGENT ENERGY, INC.	FUEL CELLS AND FUEL CELL COMPONENTS HAVING ASYMMETRIC ARCHITECTURE AND METHODS THEREOF
9184464	2015	2015	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
9184478	2011	2015	ARIZONA STATE UNIVERSITY	METAL-AIR CELL WITH PERFORMANCE ENHANCING ADDITIVE
9203100	2008	2015	INTELLIGENT ENERGY, INC.	FUEL CELL SYSTEM
9209494	2014	2015	PALO ALTO RESEARCH CENTER INCORPORATED	MONITORING/MANAGING ELECTROCHEMICAL ENERGY DEVICE USING DETECTED INTERCALATION STAGE CHANGES
EP2831938	2012	2015	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE SYSTEMS HAVING AN ELECTRODE COMPRISING LIXSY
EP2843742	2012	2015	DELPHI TECHNOLOGIES, INC.	FUEL CELL WITH INTERNAL FLOW CONTROL
EP2851987	2014	2015	DELPHI TECHNOLOGIES,	FUEL CELL CASSETTE WITH COMPLIANT SEAL

			INC.	
EP2875537	2013	2015	MO-SCI CORPORATION	VISCOUS SEALING GLASS COMPOSITIONS FOR SOLID OXIDE FUELS CELLS
EP2920835	2013	2015	CITY UNIVERSITY OF NEW YORK	A MAGNETIC DEVICE FOR PRODUCING ELECTROLYTE FLOW IN BATTERY SYSTEMS
EP2928006	2015	2015	PALO ALTO RESEARCH CENTER INCORPORATED	METHOD FOR MONITORING/MANAGING ELECTROCHEMICAL ENERGY DEVICE BY DETECTING INTERCALATION STAGE CHANGES
EP2932542	2013	2015	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
EP2935155	2013	2015	PRAXAIR TECHNOLOGY, INC.	METHOD FOR SEALING AN OXYGEN TRANSPORT MEMBRANE ASSEMBLY
WO2015006557	2014	2015	PENN STATE UNIVERSITY	MESOPOROUS SILICON SYNTHESIS AND APPLICATIONS IN LI-ION BATTERIES AND SOLAR HYDROGEN FUEL CELLS
WO2015157492	2015	2015	BATTELLE MEMORIAL INSTITUTE	METHODS AND SYSTEMS FOR FUEL PRODUCTION IN ELECTROCHEMICAL CELLS AND REACTORS
WO2015196052	2015	2015	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LUBRICANT-IMPREGNATED SURFACES FOR ELECTROCHEMICAL APPLICATIONS, AND DEVICES AND SYSTEMS USING SAME
9236615	2014	2016	UNIVERSITY OF HOUSTON	METHODS FOR USING NOVEL CATHODE AND ELECTROLYTE MATERIALS FOR SOLID OXIDE FUEL CELLS AND ION TRANSPORT MEMBRANES
9240597	2011	2016	UNIVERSITY OF SOUTH CAROLINA	NI MODIFIED CERAMIC ANODES FOR DIRECT-METHANE SOLID OXIDE FUEL CELLS
9273280	2013	2016	UNIVERSITY OF MASSACHUSETTS	GEOBACTER STRAINS THAT USE ALTERNATE ORGANIC COMPOUNDS, METHODS OF MAKING, AND METHODS OF USE THEREOF
9276267	2008	2016	DELPHI TECHNOLOGIES, INC.	LOW-TEMPERATURE BONDING OF REFRACTORY CERAMIC LAYERS
9281527	2013	2016	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
9334194	2014	2016	UNIVERSITY OF COLORADO	METHODS OF FLASH SINTERING
9343746	2009	2016	UNIVERSITY OF	ADVANCED MATERIALS AND

			FLORIDA	DESIGN FOR LOW TEMPERATURE SOFCS
9356307	2010	2016	DELPHI TECHNOLOGIES, INC.	MULTIPLE STACK FUEL CELL SYSTEM
9362583	2015	2016	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
9376741	2013	2016	ATI PROPERTIES, INC.	ARTICLES COMPRISING FERRITIC STAINLESS STEELS
9385392	2015	2016	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
9406944	2012	2016	UNIVERSITY OF SOUTH CAROLINA	SULFUR-TOLERANT ANODE MATERIAL FOR DIRECT HYDROCARBON SOLID OXIDE FUEL CELLS
9406960	2012	2016	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE SYSTEMS HAVING AN ELECTRODE COMPRISING LIXSY
9455456	2015	2016	BALLARD POWER SYSTEMS INC.	SOLID OXIDE FUEL CELL POWER PLANT WITH AN ANODE RECYCLE LOOP TURBOCHARGER
9461328	2012	2016	BALLARD POWER SYSTEMS INC.	SOLID OXIDE FUEL CELL POWER PLANT HAVING A BOOTSTRAP START-UP SYSTEM
9463428	2012	2016	3M INNOVATIVE PROPERTIES COMPANY	PALLADIUM-BASED CATALYST AND SUPPORT SYSTEMS
9480856	2015	2016	UNIVERSITY OF NEVADA LAS VEGAS	X-RAY TARGETED BOND OR COMPOUND DESTRUCTION
9486742	2011	2016	SANDIA CORPORATION	BIOMIMETIC MEMBRANES AND METHODS OF MAKING BIOMIMETIC MEMBRANES
9486786	2010	2016	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGHLY DISPERSED METAL CATALYST
9493397	2010	2016	CORNELL RESEARCH FOUNDATION, INC.	IONOMERS AND METHODS OF MAKING SAME AND USES THEREOF
9502730	2012	2016	UNIVERSITY OF CALIFORNIA	PRINTED BIOFUEL CELLS
9515340	2011	2016	SANDIA CORPORATION	CONDUCTIVE POLYMER LAYERS TO LIMIT TRANSFER OF FUEL REACTANTS TO CATALYSTS OF FUEL CELLS TO REDUCE REACTANT CROSSOVER
9525181	2013	2016	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
9530991	2013	2016	MO-SCI CORPORATION	VISCOUS SEALING GLASS COMPOSITIONS FOR SOLID

				OXIDE FUEL CELLS
EP2973824	2014	2016	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM INCLUDING SACRIFICIAL NICKEL SOURCE
EP2973825	2014	2016	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM CONFIGURED TO CAPTURE CHROMIUM
EP2992566	2014	2016	AUDI AG	FUEL CELL SYSTEM BLOWER CONFIGURATION
WO2016014578	2015	2016	LG FUEL CELL SYSTEMS, INC.	COMPOSITION FOR FUEL CELL ELECTRODE
9561476	2012	2017	PRAXAIR TECHNOLOGY, INC.	CATALYST CONTAINING OXYGEN TRANSPORT MEMBRANE
9561497	2013	2017	UNIVERSITY OF PITTSBURGH	NON-NOBLE METAL BASED ELECTRO-CATALYST COMPOSITIONS FOR PROTON EXCHANGE MEMBRANE BASED WATER ELECTROLYSIS AND METHODS OF MAKING
9564643	2013	2017	UT-BATTELLE, LLC	ENGINEERED GLASS SEALS FOR SOLID-OXIDE FUEL CELLS
9564650	2012	2017	BROWN UNIVERSITY	METHODS FOR CONTINUOUS DIRECT CARBON FUEL CELL OPERATION WITH A CIRCULATING ELECTROLYTE SLURRY
9580789	2013	2017	ATI PROPERTIES, INC.	METHOD FOR REDUCING FORMATION OF ELECTRICALLY RESISTIVE LAYER ON FERRITIC STAINLESS STEELS
9583779	2014	2017	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	METAL SULFIDE ELECTRODES AND ENERGY STORAGE DEVICES THEREOF
9583796	2014	2017	PALO ALTO RESEARCH CENTER INCORPORATED	METHOD FOR MONITORING/MANAGING ELECTROCHEMICAL ENERGY DEVICE BY DETECTING INTERCALATION STAGE CHANGES
9593215	2015	2017	UNIVERSITY OF CALIFORNIA	POLYMER USEFUL FOR AN ION EXCHANGE MEMBRANE
9598769	2014	2017	UCHICAGO ARGONNE, LLC	METHOD AND SYSTEM FOR CONTINUOUS ATOMIC LAYER DEPOSITION
9614231	2011	2017	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
9614251	2010	2017	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	HIGH-PERFORMANCE RECHARGEABLE BATTERIES WITH NANOPARTICLE ACTIVE MATERIALS, PHOTOCHEMICALLY

				REGENERABLE ACTIVE MATERIALS, AND FAST SOLID-STATE ION CONDUCTORS
9618494	2014	2017	NORTHERN ILLINOIS UNIVERSITY	SENSORS AND DEVICES CONTAINING ULTRA-SMALL NANOWIRE ARRAYS
9620792	2011	2017	AUDI AG	THERMAL ENERGY RECYCLING FUEL CELL ARRANGEMENT
9656243	2014	2017	PENN STATE UNIVERSITY	MESOPOROUS SILICON SYNTHESIS AND APPLICATIONS IN LI-ION BATTERIES AND SOLAR HYDROGEN FUEL CELLS
9666880	2013	2017	DELPHI TECHNOLOGIES, INC.	INTERCONNECT FOR FUEL CELL STACK
9670064	2012	2017	CONSOLIDATED NUCLEAR SECURITY LLC	PRODUCTION OF HEAVY WATER
9685684	2013	2017	SANDIA CORPORATION	ELECTROCHEMICAL CELL STRUCTURE INCLUDING AN IONOMERIC BARRIER
9692075	2016	2017	UCHICAGO ARGONNE, LLC	MULTI-LAYERED PROTON-CONDUCTING ELECTROLYTE
9692078	2016	2017	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	HIGH-PERFORMANCE RECHARGEABLE BATTERIES WITH FAST SOLID-STATE ION CONDUCTORS
9692079	2009	2017	DELPHI TECHNOLOGIES, INC.	LAMINATED PLATE REPEATING FUEL CELL UNIT FOR AN SOFC STACK
9705141	2015	2017	INTELLIGENT ENERGY, INC.	FUEL CELL SYSTEM
9711818	2015	2017	WISCONSIN ALUMNI RESEARCH FOUNDATION	CHARGE TRANSFER MEDIATOR BASED SYSTEMS FOR ELECTROCATALYTIC OXYGEN REDUCTION
9719529	2012	2017	UNIVERSITY OF DELAWARE	DEVICES, SYSTEMS, AND METHODS FOR VARIABLE FLOW RATE FUEL EJECTION
9728767	2013	2017	CITY UNIVERSITY OF NEW YORK	MAGNETIC DEVICE FOR PRODUCING ELECTROLYTE FLOW IN BATTERY SYSTEMS
9748581	2015	2017	STANFORD UNIVERSITY	FUNCTIONALIZED GRAPHENE-PT COMPOSITES FOR FUEL CELLS AND PHOTOELECTROCHEMICAL CELLS
9786944	2010	2017	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
9812717	2013	2017	DELPHI TECHNOLOGIES, INC.	FUEL CELL CASSETTE WITH COMPLIANT SEAL

9812727	2017	2017	WISCONSIN ALUMNI RESEARCH FOUNDATION	CHARGE TRANSFER MEDIATOR BASED SYSTEMS FOR ELECTROCATALYTIC OXYGEN REDUCTION
9831510	2013	2017	AUDI AG	FUEL CELL SYSTEM BLOWER CONFIGURATION
9831517	2015	2017	KOREA INSTITUTE OF ENERGY RESEARCH	UNIT CELL OF SOLID OXIDE FUEL CELL, STACK USING THE UNIT CELL, AND METHODS OF MANUFACTURING THE UNIT CELL AND THE STACK
9831518	2016	2017	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
9831519	2016	2017	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY
9840780	2015	2017	BATTELLE MEMORIAL INSTITUTE	SYSTEM AND PROCESS FOR ALUMINIZATION OF METAL-CONTAINING SUBSTRATES
9843054	2015	2017	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
9850140	2010	2017	CORNELL RESEARCH FOUNDATION, INC.	CONDUCTING METAL OXIDE AND METAL NITRIDE NANOPARTICLES
EP3166168	2011	2017	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
EP3168913	2012	2017	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
EP3172788	2015	2017	LG FUEL CELL SYSTEMS, INC.	COMPOSITION FOR FUEL CELL ELECTRODE
EP3206023	2008	2017	UNIVERSITY OF FLORIDA	ELECTRIC-FIELD ENHANCED PERFORMANCE IN CATALYSIS AND SOLID-STATE DEVICES INVOLVING GASES
WO2017066725	2016	2017	CALIFORNIA INSTITUTE OF TECHNOLOGY	METHANE OXIDATION METHODS AND COMPOSITIONS
WO2017075429	2016	2017	LG FUEL CELL SYSTEMS, INC.	COMPOSITION FOR FUEL CELL ELECTRODE
WO2017214141	2017	2017	LG FUEL CELL SYSTEMS, INC.	COMPOSITION OF A NICKELATE COMPOSITE CATHODE FOR A FUEL CELL
WO2017214152	2017	2017	LG FUEL CELL SYSTEMS, INC.	COMPOSITION OF A NICKELATE COMPOSITE CATHODE FOR A FUEL CELL
9856449	2015	2018	UNIVERSITY OF MASSACHUSETTS	MICROBIAL PRODUCTION OF MULTI-CARBON CHEMICALS AND FUELS FROM WATER AND CARBON DIOXIDE USING ELECTRIC CURRENT
9874158	2015	2018	LG FUEL CELL	ENGINE SYSTEMS AND

			SYSTEMS, INC.	METHODS OF OPERATING AN ENGINE
9879352	2015	2018	BATTELLE MEMORIAL INSTITUTE	METHODS AND SYSTEMS FOR FUEL PRODUCTION IN ELECTROCHEMICAL CELLS AND REACTORS
9935318	2014	2018	UNITED STATES DEPARTMENT OF ENERGY	SOLID OXIDE FUEL CELL CATHODE WITH OXYGEN-REDUCING LAYER
9937490	2014	2018	ARGONNE NATIONAL LABORATORY	HYDROTHERMAL PERFORMANCE OF CATALYST SUPPORTS
9943841	2017	2018	DIOXIDE MATERIALS INC	METHOD OF MAKING AN ANION EXCHANGE MEMBRANE
9945040	2016	2018	DIOXIDE MATERIALS INC	CATALYST LAYERS AND ELECTROLYZERS
9947481	2015	2018	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LUBRICANT-IMPREGNATED SURFACES FOR ELECTROCHEMICAL APPLICATIONS, AND DEVICES AND SYSTEMS USING SAME
9957624	2016	2018	DIOXIDE MATERIALS INC	ELECTROCHEMICAL DEVICES COMPRISING NOVEL CATALYST MIXTURES
9960428	2016	2018	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF FORMING CATALYST LAYER BY SINGLE STEP INFILTRATION
9969645	2013	2018	PRAXAIR TECHNOLOGY, INC.	METHOD FOR SEALING AN OXYGEN TRANSPORT MEMBRANE ASSEMBLY
9979039	2014	2018	UNIVERSITY OF PENNSYLVANIA	DIRECT CARBON FUEL CELL AND STACK DESIGNS
10003083	2015	2018	LG FUEL CELL SYSTEMS, INC.	COMPOSITION FOR FUEL CELL ELECTRODE
10011813	2016	2018	CALIFORNIA INSTITUTE OF TECHNOLOGY	METHANE OXIDATION METHODS AND COMPOSITIONS
10014529	2016	2018	COLORADO SCHOOL OF MINES	TRIPLE CONDUCTING CATHODE MATERIAL FOR INTERMEDIATE TEMPERATURE PROTONIC CERAMIC ELECTROCHEMICAL DEVICES
10014531	2014	2018	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM CONFIGURED TO CAPTURE CHROMIUM
10026972	2016	2018	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
10041179	2016	2018	UNIVERSITY OF PITTSBURGH	NON-NOBLE METAL BASED ELECTRO-CATALYST COMPOSITIONS FOR PROTON EXCHANGE MEMBRANE BASED WATER ELECTROLYSIS AND METHODS OF MAKING

10044056	2014	2018	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM INCLUDING SACRIFICIAL NICKEL SOURCE
10059584	2016	2018	COLORADO SCHOOL OF MINES	CATHODE MATERIAL FOR LOW TEMPERATURE SOLID OXIDE FUEL CELLS
10062909	2016	2018	LG FUEL CELL SYSTEMS, INC.	COMPOSITION FOR FUEL CELL ELECTRODE
10087531	2015	2018	WEST VIRGINIA UNIVERSITY	IMPREGNATION PROCESS USING A BIO-TEMPLATING METHOD FOR NANO-CATALYST INCORPORATION INTO THE ELECTRODES OF SOLID-STATE ELECTROCHEMICAL CELLS
10115973	2016	2018	LG FUEL CELL SYSTEMS, INC.	COMPOSITION OF A NICKELATE COMPOSITE CATHODE FOR A FUEL CELL
10115974	2016	2018	LG FUEL CELL SYSTEMS, INC.	COMPOSITION OF A NICKELATE COMPOSITE CATHODE FOR A FUEL CELL
10128510	2014	2018	UWM RESEARCH FOUNDATION LLC	ADVANCED ELECTROCATALYSTS FOR OXYGEN REDUCTION REACTION
10130916	2016	2018	SANDIA CORPORATION	BIOMIMETIC MEMBRANES AND METHODS OF MAKING BIOMIMETIC MEMBRANES
EP3276728	2012	2018	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
EP3306726	2012	2018	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
10186711	2013	2019	TOYOTA MOTOR CORP	PHOTOCATALYTIC METHODS FOR PREPARATION OF ELECTROCATALYST MATERIALS
10186740	2017	2019	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	ELECTROCHEMICAL CELL HAVING A VANADIUM PHOSPHOROUS ALLOY ELECTRODE
10197521	2015	2019	UNIVERSITY OF FLORIDA	ELECTRIC-FIELD ENHANCED PERFORMANCE IN CATALYSIS AND SOLID-STATE DEVICES INVOLVING GASES
10236518	2015	2019	24M TECHNOLOGIES, INC.	HIGH ENERGY DENSITY REDOX FLOW DEVICE
10322405	2016	2019	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGHLY DISPERSED METAL CATALYST AND RELATED METHODS
10326149	2017	2019	LG FUEL CELL SYSTEMS, INC.	FUEL CELL SYSTEM WITH INTERCONNECT
10374236	2015	2019	ARIZONA STATE UNIVERSITY	METAL-AIR CELL WITH PERFORMANCE ENHANCING

				ADDITIVE
10428432	2018	2019	DIOXIDE MATERIALS INC	CATALYST LAYERS AND ELECTROLYZERS
10435803	2018	2019	UNIVERSITY OF PITTSBURGH	NON-NOBLE METAL BASED ELECTRO-CATALYST COMPOSITIONS FOR PROTON EXCHANGE MEMBRANE BASED WATER ELECTROLYSIS AND METHODS OF MAKING
10483582	2017	2019	24M TECHNOLOGIES, INC.	SEMI-SOLID ELECTRODES HAVING HIGH RATE CAPABILITY

Appendix PD-A. Hydrogen Production Patents in Families Associated with HFTO Funding

Patent #	Application Year	Issue / Publication Year	Original Assignee	Title
4142300	1977	1979	UNITED STATES DEPARTMENT OF ENERGY	LANTHANUM NICKEL ALUMINUM ALLOY
4358429	1981	1982	UNITED STATES DEPARTMENT OF ENERGY	OXYGEN STABILIZED ZIRCONIUM VANADIUM INTERMETALLIC COMPOUND
4473622	1982	1984	UNASSIGNED	RAPID STARTING METHANOL REACTOR SYSTEM
4919813	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	PHOTOENHANCED ANAEROBIC DIGESTION OF ORGANIC ACIDS
4942269	1988	1990	MIDWEST RESEARCH INSTITUTE	PROCESS FOR FRACTIONATING FAST-PYROLYSIS OILS, AND PRODUCTS DERIVED THEREFROM
WO1991002701	1990	1991	UNITED STATES DEPARTMENT OF ENERGY	PHOTOENHANCED ANAEROBIC DIGESTION OF ORGANIC ACIDS
EP0440773	1990	1992	UNITED STATES DEPARTMENT OF ENERGY	PHOTOENHANCED ANAEROBIC DIGESTION OF ORGANIC ACIDS
5250427	1992	1993	MIDWEST RESEARCH INSTITUTE	PHOTOCONVERSION OF GASIFIED ORGANIC MATERIALS INTO BIOLOGICALLY-DEGRADABLE PLASTICS
5271916	1992	1993	GENERAL MOTORS CORPORATION	DEVICE FOR STAGED CARBON MONOXIDE OXIDATION
5367283	1992	1994	MARTIN MARIETTA ENERGY SYSTEMS, INC.	THIN FILM HYDROGEN SENSOR
WO1994000559	1993	1994	MIDWEST RESEARCH INSTITUTE	PHOTOCONVERSION OF GASIFIED ORGANIC MATERIALS INTO BIOLOGICALLY-DEGRADABLE PLASTICS
5451920	1993	1995	MARTIN MARIETTA ENERGY SYSTEMS, INC.	THICK FILM HYDROGEN SENSOR
EP0662123	1993	1995	MIDWEST RESEARCH INSTITUTE	PHOTOCONVERSION OF GASIFIED ORGANIC MATERIALS INTO BIOLOGICALLY-DEGRADABLE PLASTICS.
EP0732138	1996	1996	AIR PRODUCTS AND CHEMICALS, INC.	PLANAR SOLID-STATE MEMBRANE MODULE
EP0737648	1996	1996	AIR PRODUCTS AND	PROCESS FOR OPERATING

			CHEMICALS, INC.	EQUILIBRIUM CONTROLLED REACTIONS
WO1996040413	1996	1996	UNIVERSITY OF CALIFORNIA	COMPOSITE METAL MEMBRANE
5637415	1996	1997	GENERAL MOTORS CORPORATION	CONTROLLED CO PREFERENTIAL OXIDATION
5656064	1995	1997	AIR PRODUCTS AND CHEMICALS, INC.	BASE TREATED ALUMINA IN PRESSURE SWING ADSORPTION
5681373	1995	1997	AIR PRODUCTS AND CHEMICALS, INC.	PLANAR SOLID-STATE MEMBRANE MODULE
EP0766991	1996	1997	AIR PRODUCTS AND CHEMICALS, INC.	THE USE OF BASE TREATED ALUMINA IN PRESSURE SWING ADSORPTION
WO1997037258	1997	1997	MIDWEST RESEARCH INSTITUTE	FIBER-OPTIC SENSING DEVICE
5708735	1996	1998	UNASSIGNED	FIBER OPTIC DEVICE FOR SENSING THE PRESENCE OF A GAS
5712220	1996	1998	AIR PRODUCTS AND CHEMICALS, INC.	COMPOSITIONS CAPABLE OF OPERATING UNDER HIGH CARBON DIOXIDE PARTIAL PRESSURES FOR USE IN SOLID-STATE OXYGEN PRODUCING DEVICES
5738708	1995	1998	UNIVERSITY OF CALIFORNIA	COMPOSITE METAL MEMBRANE
5817597	1996	1998	AIR PRODUCTS AND CHEMICALS, INC.	COMPOSITIONS CAPABLE OF OPERATING UNDER HIGH OXYGEN PARTIAL PRESSURES FOR USE IN SOLID-STATE OXYGEN PRODUCING DEVICES
5833834	1997	1998	SOLAR REACTOR TECHNOLOGIES INC.	METHOD FOR GENERATING HYDROGEN FROM HBR
EP0827227	1997	1998	GENERAL MOTORS CORPORATION	CONTROLLED SELECTIVE CARBON MONOXIDE OXIDATION
EP0871029	1997	1998	GENERAL MOTORS CORPORATION	THIN FILM HYDROGEN SENSOR
EP0882670	1998	1998	AIR PRODUCTS AND CHEMICALS, INC.	SYNTHESIS GAS PRODUCTION BY ION TRANSPORT MEMBRANES
WO1998008771	1997	1998	ARTHUR D. LITTLE, INC.	METHOD AND APPARATUS FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
WO1998055227	1998	1998	UNIVERSITY OF CHICAGO	PARTIAL OXIDATION CATALYST
5871952	1997	1999	MIDWEST RESEARCH INSTITUTE	PROCESS FOR SELECTION OF OXYGEN-TOLERANT ALGAL MUTANTS THAT

				PRODUCE H2 UNDER AEROBIC CONDITIONS
5886614	1997	1999	GENERAL MOTORS CORPORATION	THIN FILM HYDROGEN SENSOR
5895518	1996	1999	SANDIA CORPORATION	SYNTHESIS OF ALLOYS WITH CONTROLLED PHASE STRUCTURE
5917136	1996	1999	AIR PRODUCTS AND CHEMICALS, INC.	CARBON DIOXIDE PRESSURE SWING ADSORPTION PROCESS USING MODIFIED ALUMINA ADSORBENTS
5929286	1998	1999	UNIVERSITY OF CHICAGO	METHOD FOR MAKING HYDROGEN RICH GAS FROM HYDROCARBON FUEL
5939025	1995	1999	UNIVERSITY OF CHICAGO	METHANOL PARTIAL OXIDATION REFORMER
5942346	1998	1999	UNIVERSITY OF CHICAGO	METHANOL PARTIAL OXIDATION REFORMER
6006582	1998	1999	ADVANCED TECHNOLOGY MATERIALS, INC.	HYDROGEN SENSOR UTILIZING RARE EARTH METAL THIN FILM DETECTION ELEMENT
EP0890123	1997	1999	MIDWEST RESEARCH INSTITUTE	FIBER-OPTIC SENSING DEVICE
EP0922011	1997	1999	ARTHUR D. LITTLE, INC.	METHOD AND APPARATUS FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
EP0926096	1998	1999	AIR PRODUCTS AND CHEMICALS, INC.	PRODUCTION OF SYNTHESIS GAS BY MIXED CONDUCTING MEMBRANES
EP0939672	1998	1999	UNIVERSITY OF CHICAGO	PARTIAL OXIDATION CATALYST
WO1999036351	1999	1999	ARTHUR D. LITTLE, INC.	REACTOR FOR PRODUCING HYDROGEN FROM HYDROCARBON FUELS
6048472	1997	2000	AIR PRODUCTS AND CHEMICALS, INC.	PRODUCTION OF SYNTHESIS GAS BY MIXED CONDUCTING MEMBRANES
6051125	1998	2000	UNIVERSITY OF CALIFORNIA	NATURAL GAS-ASSISTED STEAM ELECTROLYZER
6077323	1997	2000	AIR PRODUCTS AND CHEMICALS, INC.	SYNTHESIS GAS PRODUCTION BY ION TRANSPORT MEMBRANES
6083425	1998	2000	ARTHUR D. LITTLE, INC.	METHOD FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
6093306	1998	2000	SOLAR REACTOR TECHNOLOGIES INC.	COMPREHENSIVE SYSTEM FOR UTILITY LOAD LEVELING, HYDROGEN PRODUCTION, STACK GAS

				CLEANUP, GREENHOUSE GAS ABATEMENT, AND METHANOL SYNTHESIS
6103143	1999	2000	AIR PRODUCTS AND CHEMICALS, INC.	PROCESS AND APPARATUS FOR THE PRODUCTION OF HYDROGEN BY STEAM REFORMING OF HYDROCARBON
6110861	1997	2000	UNIVERSITY OF CHICAGO	PARTIAL OXIDATION CATALYST
6110979	1998	2000	AIR PRODUCTS AND CHEMICALS, INC.	UTILIZATION OF SYNTHESIS GAS PRODUCED BY MIXED CONDUCTING MEMBRANES
6114400	1998	2000	AIR PRODUCTS AND CHEMICALS, INC.	SYNTHESIS GAS PRODUCTION BY MIXED CONDUCTING MEMBRANES WITH INTEGRATED CONVERSION INTO LIQUID PRODUCTS
6123913	1998	2000	ARTHUR D. LITTLE, INC.	METHOD FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
6126908	1996	2000	ARTHUR D. LITTLE, INC.	METHOD AND APPARATUS FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
6132689	1998	2000	GENERAL MOTORS CORPORATION	MULTI-STAGE, ISOTHERMAL CO PREFERENTIAL OXIDATION REACTOR
6159272	1999	2000	MEMBRANE TECHNOLOGY AND RESEARCH, INC.	HYDROGEN RECOVERY PROCESS
6162558	1998	2000	GENERAL MOTORS CORPORATION	METHOD AND APPARATUS FOR SELECTIVE REMOVAL OF CARBON MONOXIDE
EP0977293	1999	2000	GENERAL MOTORS CORPORATION	THERMALLY INTERGRATED TWO-STAGED METHANOL REFORMER AND METHOD OF OPERATION
EP0987054	1999	2000	GENERAL MOTORS CORPORATION	A METHOD AND APPARATUS FOR SELECTIVE REMOVAL OF CARBON MONOXIDE
EP0989093	1999	2000	AIR PRODUCTS AND CHEMICALS, INC.	SYNTHESIS GAS PRODUCTION BY MIXED CONDUCTING MEMBRANES WITH INTEGRATED CONVERSION INTO LIQUID PRODUCTS
EP0989621	1999	2000	GENERAL MOTORS CORPORATION	MULTI-STAGE ISOTHERMAL CO PREFERENTIAL OXIDATION REACTOR

EP1006079	1996	2000	AIR PRODUCTS AND CHEMICALS, INC.	MATERIALS SELECTIVELY ADSORBING CO2 FROM CO2 CONTAINING STREAMS
EP1018485	1999	2000	AIR PRODUCTS AND CHEMICALS, INC.	PROCESS AND APPARATUS FOR THE PRODUCTION OF HYDROGEN BY STEAM REFORMING OF HYDROCARBON
EP1047631	1999	2000	ARTHUR D. LITTLE, INC.	REACTOR FOR PRODUCING HYDROGEN FROM HYDROCARBON FUELS
WO2000017418	1999	2000	UNIVERSITY OF CALIFORNIA	NATURAL GAS-ASSISTED STEAM ELECTROLYZER
WO2000066486	2000	2000	ARTHUR D. LITTLE, INC.	PROCESS FOR CONVERTING CARBON MONOXIDE AND WATER IN A REFORMATE STREAM AND APPARATUS THEREFORE
6207122	1998	2001	ARTHUR D. LITTLE, INC.	METHOD FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
6214066	1999	2001	AIR PRODUCTS AND CHEMICALS, INC.	SYNTHESIS GAS PRODUCTION BY ION TRANSPORT MEMBRANES
6238815	1998	2001	GENERAL MOTORS CORPORATION	THERMALLY INTEGRATED STAGED METHANOL REFORMER AND METHOD
6244367	1998	2001	UNIVERSITY OF CHICAGO	METHANOL PARTIAL OXIDATION REFORMER
6245303	1998	2001	ARTHUR D. LITTLE, INC.	REACTOR FOR PRODUCING HYDROGEN FROM HYDROCARBON FUELS
6248218	1999	2001	UNASSIGNED	CLOSED CYCLE PHOTOCATALYTIC PROCESS FOR DECOMPOSITION OF HYDROGEN SULFIDE TO ITS CONSTITUENT ELEMENTS
6254839	1998	2001	ARTHUR D. LITTLE, INC.	APPARATUS FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
6277589	1999	2001	MIDWEST RESEARCH INSTITUTE	METHOD AND APPARATUS FOR RAPID BIOHYDROGEN PHENOTYPIC SCREENING OF MICROORGANISMS USING A CHEMOCHROMIC SENSOR
6280503	1999	2001	AIR PRODUCTS AND CHEMICALS, INC.	CARBON DIOXIDE ADSORBENTS CONTAINING MAGNESIUM OXIDE SUITABLE FOR USE AT HIGH TEMPERATURES
6283723	1998	2001	VAIREX	INTEGRATED COMPRESSOR

			CORPORATION	EXPANDER APPARATUS
6296814	1998	2001	INTERNATIONAL FUEL CELLS CORPORATION	HYDROCARBON FUEL GAS REFORMER ASSEMBLY FOR A FUEL CELL POWER PLANT
6302402	1999	2001	AIR PRODUCTS AND CHEMICALS, INC.	COMPLIANT HIGH TEMPERATURE SEALS FOR DISSIMILAR MATERIALS
6303092	1995	2001	AIR PRODUCTS AND CHEMICALS, INC.	PROCESS FOR OPERATING EQUILIBRIUM CONTROLLED REACTIONS
6303098	1999	2001	UNIVERSITY OF CHICAGO	STEAM REFORMING CATALYST
6309611	1999	2001	UNIVERSITY OF CENTRAL FLORIDA	APPARATUS FOR LOW FLUX PHOTOCATALYTIC POLLUTION CONTROL
6312658	1996	2001	AIR PRODUCTS AND CHEMICALS, INC.	INTEGRATED STEAM METHANE REFORMING PROCESS FOR PRODUCING CARBON MONOXIDE AND HYDROGEN
6315870	1999	2001	UNIVERSITY OF CENTRAL FLORIDA	METHOD FOR HIGH FLUX PHOTOCATALYTIC POLLUTION CONTROL
6315973	1996	2001	AIR PRODUCTS AND CHEMICALS, INC.	PROCESS FOR OPERATING EQUILIBRIUM CONTROLLED REACTIONS
6328945	1996	2001	AIR PRODUCTS AND CHEMICALS, INC.	INTEGRATED STEAM METHANE REFORMING PROCESS FOR PRODUCING CARBON MONOXIDE
EP1066876	2000	2001	GENERAL MOTORS CORPORATION	FUEL PROCESSOR TEMPERATURE MONITORING AND CONTROL
EP1067320	2000	2001	AIR PRODUCTS AND CHEMICALS, INC.	COMPLIANT HIGH TEMPERATURE SEALS FOR DISSIMILAR MATERIALS
EP1074297	2000	2001	AIR PRODUCTS AND CHEMICALS, INC.	CARBON DIOXIDE ADSORBENTS CONTAINING MAGNESIUM OXIDE SUITABLE FOR USE AT HIGH TEMPERATURES
EP1115908	1999	2001	UNIVERSITY OF CALIFORNIA	NATURAL GAS-ASSISTED STEAM ELECTROLYZER
EP1118583	1997	2001	ARTHUR D. LITTLE, INC.	METHOD AND APPARATUS FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
WO2001014698	2000	2001	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	EMISSION ABATEMENT SYSTEM
WO2001074484	2001	2001	UNIVERSITY OF MICHIGAN	TRANSITION METAL CARBIDES, NITRIDES AND BORIDES AND THEIR OXYGEN CONTAINING

				ANALOGS USEFUL AS WATER GAS SHIFT CATALYSTS
WO2001086258	2001	2001	MIDWEST RESEARCH INSTITUTE	PD/NI-WO3 ANODIC DOUBLE LAYER GASOCHROMIC DEVICE
WO2001086265	2001	2001	MIDWEST RESEARCH INSTITUTE	H2O DOPED WO3, ULTRA-FAST, HIGH-SENSITIVITY HYDROGEN SENSORS
WO2001086266	2001	2001	MIDWEST RESEARCH INSTITUTE	PD/V2O5 DEVICE FOR H2 DETECTION
WO2001093976	2001	2001	BATTELLE MEMORIAL INSTITUTE	MICROSYSTEM CAPILLARY SEPARATIONS
WO2001095237	2001	2001	BATTELLE MEMORIAL INSTITUTE	MICROSYSTEM PROCESS NETWORKS
6334936	1999	2002	UNIVERSITY OF CENTRAL FLORIDA	METHOD FOR DECOUPLED THERMO-CATALYTIC POLLUTION CONTROL
6342128	1999	2002	UNIVERSITY OF CENTRAL FLORIDA	METHOD AND APPARATUS FOR DECOUPLED THERMO-PHOTOCATALYTIC POLLUTION CONTROL
6391484	1999	2002	GENERAL MOTORS CORPORATION	FUEL PROCESSOR TEMPERATURE MONITORING AND CONTROL
6395252	2000	2002	UT-BATTELLE, LLC	METHOD FOR THE CONTINUOUS PRODUCTION OF HYDROGEN
6401767	2001	2002	AIR PRODUCTS AND CHEMICALS, INC.	APPARATUS AND METHOD FOR GROUNDING COMPRESSED FUEL FUELING OPERATOR
6402930	2000	2002	DE NORA ELETTRODI S.P.A.	PROCESS FOR THE ELECTROLYSIS OF TECHNICAL-GRADE HYDROCHLORIC ACID CONTAMINATED WITH ORGANIC SUBSTANCES USING OXYGEN-CONSUMING CATHODES
6448068	2001	2002	MIDWEST RESEARCH INSTITUTE	SYSTEM FOR RAPID BIOHYDROGEN PHENOTYPIC SCREENING OF MICROORGANISMS USING A CHEMOCHROMIC SENSOR
6468480	1998	2002	UNASSIGNED	APPARATUS FOR CONVERTING HYDROCARBON FUEL INTO HYDROGEN GAS AND CARBON DIOXIDE
6478077	2001	2002	SANDIA	SELF SUPPORTING HEAT

			CORPORATION	TRANSFER ELEMENT
6492290	2000	2002	AIR PRODUCTS AND CHEMICALS, INC.	MIXED CONDUCTING MEMBRANES FOR SYNGAS PRODUCTION
EP1175372	2000	2002	NUVERA FUEL CELLS, INC.	PROCESS FOR CONVERTING CARBON MONOXIDE AND WATER IN A REFORMATE STREAM AND APPARATUS THEREFOR
EP1212520	2000	2002	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	EMISSION ABATEMENT SYSTEM
EP1262449	2002	2002	AIR PRODUCTS AND CHEMICALS, INC.	APPARATUS AND METHOD FOR GROUNDING AN OPERATOR WHO REFUELS WITH COMPRESSED FUEL
WO2002008117	2001	2002	APOLLO ENERGY SYSTEMS, INCORPORATED	AMMONIA CRACKER FOR PRODUCTION OF HYDROGEN
WO2002016015	2001	2002	AIR PRODUCTS AND CHEMICALS, INC.	MIXED CONDUCTING MEMBRANES FOR SYNGAS PRODUCTION
WO2002018675	2001	2002	DE NORA ELETTRODI S.P.A.	PROCESS FOR THE ELECTROLYSIS OF TECHNICAL-GRADE HYDROCHLORIC ACID CONTAMINATED WITH ORGANIC SUBSTANCES USING OXYGEN-CONSUMING CATHODES
WO2002046740	2001	2002	UNASSIGNED	HYDROGEN GAS INDICATOR SYSTEM
WO2002059565	2002	2002	UNIVERSITY OF CALIFORNIA	ELECTRODES FOR SOLID STATE GAS SENSOR
WO2002076883	2002	2002	UNIVERSITY OF CHICAGO	FUEL PROCESSOR AND METHOD FOR GENERATING HYDROGEN FOR FUEL CELLS
WO2002082045	2002	2002	ADVANCED TECHNOLOGY MATERIALS, INC.	MICRO-MACHINED THIN FILM SENSOR ARRAYS FOR THE DETECTION OF H2, NH3, AND SULFUR CONTAINING GASES, AND METHOD OF MAKING AND USING THE SAME
WO2002085783	2002	2002	TEXACO INC.	INTEGRATED FUEL PROCESSOR, FUEL CELL STACK AND TAIL GAS OXIDIZER WITH CARBON DIOXIDE REMOVAL
WO2002085796	2002	2002	GENERAL ATOMICS	PROCESS FOR HYDROTHERMAL TREATMENT OF MATERIALS
WO2002096797	2002	2002	NUVERA FUEL CELLS, INC.	HEAT TRANSFER OPTIMIZATION IN

				MULTISHELL REFORMER
6508862	2001	2003	BATTELLE MEMORIAL INSTITUTE	APPARATUS AND METHODS FOR SEPARATION/PURIFICATION UTILIZING RAPIDLY CYCLED THERMAL SWING SORPTION
6524550	2000	2003	UNASSIGNED	PROCESS FOR CONVERTING CARBON MONOXIDE AND WATER IN A REFORMATE STREAM
6531035	2001	2003	UNIVERSITY OF CENTRAL FLORIDA	APPARATUS AND METHOD FOR LOW FLUX PHOTOCATALYTIC POLLUTION CONTROL
6551561	2001	2003	UNIVERSITY OF CENTRAL FLORIDA	APPARATUS FOR DECOUPLED THERMO-PHOTOCATALYTIC POLLUTION CONTROL
6560958	1999	2003	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	EMISSION ABATEMENT SYSTEM
6569226	2001	2003	UNITED STATES DEPARTMENT OF ENERGY	METAL/CERAMIC COMPOSITES WITH HIGH HYDROGEN PERMEABILITY
6572829	2001	2003	UNIVERSITY OF CENTRAL FLORIDA	CLOSED CYCLE PHOTOCATALYTIC PROCESS FOR DECOMPOSITION OF HYDROGEN SULFIDE TO ITS CONSTITUENT ELEMENTS
6582666	2001	2003	UNASSIGNED	APPARATUS FOR HIGH FLUX PHOTOCATALYTIC POLLUTION CONTROL USING A ROTATING FLUIDIZED BED REACTOR
6596236	2001	2003	ADVANCED TECHNOLOGY MATERIALS, INC.	MICRO-MACHINED THIN FILM SENSOR ARRAYS FOR THE DETECTION OF H2 CONTAINING GASES, AND METHOD OF MAKING AND USING THE SAME
6602324	2001	2003	AIR PRODUCTS AND CHEMICALS, INC.	SULFUR CONTROL IN ION-CONDUCTING MEMBRANE SYSTEMS
6605202	2002	2003	UNIVERSITY OF CALIFORNIA	ELECTRODES FOR SOLID STATE GAS SENSOR
6623720	2001	2003	UNIVERSITY OF MICHIGAN	TRANSITION METAL CARBIDES, NITRIDES AND BORIDES, AND THEIR OXYGEN CONTAINING ANALOGS USEFUL AS WATER GAS SHIFT CATALYSTS
6641625	2000	2003	NUVERA FUEL CELLS, INC.	INTEGRATED HYDROCARBON

				REFORMING SYSTEM AND CONTROLS
6653005	2001	2003	UNIVERSITY OF CENTRAL FLORIDA	PORTABLE HYDROGEN GENERATOR-FUEL CELL APPARATUS
6666909	2000	2003	BATTELLE MEMORIAL INSTITUTE	MICROSYSTEM CAPILLARY SEPARATIONS
6670058	2001	2003	UNIVERSITY OF CENTRAL FLORIDA	THERMOCATALYTIC PROCESS FOR CO2-FREE PRODUCTION OF HYDROGEN AND CARBON FROM HYDROCARBONS
EP1279028	2001	2003	MIDWEST RESEARCH INSTITUTE	PD/V2 O5 DEVICE FOR COLORIMETRIC H2 DETECTION
EP1279029	2001	2003	MIDWEST RESEARCH INSTITUTE	H2O DOPED WO3, ULTRA-FAST, HIGH-SENSITIVE HYDROGEN SENSORS
EP1279030	2001	2003	MIDWEST RESEARCH INSTITUTE	PD/NI-WO3 ANODIC DOUBLE LAYER COLORIMETRIC GAS SENSOR
EP1286904	2001	2003	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL DEVICE FOR HEAT OR MASS TRANSFER
EP1312407	2002	2003	AIR PRODUCTS AND CHEMICALS, INC.	SULFUR CONTROL IN ION-CONDUCTING MEMBRANE SYSTEMS
EP1313893	2001	2003	DE NORA ELETTRODI S.P.A.	PROCESS FOR THE ELECTROLYSIS OF TECHNICAL-GRADE HYDROCHLORIC ACID CONTAMINATED WITH ORGANIC SUBSTANCES USING OXYGEN-CONSUMING CATHODES
EP1317319	2001	2003	AIR PRODUCTS AND CHEMICALS, INC.	MIXED CONDUCTING MEMBRANES FOR SYNGAS PRODUCTION
EP1333902	2001	2003	BATTELLE MEMORIAL INSTITUTE	MICROSYSTEM CAPILLARY SEPARATIONS
EP1336428	2003	2003	AIR PRODUCTS AND CHEMICALS, INC.	CATALYST HOLDER AND AGITATION SYSTEM FOR CONVERTING STIRRED TANK REACTOR TO FIXED BED REACTOR
EP1341604	2001	2003	MIDWEST RESEARCH INSTITUTE	SOLAR THERMAL AEROSOL FLOW REACTION PROCESS
EP1350097	2001	2003	UNASSIGNED	HYDROGEN GAS INDICATOR SYSTEM
WO2003004145	2002	2003	MILLENNIUM CELL, INC.	PORTABLE HYDROGEN GENERATOR
WO2003007263	2002	2003	OHIO STATE	CARBON MONOXIDE

			UNIVERSITY	SENSOR AND METHOD OF USE
WO2003020850	2002	2003	UNIVERSITY OF MICHIGAN	SELECTIVE SORBENTS FOR PURIFICATION OF HYDROCARBONS
WO2003027005	2002	2003	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	PLASMATRON-CATALYST SYSTEM
WO2003049835	2002	2003	BATTELLE MEMORIAL INSTITUTE	IMPROVED CONDITIONS FOR FLUID SEPARATIONS IN MICROCHANNELS, CAPILLARY-DRIVEN FLUID SEPARATIONS, AND LAMINATED DEVICES CAPABLE OF SEPARATING FLUIDS
WO2003049853	2001	2003	MIDWEST RESEARCH INSTITUTE	SOLAR THERMAL AEROSOL FLOW REACTION PROCESS
WO2003076050	2003	2003	ELTRON RESEARCH, INC.	HYDROGEN TRANSPORT MEMBRANES
WO2003078052	2003	2003	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL REACTORS WITH TEMPERATURE CONTROL
WO2003102397	2003	2003	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LOW CURRENT PLASMATRON FUEL CONVERTER HAVING ENLARGED VOLUME DISCHARGES
WO2003106946	2003	2003	NUVERA FUEL CELLS, INC.	PREFERENTIAL OXIDATION REACTOR TEMPERATURE REGULATION
6682838	2002	2004	TEXACO INC.	INTEGRATED FUEL PROCESSOR, FUEL CELL STACK, AND TAIL GAS OXIDIZER WITH CARBON DIOXIDE REMOVAL
6709602	2001	2004	GENERAL ATOMICS	PROCESS FOR HYDROTHERMAL TREATMENT OF MATERIALS
6713040	2001	2004	ARGONNE NATIONAL LABORATORY	METHOD FOR GENERATING HYDROGEN FOR FUEL CELLS
6716275	2001	2004	SANDIA CORPORATION	GAS IMPERMEABLE GLAZE FOR SEALING A POROUS CERAMIC SURFACE
6718753	2002	2004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	EMISSION ABATEMENT SYSTEM UTILIZING PARTICULATE TRAPS
6723566	2003	2004	MIDWEST RESEARCH INSTITUTE	PD/NI-WO3 ANODIC DOUBLE LAYER GASOCHROMIC DEVICE
6783742	2001	2004	NUVERA FUEL CELLS, INC.	REACTOR FOR PRODUCING HYDROGEN FROM HYDROCARBON FUELS

6783750	2001	2004	PRAXAIR TECHNOLOGY, INC.	HYDROGEN PRODUCTION METHOD
6793899	2001	2004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	PLASMATRON-CATALYST SYSTEM
6814781	2002	2004	BATTELLE MEMORIAL INSTITUTE	METHODS FOR SEPARATION/PURIFICATION UTILIZING RAPIDLY CYCLED THERMAL SWING SORPTION
EP1384059	2002	2004	ADVANCED TECHNOLOGY MATERIALS, INC.	THIN FILM SENSOR ARRAY FOR THE DETECTION OF GASES AND METHOD OF MAKING
EP1390292	2002	2004	TEXACO INC.	INTEGRATED FUEL PROCESSOR, FUEL CELL STACK AND TAIL GAS OXIDIZER WITH CARBON DIOXIDE REMOVAL
EP1390302	2002	2004	GENERAL ATOMICS	PROCESS FOR HYDROTHERMAL TREATMENT OF MATERIALS
EP1397307	2002	2004	NUVERA FUEL CELLS, INC.	HEAT TRANSFER OPTIMIZATION IN MULTISHELL REFORMER
EP1419492	2002	2004	OHIO STATE UNIVERSITY	CARBON MONOXIDE SENSOR AND METHOD OF USE
EP1420197	2003	2004	AIR PRODUCTS AND CHEMICALS, INC.	ROTARY SEQUENCING VALVE WITH FLEXIBLE PORT PLATE
EP1433739	2002	2004	AIR PRODUCTS AND CHEMICALS, INC.	APPARATUS AND METHOD FOR GROUNDING COMPRESSED FUEL FUELING OPERATOR
EP1459800	2004	2004	AIR PRODUCTS AND CHEMICALS, INC.	PLANAR CERAMIC MEMBRANE ASSEMBLY AND OXIDATION REACTOR SYSTEM
EP1461132	2002	2004	BATTELLE MEMORIAL INSTITUTE	IMPROVED CONDITIONS FOR FLUID SEPARATIONS IN MICROCHANNELS, CAPILLARY-DRIVEN FLUID SEPARATIONS
EP1466693	2004	2004	AIR PRODUCTS AND CHEMICALS, INC.	METHOD OF JOINING ITM MATERIALS USING A PARTIALLY- OR FULLY-TRANSIENT LIQUID PHASE
EP1466694	2004	2004	AIR PRODUCTS AND CHEMICALS, INC.	METHOD OF FORMING A JOINT
EP1475349	2004	2004	AIR PRODUCTS AND CHEMICALS, INC.	HYDROGEN STORAGE BY REVERSIBLE HYDROGENATION OF PI-CONJUGATED SUBSTRATES
EP1483047	2003	2004	BATTELLE	TEMPERATURE CONTROL

			MEMORIAL INSTITUTE	FOR WATER-GAS-SHIFT REACTION
EP1487563	2003	2004	ELTRON RESEARCH, INC.	HYDROGEN TRANSPORT MEMBRANES
WO2004027336	2002	2004	MIDWEST RESEARCH INSTITUTE	CARBON NANOTUBE HEAT-EXCHANGE SYSTEMS
WO2004050961	2003	2004	UNIVERSITY OF TOLEDO	INTEGRATED PHOTOELECTROCHEMICAL CELL AND SYSTEM HAVING A LIQUID ELECTROLYTE
WO2004058399	2003	2004	HONDA CORP	PLATINUM AND RHODIUM AND/OR IRON CONTAINING CATALYST FORMULATIONS FOR HYDROGEN GENERATION
WO2004067138	2004	2004	BATTELLE MEMORIAL INSTITUTE	METHODS FOR FLUID SEPARATIONS, AND DEVICES CAPABLE OF SEPARATING FLUIDS
WO2004071946	2004	2004	MILLENNIUM CELL, INC.	HYDROGEN GAS GENERATION SYSTEM
WO2004081259	2004	2004	UNIVERSITY OF CALIFORNIA	A SYSTEM FOR THE CO-PRODUCTION OF ELECTRICITY AND HYDROGEN
WO2004093524	2004	2004	MIDWEST RESEARCH INSTITUTE	OXYGEN-RESISTANT HYDROGENASES AND METHODS FOR DESIGNING AND MAKING SAME
WO2004104140	2004	2004	BATTELLE MEMORIAL INSTITUTE	RAPID START FUEL REFORMING SYSTEMS AND TECHNIQUES
6869462	2003	2005	BATTELLE MEMORIAL INSTITUTE	METHODS OF CONTACTING SUBSTANCES AND MICROSYSTEM CONTACTORS
6872378	2003	2005	MIDWEST RESEARCH INSTITUTE	SOLAR THERMAL AEROSOL FLOW REACTION PROCESS
6875247	2001	2005	BATTELLE MEMORIAL INSTITUTE	CONDITIONS FOR FLUID SEPARATIONS IN MICROCHANNELS, CAPILLARY-DRIVEN FLUID SEPARATIONS, AND LAMINATED DEVICES CAPABLE OF SEPARATING FLUIDS
6875417	2002	2005	UNIVERSITY OF KENTUCKY	CATALYTIC CONVERSION OF HYDROCARBONS TO HYDROGEN AND HIGH-VALUE CARBON
6878362	2002	2005	GENERAL ELECTRIC COMPANY	FUEL PROCESSOR APPARATUS AND METHOD BASED ON AUTOTHERMAL CYCLIC REFORMING

6881386	2002	2005	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LOW CURRENT PLASMATRON FUEL CONVERTER HAVING ENLARGED VOLUME DISCHARGES
6887728	2003	2005	UNIVERSITY OF HAWAII	HYBRID SOLID STATE/ELECTROCHEMICAL PHOTOELECTRODE FOR HYDROGEN PRODUCTION
6889710	2002	2005	AIR PRODUCTS AND CHEMICALS, INC.	ROTARY SEQUENCING VALVE WITH FLEXIBLE PORT PLATE
6895805	2003	2005	UNASSIGNED	HYDROGEN GAS INDICATOR SYSTEM
6899744	2003	2005	ELTRON RESEARCH, INC.	HYDROGEN TRANSPORT MEMBRANES
6901904	2003	2005	MECHANOLOGY, INC.	SEALING INTERSECTING VANE MACHINES
6932847	2001	2005	MILLENNIUM CELL, INC.	PORTABLE HYDROGEN GENERATOR
6936363	2003	2005	APOLLO ENERGY SYSTEMS, INCORPORATED	AMMONIA CRACKER FOR PRODUCTION OF HYDROGEN
6967063	2001	2005	UNIVERSITY OF CHICAGO	AUTOTHERMAL HYDRODESULFURIZING REFORMING METHOD AND CATALYST
EP1504811	2004	2005	AIR PRODUCTS AND CHEMICALS, INC.	PRESSURE VESSEL CONTAINING ION TRANSPORT MEMBRANE MODULES AND PROCESSES MAKING USE THEREOF
EP1532355	2003	2005	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LOW CURRENT PLASMATRON FUEL CONVERTER HAVING ENLARGED VOLUME DISCHARGES
EP1533269	2002	2005	AIR PRODUCTS AND CHEMICALS, INC.	APPARATUS AND METHOD FOR GROUNDING COMPRESSED FUEL FUELING OPERATOR
EP1578529	2003	2005	HONDA CORP	PLATINUM AND RHODIUM AND/OR IRON CONTAINING CATALYST FORMULATIONS FOR HYDROGEN GENERATION
EP1581784	2003	2005	NUVERA FUEL CELLS, INC.	PREFERENTIAL OXIDATION REACTOR TEMPERATURE REGULATION
EP1587596	2004	2005	BATTELLE MEMORIAL INSTITUTE	METHODS FOR FLUID SEPARATIONS, AND DEVICES CAPABLE OF SEPARATING FLUIDS
EP1601613	2004	2005	MILLENNIUM CELL, INC.	HYDROGEN GAS GENERATION SYSTEM
WO2005025723	2004	2005	ELTRON RESEARCH,	DENSE, LAYERED

			INC.	MEMBRANES FOR HYDROGEN SEPARATION
WO2005042694	2003	2005	MIDWEST RESEARCH INSTITUTE	MULTI-STAGE MICROBIAL SYSTEM FOR CONTINUOUS HYDROGEN PRODUCTION
WO2005062850	2004	2005	MECHANOLOGY, INC.	IMPROVEMENTS IN SEALING INTERSECTING VANE MACHINES
WO2005064138	2004	2005	MECHANOLOGY, INC.	IMPROVEMENTS IN INTERSECTING VANE MACHINES
WO2005072254	2005	2005	UNIVERSITY OF CALIFORNIA	MODULATION OF SULFATE PERMEASE FOR PHOTOSYNTHETIC HYDROGEN PRODUCTION
WO2005080201	2005	2005	GAS TECHNOLOGY INSTITUTE	CONTROL METHOD FOR HIGH-PRESSURE HYDROGEN VEHICLE FUELING STATION DISPENSERS
WO2005113125	2005	2005	NUVERA FUEL CELLS, INC.	STARTUP BURNER
6985082	2001	2006	NEXTECH MATERIALS, LTD.	CARBON MONOXIDE SENSOR AND METHOD OF USE
6986797	2000	2006	NUVERA FUEL CELLS, INC.	AUXILIARY REACTOR FOR A HYDROCARBON REFORMING SYSTEM
6989252	2000	2006	MIDWEST RESEARCH INSTITUTE	HYDROGEN PRODUCTION USING HYDROGENASE-CONTAINING OXYGENIC PHOTOSYNTHETIC ORGANISMS
7001446	2003	2006	ELTRON RESEARCH, INC.	DENSE, LAYERED MEMBRANES FOR HYDROGEN SEPARATION
7011694	2002	2006	UNIVERSITY OF KENTUCKY	CO2-SELECTIVE MEMBRANES CONTAINING AMINO GROUPS
7011898	2003	2006	AIR PRODUCTS AND CHEMICALS, INC.	METHOD OF JOINING ITM MATERIALS USING A PARTIALLY OR FULLY-TRANSIENT LIQUID PHASE
7029574	2003	2006	UNIVERSITY OF MICHIGAN	SELECTIVE SORBENTS FOR PURIFICATION OF HYDROCARBONS
7033570	2003	2006	MIDWEST RESEARCH INSTITUTE	SOLAR-THERMAL FLUID-WALL REACTION PROCESSING
7041616	2003	2006	SANDIA CORPORATION	ENHANCED SELECTIVITY OF ZEOLITES BY CONTROLLED CARBON DEPOSITION
7051540	2003	2006	BATTELLE MEMORIAL INSTITUTE	METHODS FOR FLUID SEPARATIONS, AND DEVICES CAPABLE OF

				SEPARATING FLUIDS
7053256	2003	2006	UNIVERSITY OF MICHIGAN	SELECTIVE SORBENTS FOR PURIFICATION OF HYDROCARBONS
7059364	2004	2006	GAS TECHNOLOGY INSTITUTE	CONTROL METHOD FOR HIGH-PRESSURE HYDROGEN VEHICLE FUELING STATION DISPENSERS
7063131	2002	2006	NUVERA FUEL CELLS, INC.	PERFORATED FIN HEAT EXCHANGERS AND CATALYTIC SUPPORT
7066973	2000	2006	NUVERA FUEL CELLS, INC.	INTEGRATED REFORMER AND SHIFT REACTOR
7067453	2002	2006	INNOVATEK, INC.	HYDROCARBON FUEL REFORMING CATALYST AND USE THEREOF
7067456	2003	2006	OHIO STATE UNIVERSITY	SORBENT FOR SEPARATION OF CARBON DIOXIDE (CO2) FROM GAS MIXTURES
7074369	2001	2006	UNIVERSITY OF CENTRAL FLORIDA	METHOD AND APPARATUS FOR DECOUPLED THERMO-CATALYTIC POLLUTION CONTROL
7074962	2002	2006	AIR PRODUCTS AND CHEMICALS, INC.	CATALYST HOLDER AND AGITATION SYSTEM FOR CONVERTING STIRRED TANK REACTOR TO FIXED BED REACTOR
7087211	2003	2006	UNIVERSITY OF CHICAGO	HYDROGEN PRODUCTION BY HIGH TEMPERATURE WATER SPLITTING USING ELECTRON CONDUCTING MEMBRANES
7094301	2003	2006	AIR PRODUCTS AND CHEMICALS, INC.	METHOD OF FORMING A JOINT
7094333	2003	2006	UNIVERSITY OF MICHIGAN	SELECTIVE SORBENTS FOR PURIFICATION OF HYDROCARBONS
7101530	2003	2006	AIR PRODUCTS AND CHEMICALS, INC.	HYDROGEN STORAGE BY REVERSIBLE HYDROGENATION OF PI-CONJUGATED SUBSTRATES
7105033	2003	2006	MILLENNIUM CELL, INC.	HYDROGEN GAS GENERATION SYSTEM
7119226	2005	2006	PENN STATE UNIVERSITY	PROCESS FOR THE CONVERSION OF METHANE
7122873	2005	2006	UNIVERSITY OF HAWAII	HYBRID SOLID STATE/ELECTROCHEMICAL PHOTOELECTRODE FOR HYRODROGEN PRODUCTION
7125540	2000	2006	BATTELLE MEMORIAL INSTITUTE	MICROSYSTEM PROCESS NETWORKS
7148389	2002	2006	UNIVERSITY OF	SELECTIVE SORBENTS FOR

			MICHIGAN	PURIFICATION OF HYDROCARTONS
EP1629068	2004	2006	BATTELLE MEMORIAL INSTITUTE	RAPID START FUEL REFORMING SYSTEMS AND TECHNIQUES
EP1637215	2005	2006	AIR PRODUCTS AND CHEMICALS, INC.	OPERATION OF MIXED CONDUCTING METAL OXIDE MEMBRANE SYSTEMS UNDER TRANSIENT CONDITIONS
EP1676624	2005	2006	AIR PRODUCTS AND CHEMICALS, INC.	FEED GAS CONTAMINANT REMOVAL IN ION TRANSPORT MEMBRANE SYSTEMS
EP1676811	2005	2006	AIR PRODUCTS AND CHEMICALS, INC.	ION TRANSPORT MEMBRANE MODULE AND VESSEL SYSTEM WITH DIRECTED INTERNAL GAS FLOW
EP1691127	2006	2006	AIR PRODUCTS AND CHEMICALS, INC.	METHOD FOR DELIVERING CRYOGENIC FLUID, IN LIQUID OR IN GAS PHASE, TO A NETWORK OF RECEIVING FUEL STATIONS
EP1709310	2004	2006	MECHANOLOGY, INC.	IMPROVEMENTS IN INTERSECTING VANE MACHINES
EP1713691	2005	2006	GAS TECHNOLOGY INSTITUTE	CONTROL METHOD FOR HIGH-PRESSURE HYDROGEN VEHICLE FUELING STATION DISPENSERS
EP1716908	2006	2006	AIR PRODUCTS AND CHEMICALS, INC.	SOLID-STATE MEMBRANE MODULE
WO2006009787	2005	2006	NUVERA FUEL CELLS, INC.	DEVICE FOR COOLING AND HUMIDIFYING REFORMATE
WO2006050531	2005	2006	OHIO STATE UNIVERSITY	MEMBRANES, METHODS OF MAKING MEMBRANES, AND METHODS OF SEPARATING GASES USING MEMBRANES
WO2006083296	2005	2006	NUVERA FUEL CELLS, INC.	FUEL FIRED HYDROGEN GENERATOR
WO2006091756	2006	2006	UNIVERSITY OF COLORADO	MIS-BASED SENSORS WITH HYDROGEN SELECTIVITY
WO2006093998	2006	2006	MIDWEST RESEARCH INSTITUTE	PROCESS AND GENES FOR EXPRESSION AND OVER-EXPRESSION OF ACTIVE [FEFE] HYDROGENASES
WO2006110780	2006	2006	UNIVERSITY OF SOUTH CAROLINA	PRODUCTION OF LOW TEMPERATURE ELECTROLYTIC HYDROGEN
WO2006124195	2006	2006	CATACEL CORP.	CATALYTIC REACTOR HAVING RADIAL LEAVES
WO2006138485	2006	2006	OHIO STATE UNIVERSITY	CATALYST FOR HYDROGEN PRODUCTION FROM WATER GAS SHIFT REACTION

7157167	2003	2007	UNIVERSITY OF CENTRAL FLORIDA	THERMOCATALYTIC PROCESS FOR CO2-FREE PRODUCTION OF HYDROGEN AND CARBON FROM HYDROCARBONS
7162993	2003	2007	MECHANOLOGY, INC.	INTERSECTING VANE MACHINES
7176005	2004	2007	UNIVERSITY OF CALIFORNIA	MODULATION OF SULFATE PERMEASE FOR PHOTOSYNTHETIC HYDROGEN PRODUCTION
7179323	2003	2007	AIR PRODUCTS AND CHEMICALS, INC.	ION TRANSPORT MEMBRANE MODULE AND VESSEL SYSTEM
7214333	2003	2007	LOS ALAMOS NATIONAL SECURITY, LLC	ELECTRODES FOR SOLID STATE GAS SENSOR
7225789	2005	2007	MECHANOLOGY, INC.	SEALING INTERSECTING VANE MACHINES
7229785	2004	2007	MIDWEST RESEARCH INSTITUTE	FLUORESCENCE TECHNIQUE FOR ON-LINE MONITORING OF STATE OF HYDROGEN-PRODUCING MICROORGANISMS
7233034	2005	2007	MIDWEST RESEARCH INSTITUTE	HYDROGEN PERMEABLE PROTECTIVE COATING FOR A CATALYTIC SURFACE
7242311	2004	2007	CATERPILLAR INC.	METHOD AND SYSTEM FOR PROVIDING WORK MACHINE MULTI-FUNCTIONAL USER INTERFACE
7264025	2005	2007	AIR PRODUCTS AND CHEMICALS, INC.	OPTIMIZED CRYOGENIC FLUID SUPPLY METHOD
7270905	2005	2007	BATTELLE MEMORIAL INSTITUTE	MICROSYSTEM PROCESS NETWORKS
7272941	2005	2007	BATTELLE MEMORIAL INSTITUTE	METHODS FOR FLUID SEPARATIONS, AND DEVICES CAPABLE OF SEPARATING FLUIDS
7276306	2003	2007	UNIVERSITY OF CALIFORNIA	SYSTEM FOR THE CO-PRODUCTION OF ELECTRICITY AND HYDROGEN
7279027	2003	2007	AIR PRODUCTS AND CHEMICALS, INC.	PLANAR CERAMIC MEMBRANE ASSEMBLY AND OXIDATION REACTOR SYSTEM
7279143	2004	2007	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	PLASMATRON-CATALYST SYSTEM
7297324	2003	2007	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL REACTORS WITH TEMPERATURE CONTROL
7311755	2004	2007	AIR PRODUCTS AND	CONTROL OF

			CHEMICALS, INC.	DIFFERENTIAL STRAIN DURING HEATING AND COOLING OF MIXED CONDUCTING METAL OXIDE MEMBRANES
EP1750835	2005	2007	NUVERA FUEL CELLS, INC.	STARTUP BURNER
EP1775260	2006	2007	AIR PRODUCTS AND CHEMICALS, INC.	ION TRANSPORT MEMBRANE SYSTEM
EP1784259	2005	2007	NUVERA FUEL CELLS, INC.	DEVICE FOR COOLING AND HUMIDIFYING REFORMATE
EP1786725	2005	2007	NUVERA FUEL CELLS, INC.	FUEL FIRED HYDROGEN GENERATOR
EP1788293	2006	2007	AIR PRODUCTS AND CHEMICALS, INC.	SEAL ASSEMBLY FOR MATERIALS WITH DIFFERENT COEFFICIENTS OF THERMAL EXPANSION
EP1795252	2006	2007	AIR PRODUCTS AND CHEMICALS, INC.	MODULE ISOLATION DEVICES
EP1804962	2005	2007	PRAXAIR TECHNOLOGY, INC.	CATALYTIC REACTOR
EP1814646	2005	2007	BOSTON UNIVERSITY	COMPOSITE MIXED OXIDE IONIC AND ELECTRONIC CONDUCTORS FOR HYDROGEN SEPARATION
EP1816112	2007	2007	AIR PRODUCTS AND CHEMICALS, INC.	METHOD OF FORMING A CERAMIC TO CERAMIC JOINT
EP1826177	2007	2007	AIR PRODUCTS AND CHEMICALS, INC.	PRODUCTION OF CARBON MONOXIDE-FREE HYDROGEN FROM A HIGH-PURITY SOURCE
EP1853716	2006	2007	MIDWEST RESEARCH INSTITUTE	PROCESS AND GENES FOR EXPRESSION AND OVER-EXPRESSION OF ACTIVE [FEFE] HYDROGENASES
WO2007001350	2005	2007	PRAXAIR TECHNOLOGY, INC.	CATALYTIC REACTOR
WO2007005255	2006	2007	GENERAL ELECTRIC COMPANY	SYSTEM AND METHOD FOR HYDROGEN PRODUCTION
WO2007011401	2005	2007	BOSTON UNIVERSITY	COMPOSITE MIXED OXIDE IONIC AND ELECTRONIC CONDUCTORS FOR HYDROGEN SEPARATION
WO2007015969	2006	2007	CATACEL CORP.	REACTOR HAVING IMPROVED HEAT TRANSFER
WO2007035303	2006	2007	BATTELLE MEMORIAL INSTITUTE	MIXING IN WICKING STRUCTURES AND THE USE OF ENHANCED MIXING WITHIN WICKS IN MICROCHANNEL DEVICES
WO2007037933	2006	2007	GENERAL ELECTRIC COMPANY	FUNCTIONALIZED INORGANIC MEMBRANES FOR GAS SEPARATION
WO2007040656	2006	2007	CATERPILLAR INC.	CROWD FORCE CONTROL

				IN ELECTRICALLY PROPELLED WORK MACHINE
WO2007046815	2005	2007	OHIO STATE UNIVERSITY	SEPARATION OF CARBON DIOXIDE (CO2) FROM GAS MIXTURES BY CALCIUM BASED REACTION SEPARATION (CARS-CO2) PROCESS
WO2007050149	2006	2007	CATERPILLAR INC.	IN-LINE DRIVETRAIN AND FOUR WHEEL DRIVE WORK MACHINE USING SAME
WO2007092844	2007	2007	ELTRON RESEARCH, INC.	HYDROGEN SEPARATION PROCESS
WO2007106138	2006	2007	INTELLIGENT ENERGY, INC.	FUEL STEAM REFORMER SYSTEM AND REFORMER STARTUP PROCESS
WO2007106139	2006	2007	INTELLIGENT ENERGY, INC.	HYDROGEN PURIFICATION PROCESS AND SYSTEM
WO2007112314	2007	2007	WISCONSIN ALUMNI RESEARCH FOUNDATION	METHOD FOR PRODUCING BIO-FUEL THAT INTEGRATES HEAT FROM CARBON-CARBON BOND-FORMING REACTIONS TO DRIVE BIOMASS GASIFICATION REACTIONS
WO2007134340	2007	2007	UNASSIGNED	DESIGNER PROTON-CHANNEL TRANSGENIC ALGAE FOR PHOTOBIOLOGICAL HYDROGEN PRODUCTION
WO2007143354	2007	2007	UNASSIGNED	SWITCHABLE PHOTOSYSTEM-II DESIGNER ALGAE FOR PHOTOBIOLOGICAL HYDROGEN PRODUCTION
7323159	2004	2008	UCHICAGO ARGONNE, LLC	METHOD FOR FAST START OF A FUEL PROCESSOR
7335247	2007	2008	AIR PRODUCTS AND CHEMICALS, INC.	ION TRANSPORT MEMBRANE MODULE AND VESSEL SYSTEM
7340938	2006	2008	UNIVERSITY OF COLORADO	MIS-BASED SENSORS WITH HYDROGEN SELECTIVITY
7344576	2005	2008	BATTELLE MEMORIAL INSTITUTE	CONDITIONS FOR FLUID SEPARATIONS IN MICROCHANNELS, CAPILLARY-DRIVEN FLUID SEPARATIONS, AND LAMINATED DEVICES CAPABLE OF SEPARATING FLUIDS
7351395	2005	2008	AIR PRODUCTS AND CHEMICALS, INC.	HYDROGEN STORAGE BY REVERSIBLE HYDROGENATION OF PI-CONJUGATED SUBSTRATES
7354465	2005	2008	NUVERA FUEL	DEVICE FOR COOLING AND

			CELLS, INC.	HUMIDIFYING REFORMATE
7361430	2004	2008	UNITED STATES DEPARTMENT OF ENERGY	CARBON NANOTUBE-POLYMER COMPOSITE ACTUATORS
7367996	2001	2008	NUVERA FUEL CELLS, INC.	HEAT TRANSFER OPTIMIZATION IN MULTI SHELLED REFORMERS
7370511	2004	2008	MST TECHNOLOGY GMBH	GAS SENSOR WITH ATTENUATED DRIFT CHARACTERISTIC
7396382	2005	2008	GENERAL ELECTRIC COMPANY	FUNCTIONALIZED INORGANIC MEMBRANES FOR GAS SEPARATION
7407458	2005	2008	CATERPILLAR INC.	IN-LINE DRIVETRAIN AND FOUR WHEEL DRIVE WORK MACHINE USING SAME
7419635	2003	2008	MIDWEST RESEARCH INSTITUTE	PD/V2O5 DEVICE FOR COLORIMETRIC H2 DETECTION
7425231	2005	2008	AIR PRODUCTS AND CHEMICALS, INC.	FEED GAS CONTAMINANT REMOVAL IN ION TRANSPORT MEMBRANE SYSTEMS
7429372	2004	2008	AIR PRODUCTS AND CHEMICALS, INC.	HYDROGEN STORAGE BY REVERSIBLE HYDROGENATION OF PI-CONJUGATED SUBSTRATES
7434547	2005	2008	NUVERA FUEL CELLS, INC.	FUEL FIRED HYDROGEN GENERATOR
7439273	2006	2008	INTELLIGENT ENERGY, INC.	HYDROGEN PURIFICATION PROCESS AND SYSTEM
7448441	2004	2008	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	CARBON NANOTUBE HEAT-EXCHANGE SYSTEMS
7452407	2006	2008	AIR PRODUCTS AND CHEMICALS, INC.	PRODUCTION OF CARBON MONOXIDE-FREE HYDROGEN AND HELIUM FROM A HIGH-PURITY SOURCE
7468092	2005	2008	AIR PRODUCTS AND CHEMICALS, INC.	OPERATION OF MIXED CONDUCTING METAL OXIDE MEMBRANE SYSTEMS UNDER TRANSIENT CONDITIONS
EP1888221	2006	2008	CATACEL CORP.	CATALYTIC REACTOR HAVING RADIAL LEAVES
EP1901844	2006	2008	OHIO STATE UNIVERSITY	CATALYST FOR HYDROGEN PRODUCTION FROM WATER GAS SHIFT REACTION
EP1904401	2006	2008	GENERAL ELECTRIC COMPANY	SYSTEM AND METHOD FOR HYDROGEN PRODUCTION
EP1910765	2006	2008	CATACEL CORP.	REACTOR HAVING IMPROVED HEAT TRANSFER
EP1920827	2007	2008	GENERAL ELECTRIC COMPANY	APPARATUS FOR CARBON DIOXIDE REMOVAL FROM A

				FLUID STREAM
EP1924351	2006	2008	BATTELLE MEMORIAL INSTITUTE	MIXING IN WICKING STRUCTURES AND THE USE OF ENHANCED MIXING WITHIN WICKS IN MICROCHANNEL DEVICES
EP1931452	2006	2008	GENERAL ELECTRIC COMPANY	FUNCTIONALIZED INORGANIC MEMBRANES FOR GAS SEPARATION
EP1948349	2005	2008	OHIO STATE UNIVERSITY	SEPARATION OF CARBON DIOXIDE (CO2) FROM GAS MIXTURES BY CALCIUM BASED REACTION SEPARATION (CARS-CO2) PROCESS
EP1972367	2008	2008	AIR PRODUCTS AND CHEMICALS, INC.	ADSORPTION PROCESS TO RECOVER HYDROGEN FROM FEED GAS MIXTURES HAVING LOW HYDROGEN CONCENTRATION
EP1996533	2006	2008	INTELLIGENT ENERGY, INC.	HYDROGEN PURIFICATION PROCESS AND SYSTEM
EP2004544	2006	2008	INTELLIGENT ENERGY, INC.	FUEL STEAM REFORMER SYSTEM AND REFORMER STARTUP PROCESS
EP2007850	2007	2008	WISCONSIN ALUMNI RESEARCH FOUNDATION	METHOD FOR PRODUCING BIO-FUEL THAT INTEGRATES HEAT FROM CARBON-CARBON BOND-FORMING REACTIONS TO DRIVE BIOMASS GASIFICATION REACTIONS
WO2008016728	2007	2008	BATTELLE ENERGY ALLIANCE, LLC	HIGH TEMPERATURE ELECTROLYSIS FOR SYNGAS PRODUCTION
WO2008019181	2007	2008	UNIVERSITY OF MICHIGAN	REDUCIBLE OXIDE BASED CATALYSTS
WO2008036902	2007	2008	ELTRON RESEARCH, INC.	CYCLIC CATALYTIC UPGRADING OF CHEMICAL SPECIES USING METAL OXIDE MATERIALS
WO2008041968	2006	2008	UNITED TECHNOLOGIES CORPORATION	PD MEMBRANE HAVING IMPROVED H2-PERMEANCE, AND METHOD OF MAKING
WO2008069830	2007	2008	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS
WO2008076903	2007	2008	CATACEL CORP.	STACKABLE STRUCTURAL REACTOR
WO2008097691	2008	2008	ARIZONA PUBLIC SERVICE COMPANY	SYSTEM AND METHOD FOR PRODUCING SUBSTITUTE NATURAL GAS FROM COAL
WO2008105770	2007	2008	UTC POWER CORPORATION	DURABLE PD-BASED ALLOY AND HYDROGEN GENERATION MEMBRANE THEREOF
WO2008144038	2008	2008	ENERFUEL, INC.	HYDROGEN PRODUCTION

				FROM BOROHYDRIDES AND GLYCEROL
7472936	2005	2009	CATACEL CORP.	TOOL FOR INSERTION AND REMOVAL OF A CATALYTIC REACTOR CARTRIDGE
7473466	2003	2009	UNIVERSITY OF CENTRAL FLORIDA	FILAMENTOUS CARBON PARTICLES FOR CLEANING OIL SPILLS AND METHOD OF PRODUCTION
7485161	2005	2009	AIR PRODUCTS AND CHEMICALS, INC.	DEHYDROGENATION OF LIQUID FUEL IN MICROCHANNEL CATALYTIC REACTOR
7500999	2004	2009	PRAXAIR TECHNOLOGY, INC.	CATALYTIC REACTOR
7501101	2005	2009	BATTELLE MEMORIAL INSTITUTE	MICROCHANNEL APPARATUS COMPRISING PLURAL MICROCHANNELS AND METHODS OF CONDUCTING UNIT OPERATIONS
7501102	2005	2009	CATACEL CORP.	REACTOR HAVING IMPROVED HEAT TRANSFER
7501270	2005	2009	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	OXYGEN-RESISTANT HYDROGENASES AND METHODS FOR DESIGNING AND MAKING SAME
7504083	2006	2009	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	PROCESS OF FORMING A SOL-GEL/METAL HYDRIDE COMPOSITE
7507384	2003	2009	NUVERA FUEL CELLS, INC.	PREFERENTIAL OXIDATION REACTOR TEMPERATURE REGULATION
7507690	2004	2009	UCHICAGO ARGONNE, LLC	AUTOTHERMAL REFORMING CATALYST HAVING PEROVSKITE STRUCTURE
7513932	2007	2009	AIR PRODUCTS AND CHEMICALS, INC.	PLANAR CERAMIC MEMBRANE ASSEMBLY AND OXIDATION REACTOR SYSTEM
7513978	2004	2009	UNASSIGNED	METHOD AND APPARATUS FOR GENERATING HYDROGEN
7519462	2005	2009	CATERPILLAR INC.	CROWD FORCE CONTROL IN ELECTRICALLY PROPELLED MACHINE
7520917	2005	2009	BATTELLE MEMORIAL INSTITUTE	DEVICES WITH EXTENDED AREA STRUCTURES FOR MASS TRANSFER PROCESSING OF FLUIDS
7530931	2005	2009	MILLENNIUM CELL, INC.	HYDROGEN GENERATOR
7540475	2005	2009	BATTELLE MEMORIAL	MIXING IN WICKING STRUCTURES AND THE USE

			INSTITUTE	OF ENHANCED MIXING WITHIN WICKS IN MICROCHANNEL DEVICES
7540892	2006	2009	MILLENNIUM CELL, INC.	HYDROGEN GAS GENERATION SYSTEM
7556675	2005	2009	AIR PRODUCTS AND CHEMICALS, INC.	FEED GAS CONTAMINANT CONTROL IN ION TRANSPORT MEMBRANE SYSTEMS
7559978	2005	2009	GENERAL ELECTRIC COMPANY	GAS-LIQUID SEPARATOR AND METHOD OF OPERATION
7563292	2004	2009	UCHICAGO ARGONNE, LLC	FUEL PROCESSOR AND METHOD FOR GENERATING HYDROGEN FOR FUEL CELLS
7565743	2005	2009	CATACEL CORP.	METHOD FOR INSERTION AND REMOVAL OF A CATALYTIC REACTOR CARTRIDGE
7569085	2004	2009	GENERAL ELECTRIC COMPANY	SYSTEM AND METHOD FOR HYDROGEN PRODUCTION
7569293	2002	2009	NUVERA FUEL CELLS, INC.	METHODS AND SYSTEMS FOR EFFICIENT OPERATION OF INTEGRATED FUEL CELL-FUEL REFORMER SYSTEMS
7575614	2005	2009	NUVERA FUEL CELLS, INC.	STARTUP BURNER
7581765	2005	2009	AIR PRODUCTS AND CHEMICALS, INC.	SEAL ASSEMBLY FOR MATERIALS WITH DIFFERENT COEFFICIENTS OF THERMAL EXPANSION
7588626	2005	2009	BOSTON UNIVERSITY	COMPOSITE MIXED OXIDE IONIC AND ELECTRONIC CONDUCTORS FOR HYDROGEN SEPARATION
7588746	2006	2009	UNIVERSITY OF CENTRAL FLORIDA	PROCESS AND APPARATUS FOR HYDROGEN AND CARBON PRODUCTION VIA CARBON AEROSOL-CATALYZED DISSOCIATION OF HYDROCARBONS
7591864	2005	2009	UNIVERSITY OF CENTRAL FLORIDA	CATALYSTS FOR THE EVOLUTION OF HYDROGEN FROM BOROHYDRIDE SOLUTION
7597860	2005	2009	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LOW CURRENT PLASMATRON FUEL CONVERTER HAVING ENLARGED VOLUME DISCHARGES
7618600	2006	2009	SANDIA CORPORATION	REACTOR FOR REMOVING AMMONIA
7618606	2005	2009	OHIO STATE UNIVERSITY	SEPARATION OF CARBON DIOXIDE (CO2) FROM GAS

				MIXTURES BY CALCIUM BASED REACTION SEPARATION (CARS-CO2)PROCESS
EP2016037	2007	2009	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS
EP2076325	2007	2009	ELTRON RESEARCH, INC.	CYCLIC CATALYTIC UPGRADING OF CHEMICAL SPECIES USING METAL OXIDE MATERIALS
EP2097706	2007	2009	CATACEL CORP.	STACKABLE STRUCTURAL REACTOR
EP2110361	2009	2009	DELPHI TECHNOLOGIES, INC.	CARTRIDGE ADSORBER SYSTEM FOR REMOVING HYDROGEN SULFIDE FROM REFORMATE
EP2111291	2007	2009	VIRENT ENERGY SYSTEMS INC.	REACTOR SYSTEM AND PROCESS FOR PRODUCING GASEOUS PRODUCTS FROM OXYGENATED HYDROCARBONS
EP2125996	2008	2009	ARIZONA PUBLIC SERVICE COMPANY	SYSTEM AND METHOD FOR PRODUCING SUBSTITUTE NATURAL GAS FROM COAL
WO2008140617	2007	2009	VIRENT ENERGY SYSTEMS INC.	REACTOR SYSTEM FOR PRODUCING GASEOUS PRODUCTS
WO2009020626	2008	2009	CERAMATEC, INC.	PROTON CONDUCTING CERAMIC MEMBRANES FOR HYDROGEN SEPARATION
WO2009061795	2008	2009	UNIVERSITY OF COLORADO	METAL FERRITE SPINEL ENERGY STORAGE DEVICES AND METHODS FOR MAKING AND USING SAME
WO2009070760	2008	2009	ELEMENT ONE, INC.	HYDROGEN SULFIDE INDICATING PIGMENTS
WO2009075798	2008	2009	UNIVERSITY OF GEORGIA	HYDROGENASE POLYPEPTIDE AND METHODS OF USE
WO2009113982	2008	2009	UNIVERSITY OF CENTRAL FLORIDA	PROCESS AND APPARATUS FOR HYDROGEN AND CARBON PRODUCTION VIA CARBON AEROSOL-CATALYZED DISSOCIATION OF HYDROCARBONS
WO2009118929	2008	2009	TOSHIBA CORP	METHANOL OXIDATION CATALYST
WO2009124169	2009	2009	LOS ALAMOS NATIONAL SECURITY, LLC	HYDROGEN PRODUCTION USING AMMONIA BORANE
7642405	2007	2010	UNASSIGNED	SWITCHABLE PHOTOSYSTEM-II DESIGNER ALGAE FOR PHOTOBIOLOGICAL HYDROGEN PRODUCTION
7648566	2006	2010	GENERAL ELECTRIC	METHODS AND APPARATUS

			COMPANY	FOR CARBON DIOXIDE REMOVAL FROM A FLUID STREAM
7651669	2005	2010	UNITED STATES DEPARTMENT OF ENERGY	MICROSYSTEM PROCESS NETWORKS
7655183	2007	2010	UTC POWER CORPORATION	DURABLE PD-BASED ALLOY AND HYDROGEN GENERATION MEMBRANE THEREOF
7658788	2005	2010	AIR PRODUCTS AND CHEMICALS, INC.	ION TRANSPORT MEMBRANE MODULE AND VESSEL SYSTEM WITH DIRECTED INTERNAL GAS FLOW
7670587	2006	2010	INTELLIGENT ENERGY, INC.	FUEL STEAM REFORMER SYSTEM AND REFORMER STARTUP PROCESS
7678251	2007	2010	PROTON ENERGY SYSTEMS, INC.	SYSTEM AND METHOD FOR DETECTING GAS
7682580	2005	2010	CATACEL CORP.	CATALYTIC REACTOR HAVING RADIAL LEAVES
7687051	2003	2010	HONDA CORP	PLATINUM AND RHODIUM AND/OR IRON CONTAINING CATALYST FORMULATIONS FOR HYDROGEN GENERATION
7691271	2007	2010	UNIVERSITY OF CENTRAL FLORIDA	FILAMENTOUS CARBON PARTICLES FOR CLEANING OIL SPILLS AND METHOD OF PRODUCTION
7691775	2007	2010	UNIVERSITY OF MICHIGAN	REDUCIBLE OXIDE BASED CATALYSTS
7695545	2007	2010	AIR PRODUCTS AND CHEMICALS, INC.	ADSORPTION PROCESS TO RECOVER HYDROGEN FROM FEED GAS MIXTURES HAVING LOW HYDROGEN CONCENTRATION
7695580	2006	2010	AIR PRODUCTS AND CHEMICALS, INC.	METHOD OF FORMING A CERAMIC TO CERAMIC JOINT
7703472	2005	2010	AIR PRODUCTS AND CHEMICALS, INC.	MODULE ISOLATION DEVICES
7722757	2006	2010	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR THE PRODUCTION OF HYDROGEN FROM WATER
7722853	2009	2010	UNIVERSITY OF CENTRAL FLORIDA	CATALYSTS FOR THE EVOLUTION OF HYDROGEN FROM BOROHYDRIDE SOLUTION
7732174	2003	2010	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	MULTI-STAGE MICROBIAL SYSTEM FOR CONTINUOUS HYDROGEN PRODUCTION
7736609	2006	2010	ERGENICS CORP.	HYDROGEN PURIFICATION SYSTEM
7744733	2007	2010	PROTON ENERGY	GAS VENTING SYSTEM

			SYSTEMS, INC.	
7745696	2006	2010	UNIVERSITY OF CALIFORNIA	SUPPRESSION OF TLA1 GENE EXPRESSION FOR IMPROVED SOLAR CONVERSION EFFICIENCY AND PHOTOSYNTHETIC PRODUCTIVITY IN PLANTS AND ALGAE
7750234	2005	2010	UNIVERSITY OF TOLEDO	INTEGRATED PHOTOELECTROCHEMICAL CELL AND SYSTEM HAVING A LIQUID ELECTROLYTE
7763086	2008	2010	INTELLIGENT ENERGY, INC.	HYDROGEN PURIFICATION PROCESS AND SYSTEM
7763217	2005	2010	BATTELLE MEMORIAL INSTITUTE	RAPID START FUEL REFORMING SYSTEMS AND TECHNIQUES
7766986	2008	2010	AIR PRODUCTS AND CHEMICALS, INC.	DEHYDROGENATION OF LIQUID FUEL IN MICROCHANNEL CATALYTIC REACTOR
7767867	2007	2010	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS
7771519	2007	2010	AIR PRODUCTS AND CHEMICALS, INC.	LINERS FOR ION TRANSPORT MEMBRANE SYSTEMS
7803349	2006	2010	UNIVERSITY OF CENTRAL FLORIDA	METHOD AND APPARATUS FOR HYDROGEN PRODUCTION FROM WATER
7820022	2005	2010	GENERAL ELECTRIC COMPANY	PHOTOELECTROCHEMICAL CELL AND METHOD OF MANUFACTURE
7824574	2007	2010	ELTRON RESEARCH, INC.	CYCLIC CATALYTIC UPGRADING OF CHEMICAL SPECIES USING METAL OXIDE MATERIALS
7842276	2010	2010	UNIVERSITY OF CENTRAL FLORIDA	CATALYSTS FOR THE EVOLUTION OF HYDROGEN FROM BOROHYDRIDE SOLUTION
7850838	2006	2010	PROTON ENERGY SYSTEMS, INC.	COLD WEATHER HYDROGEN GENERATION SYSTEM AND METHOD OF OPERATION
EP2014357	2008	2010	AIR PRODUCTS AND CHEMICALS, INC.	STAGED MEMBRANE OXIDATION REACTOR SYSTEM
EP2027909	2008	2010	AIR PRODUCTS AND CHEMICALS, INC.	LINERS FOR ION TRANSPORT MEMBRANE SYSTEMS
EP2168188	2008	2010	ENERFUEL, INC.	HYDROGEN PRODUCTION FROM BOROHYDRIDES AND GLYCEROL
EP2176867	2008	2010	CERAMATEC, INC.	PROTON CONDUCTING CERAMIC MEMBRANES FOR HYDROGEN SEPARATION

EP2212662	2008	2010	UNIVERSITY OF COLORADO	METAL FERRITE SPINEL ENERGY STORAGE DEVICES AND METHODS FOR MAKING AND USING SAME
EP2229446	2008	2010	UNIVERSITY OF GEORGIA	HYDROGENASE POLYPEPTIDE AND METHODS OF USE
WO2010017513	2009	2010	CERAMATEC, INC.	PLASMA-CATALYZED FUEL REFORMER
WO2010033789	2009	2010	UNIVERSITY OF MASSACHUSETTS	PRODUCTION OF HYDROGEN, LIQUID FUELS, AND CHEMICALS FROM CATALYTIC PROCESSING OF BIO-OILS
WO2010045232	2009	2010	OHIO STATE UNIVERSITY	CALCIUM LOOPING PROCESS FOR HIGH PURITY HYDROGEN PRODUCTION INTERGRATED WITH CAPTURE OF CARBON DIOXIDE, SULFUR AND HALIDES
WO2010111357	2010	2010	CONCEPTS ETI, INC.	HIGH-FLOW-CAPACITY CENTRIFUGAL HYDROGEN GAS COMPRESSION SYSTEMS, METHODS AND COMPONENTS THEREFOR
WO2010114849	2010	2010	SIGNA CHEMISTRY, INC.	HYDROGEN GENERATION SYSTEMS AND METHODS UTILIZING SODIUM SILICIDE AND SODIUM SILICA GEL MATERIALS
WO2010119334	2010	2010	GENESIS FUELTECH, INC.	HYDROGEN PURIFIER MODULE AND METHOD FOR FORMING THE SAME
WO2010123551	2010	2010	LOS ALAMOS NATIONAL SECURITY, LLC	REGENERATION OF AMMONIA BORANE FROM POLYBORAZYLENE
WO2010128374	2010	2010	GENESIS FUELTECH, INC.	HYDROGEN PURIFIER MODULE WITH MEMBRANE SUPPORT
7872054	2007	2011	WISCONSIN ALUMNI RESEARCH FOUNDATION	METHOD FOR PRODUCING BIO-FUEL THAT INTEGRATES HEAT FROM CARBON-CARBON BOND-FORMING REACTIONS TO DRIVE BIOMASS GASIFICATION REACTIONS
7879750	2006	2011	GENERAL ELECTRIC COMPANY	ANODES FOR ALKALINE ELECTROLYSIS
7896952	2008	2011	DELPHI TECHNOLOGIES, INC.	CARTRIDGE ADSORBER SYSTEM FOR REMOVING HYDROGEN SULFIDE FROM REFORMATE
7896953	2008	2011	UNIVERSITY OF SOUTH FLORIDA	PRACTICAL METHOD OF CO2 SEQUESTRATION
7897057	2007	2011	OPTECH VENTURES,	SENSOR FOR DETECTION OF

			LLC	GAS SUCH AS HYDROGEN AND METHOD OF FABRICATION
7897122	2006	2011	MEDIA AND PROCESS TECHNOLOGY	HYBRID ADSORPTIVE MEMBRANE REACTOR
7906079	2007	2011	CATACEL CORP.	STACKABLE STRUCTURAL REACTOR
7910373	2003	2011	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	H2O DOPED WO3, ULTRA-FAST, HIGH-SENSITIVITY HYDROGEN SENSORS
7914683	2009	2011	UNIVERSITY OF CENTRAL FLORIDA	PARTICLES OF SPILLED OIL-ABSORBING CARBON IN CONTACT WITH WATER
7926793	2009	2011	BATTELLE MEMORIAL INSTITUTE	MIXING IN WICKING STRUCTURES AND THE USE OF ENHANCED MIXING WITHIN WICKS IN MICROCHANNEL DEVICES
7932437	2007	2011	UNASSIGNED	DESIGNER PROTON-CHANNEL TRANSGENIC ALGAE FOR PHOTOBIOLOGICAL HYDROGEN PRODUCTION
7938893	2006	2011	GAS TECHNOLOGY INSTITUTE	MEMBRANE REACTOR FOR H2S, CO2 AND H2 SEPARATION
7947116	2007	2011	ELTRON RESEARCH, INC.	HYDROGEN SEPARATION PROCESS
7947251	2006	2011	OHIO STATE UNIVERSITY	CATALYST FOR HYDROGEN PRODUCTION FROM WATER GAS SHIFT REACTION
7951283	2006	2011	BATTELLE ENERGY ALLIANCE, LLC	HIGH TEMPERATURE ELECTROLYSIS FOR SYNGAS PRODUCTION
7955423	2005	2011	AIR PRODUCTS AND CHEMICALS, INC.	SOLID-STATE MEMBRANE MODULE
7981261	2006	2011	UCHICAGO ARGONNE, LLC	INTEGRATED DEVICE AND SUBSTRATE FOR SEPARATING CHARGED CARRIERS AND REDUCING PHOTOCORROSION AND METHOD FOR THE PHOTOELECTROCHEMICAL PRODUCTION OF ELECTRICITY AND PHOTOCATALYTIC PRODUCTION OF HYDROGEN
7988426	2005	2011	HONEYWELL INTERNATIONAL INC.	COMPRESSOR PORTED SHROUD FOR FOIL BEARING COOLING
7988925	2008	2011	UCHICAGO ARGONNE, LLC	FUEL PROCESSING DEVICE
7989664	2010	2011	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS

8002854	2006	2011	UNIVERSITY OF CENTRAL FLORIDA	THERMOCATALYTIC PROCESS FOR CO2-FREE PRODUCTION OF HYDROGEN AND CARBON FROM HYDROCARBONS
8003055	2008	2011	UNIVERSITY OF CENTRAL FLORIDA	VISUAL HYDROGEN DETECTOR WITH VARIABLE REVERSIBILITY
8012380	2007	2011	CERAMATEC, INC.	PROTON CONDUCTING CERAMIC MEMBRANES FOR HYDROGEN SEPARATION
8048384	2010	2011	UNIVERSITY OF CENTRAL FLORIDA	CHEMOCHROMIC HYDROGEN SENSORS
8070860	2006	2011	UNITED TECHNOLOGIES CORPORATION	PD MENBRANE HAVING IMPROVED H2-PERMEANCE, AND METHOD OF MAKING
8084265	2008	2011	ALLIANCE FOR SUSTIANABLE ENERGY, LLC	METHOD AND PD/V2 O5 DEVICE FOR H2 DETECTION
EP2276700	2009	2011	LOS ALAMOS NATIONAL SECURITY, LLC	HYDROGEN PRODUCTION USING AMMONIA BORANE
EP2352698	2009	2011	OHIO STATE UNIVERSITY	CALCIUM LOOPING PROCESS FOR HIGH PURITY HYDROGEN PRODUCTION INTERGRATED WITH CAPTURE OF CARBON DIOXIDE, SULFUR AND HALIDES
EP2353703	2004	2011	AIR PRODUCTS AND CHEMICALS, INC.	PLANAR CERAMIC CHANNELED SUPPORT LAYER ASSEMBLY AND METHOD FOR MAKING THEREOF
EP2374534	2011	2011	AIR PRODUCTS AND CHEMICALS, INC.	OPERATION OF STAGED MEMBRANE OXIDATION REACTOR SYSTEMS
EP2384806	2011	2011	AIR PRODUCTS AND CHEMICALS, INC.	FEED GAS CONTAMINANT REMOVAL PROCESS IN OXYGEN ION TRANSPORT MEMBRANE SYSTEMS
EP2389996	2011	2011	AIR PRODUCTS AND CHEMICALS, INC.	FABRICATION OF CATALYZED ION TRANSPORT MEMBRANE SYSTEMS
WO2011075490	2010	2011	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION UTILIZING INTEGRATED CO2 REMOVAL WITH STEAM REFORMING
8088261	2007	2012	GAS TECHNOLOGY INSTITUTE	CUC1 THERMOCHEMICAL CYCLE FOR HYDROGEN PRODUCTION
8110022	2009	2012	GENESIS FUELTECH, INC.	HYDROGEN PURIFIER MODULE AND METHOD FOR FORMING THE SAME
8114193	2008	2012	AIR PRODUCTS AND	ION TRANSPORT

			CHEMICALS, INC.	MEMBRANE MODULE AND VESSEL SYSTEM
8147765	2008	2012	UNIVERSITY OF CENTRAL FLORIDA	APPARATUS FOR HYDROGEN AND CARBON PRODUCTION VIA CARBON AEROSOL-CATALYZED DISSOCIATION OF HYDROCARBONS
8148583	2010	2012	AIR PRODUCTS AND CHEMICALS, INC.	FEED GAS CONTAMINANT REMOVAL IN ION TRANSPORT MEMBRANE SYSTEMS
8153698	2010	2012	VIRENT ENERGY SYSTEMS INC.	METHOD FOR PRODUCING BIO-FUEL THAT INTEGRATES HEAT FROM CARBON-CARBON BOND-FORMING REACTIONS TO DRIVE BIOMASS GASIFICATION REACTIONS
8172913	2009	2012	UNASSIGNED	ARRAY OF PLANAR MEMBRANE MODULES FOR PRODUCING HYDROGEN
8187731	2010	2012	UNIVERSITY OF COLORADO	METAL FERRITE SPINEL ENERGY STORAGE DEVICES AND METHODS FOR MAKING AND USING SAME
8198486	2011	2012	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS
8207081	2010	2012	UNIVERSITY OF CENTRAL FLORIDA	NANOCOMPOSITE FOR PHOTOCATALYTIC HYDROGEN PRODUCTION AND METHOD FOR ITS PREPARATION
8210360	2007	2012	SYNKERA TECHNOLOGIES, INC.	COMPOSITE MEMBRANES AND METHODS FOR MAKING SAME
8211825	2009	2012	INTEMATIX CORPORATION	METHANOL OXIDATION CATALYST
8216323	2005	2012	GENERAL ELECTRIC COMPANY	SYSTEM AND METHOD FOR HYDROGEN PRODUCTION
8226750	2009	2012	GENESIS FUELTECH, INC.	HYDROGEN PURIFIER MODULE WITH MEMBRANE SUPPORT
8226917	2006	2012	OHIO STATE UNIVERSITY	SEPARATION OF CARBON DIOXIDE FROM GAS MIXTURES BY CALCIUM BASED REACTION SEPARATION
8231697	2010	2012	BATTELLE MEMORIAL INSTITUTE	RAPID START FUEL REFORMING SYSTEMS AND TECHNIQUES
8236072	2007	2012	ARIZONA PUBLIC SERVICE COMPANY	SYSTEM AND METHOD FOR PRODUCING SUBSTITUTE NATURAL GAS FROM COAL
8246719	2009	2012	AIR PRODUCTS AND CHEMICALS, INC.	USE OF IMPURE INERT GASES IN THE

				CONTROLLED HEATING AND COOLING OF MIXED CONDUCTING METAL OXIDE MATERIALS
8262755	2007	2012	AIR PRODUCTS AND CHEMICALS, INC.	STAGED MEMBRANE OXIDATION REACTOR SYSTEM
8268392	2011	2012	UNIVERSITY OF CENTRAL FLORIDA	VISUAL HYDROGEN DETECTOR WITH VARIABLE REVERSIBILTY
8268897	2010	2012	UNIVERSITY OF KENTUCKY	INCORPORATION OF CATALYTIC DEHYDROGENATION INTO FISCHER-TROPSCH SYNTHESIS TO LOWER CARBON DIOXIDE EMISSIONS
8273140	2010	2012	UNIVERSITY OF CENTRAL FLORIDA	METHOD AND APPARATUS FOR HYDROGEN PRODUCTION FROM WATER
8277932	2011	2012	OHIO STATE UNIVERSITY	MEMBRANES, METHODS OF MAKING MEMBRANES, AND METHODS OF SEPARATING GASES USING MEMBRANES
8287762	2010	2012	AIR PRODUCTS AND CHEMICALS, INC.	OPERATION OF STAGED MEMBRANE OXIDATION REACTOR SYSTEMS
8309616	2011	2012	UNIVERSITY OF KENTUCKY	INCORPORATION OF CATALYTIC DEHYDROGENATION INTO FISCHER-TROPSCH SYNTHESIS TO SIGNIFICANTLY REDUCE CARBON DIOXIDE EMISSIONS
8323614	2010	2012	UNIVERSITY OF SOUTH CAROLINA	HYDROLYSIS REACTOR FOR HYDROGEN PRODUCTION
EP2404870	2006	2012	INTELLIGENT ENERGY, INC.	FUEL STEAM REFORMER SYSTEM
EP2414096	2010	2012	SIGNA CHEMISTRY, INC.	HYDROGEN GENERATION SYSTEMS AND METHODS UTILIZING SODIUM SILICIDE
EP2419194	2010	2012	GENESIS FUELTECH, INC.	HYDROGEN PURIFIER MODULE AND METHOD FOR FORMING THE SAME
EP2428265	2005	2012	AIR PRODUCTS AND CHEMICALS, INC.	FEED GAS CONTAMINANT REMOVAL IN ION TRANSPORT MEMBANE SYSTEMS
EP2476989	2007	2012	CATACEL CORP.	STACKABLE STRUCTURAL REACTOR
EP2537580	2008	2012	AIR PRODUCTS AND CHEMICALS, INC.	STAGED MEMBRANE OXIDATION REACTOR SYSTEM
WO2012030818	2011	2012	UNIVERSITY OF	CHEMOCHROMIC

			CENTRAL FLORIDA	HYDROGEN SENSORS
WO2012103432	2012	2012	CATACEL CORP.	IMPROVED STACKABLE STRUCTURAL REACTORS
WO2012112892	2012	2012	CONCEPTS ETI, INC.	TURBOMACHINERY HAVING SELF-ARTICULATING BLADES, SHUTTER VALVE, PARTIAL-ADMISSION SHUTTERS, AND/OR VARIABLE-PITCH INLET NOZZLES
WO2012151582	2012	2012	SIGNA CHEMISTRY, INC.	WATER REACTIVE HYDROGEN GENERATION SYSTEM AND METHOD WITH SEPARATION OF WASTE PRODUCTS FROM WATER REACTIVE MATERIALS
8349151	2009	2013	GINER ELECTROCHEMICAL SYSTEMS, LLC	UNIVERSAL CELL FRAME FOR HIGH-PRESSURE WATER ELECTROLYZER AND ELECTROLYZER INCLUDING THE SAME
8367027	2010	2013	LOS ALAMOS NATIONAL SECURITY, LLC	REGENERATION OF AMMONIA BORANE FROM POLYBORAZYLENE
8372170	2010	2013	INTELLIGENT ENERGY, INC.	FUEL STEAM REFORMER SYSTEM AND REFORMER STARTUP PROCESS
8397508	2008	2013	UNIVERSITY OF COLORADO	METAL FERRITE SPINEL ENERGY STORAGE DEVICES AND METHODS FOR MAKING AND USING SAME
8408005	2008	2013	PRAXAIR TECHNOLOGY, INC.	ASU NITROGEN SWEEP GAS IN HYDROGEN SEPARATION MEMBRANE FOR PRODUCTION OF HRSG DUCT BURNER FUEL
8410183	2012	2013	VIRENT ENERGY SYSTEMS INC.	METHOD FOR PRODUCING BIO-FUEL THAT INTEGRATES HEAT FROM CARBON-CARBON BOND-FORMING REACTIONS TO DRIVE BIOMASS GASIFICATION REACTIONS
8419827	2012	2013	AIR PRODUCTS AND CHEMICALS, INC.	STAGED MEMBRANE OXIDATION REACTOR SYSTEM
8435920	2010	2013	ELTRON RESEARCH, INC.	CYCLIC CATALYTIC UPGRADING OF CHEMICAL SPECIES USING METAL OXIDE MATERIALS
8453515	2010	2013	UT-BATTELLE, LLC	APPARATUS AND METHOD FOR FATIGUE TESTING OF A MATERIAL SPECIMEN IN A HIGH-PRESSURE FLUID ENVIRONMENT

8455382	2010	2013	AIR PRODUCTS AND CHEMICALS, INC.	FABRICATION OF CATALYZED ION TRANSPORT MEMBRANE SYSTEMS
8460409	2009	2013	CERAMATEC, INC.	PLASMA-CATALYZED FUEL REFORMER
8491679	2010	2013	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION UTILIZING INTEGRATED CO2 REMOVAL WITH STEAM REFORMING
8492595	2012	2013	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS
8496909	2009	2013	OHIO STATE UNIVERSITY	CALCIUM LOOPING PROCESS FOR HIGH PURITY HYDROGEN PRODUCTION INTEGRATED WITH CAPTURE OF CARBON DIOXIDE, SULFUR AND HALIDES
8499612	2010	2013	UNIVERSITY OF CALIFORNIA	HYDROGEN GAS DETECTION USING SINGLE PALLADIUM NANOWIRES
8501105	2012	2013	OHIO STATE UNIVERSITY	SEPARATION OF CARBON DIOXIDE (CO2) FROM GAS MIXTURES BY CALCIUM BASED REACTION SEPARATION (CARS-CO2) PROCESS
8524903	2010	2013	UNIVERSITY OF NORTH CAROLINA	RUTHENIUM OR OSMIUM COMPLEXES AND THEIR USES AS CATALYSTS FOR WATER OXIDATION
8574917	2008	2013	ELEMENT ONE, INC.	HYDROGEN SULFIDE INDICATING PIGMENTS
8591818	2006	2013	UNASSIGNED	GAS PERMEABLE CHEMOCHROMIC COMPOSITIONS FOR HYDROGEN SENSING
8609054	2008	2013	ENERFUEL, INC.	HYDROGEN PRODUCTION FROM BOROHYDRIDES AND GLYCEROL
8613902	2009	2013	LOS ALAMOS NATIONAL SECURITY, LLC	HYDROGEN PRODUCTION USING AMMONIA BORANE
EP2565176	2007	2013	VIRENT ENERGY SYSTEMS INC.	METHODS FOR GENERATING POLYOLS
EP2667962	2012	2013	CATACEL CORP.	IMPROVED STACKABLE STRUCTURAL REACTORS
WO2008127745	2008	2013	PRAXAIR TECHNOLOGY, INC.	NITROGEN SWEEP GAS IN HYDROGEN SEPARATION MEMBRANE FOR PRODUCTION OF H2/N2 FUEL GAS
WO2013033672	2012	2013	PURDUE RESEARCH FOUNDATION	HIGH AND RAPID HYDROGEN RELEASE FROM THERMOLYSIS OF

				AMMONIA BORANE NEAR PEM FUEL CELL OPERATING TEMPERATURES AND AMMONIA REMOVAL FOR HYDROGEN PEM FUEL CELLS
WO2013152043	2013	2013	CALIFORNIA INSTITUTE OF TECHNOLOGY	SOLAR FUELS GENERATOR
WO2013152132	2013	2013	CALIFORNIA INSTITUTE OF TECHNOLOGY	SEMICONDUCTOR STRUCTURES FOR FUEL GENERATION
WO2013181629	2013	2013	CALIFORNIA INSTITUTE OF TECHNOLOGY	SCANNING DROP SENSOR
8623662	2012	2014	UNIVERSITY OF CENTRAL FLORIDA	METHODS OF FORMING VISUAL HYDROGEN DETECTOR WITH VARIABLE REVERSIBILITY
8636883	2007	2014	ELEMENT ONE, INC.	MONITORABLE HYDROGEN SENSOR SYSTEM
8652239	2011	2014	WORCESTER POLYTECHNIC INSTITUTE	HIGH PERMEANCE SULFUR TOLERANT PD/CU ALLOY MEMBRANES
8652993	2012	2014	UNIVERSITY OF CENTRAL FLORIDA	DOPED PALLADIUM CONTAINING OXIDATION CATALYSTS
8653331	2009	2014	UNASSIGNED	PHOTOBIOLOGICAL HYDROGEN PRODUCTION WITH SWITCHABLE PHOTOSYSTEM-II DESIGNER ALGAE
8663958	2009	2014	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	OXYGEN-RESISTANT HYDROGENASES AND METHODS FOR DESIGNING AND MAKING SAME
8673035	2011	2014	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	SOLAR-THERMAL REACTION PROCESSING
8685364	2013	2014	LOS ALAMOS NATIONAL SECURITY, LLC	LIQUID COMPOSITION HAVING AMMONIA BORANE AND DECOMPOSING TO FORM HYDROGEN AND LIQUID REACTION PRODUCT
8691068	2008	2014	UNIVERSITY OF CENTRAL FLORIDA	SOLAR METAL SULFATE-AMMONIA BASED THERMOCHEMICAL WATER SPLITTING CYCLE FOR HYDROGEN PRODUCTION
8703642	2013	2014	UNIVERSITY OF CENTRAL FLORIDA	METHOD OF FORMING SUPPORTED DOPED PALLADIUM CONTAINING OXIDATION CATALYSTS
8715868	2011	2014	UNIVERSITY OF	ELECTROCHEMICAL

			SOUTH CAROLINA	REMOVAL OF CONTAMINANTS FROM HYDROGEN
8721973	2012	2014	JOHNSON MATTHEY PUBLIC LIMITED COMPANY	STACKABLE STRUCTURAL REACTORS
8728202	2012	2014	AIR PRODUCTS AND CHEMICALS, INC.	STAGED MEMBRANE OXIDATION REACTOR SYSTEM
8729798	2011	2014	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	ANTI-REFLECTIVE NANOPOROUS SILICON FOR EFFICIENT HYDROGEN PRODUCTION
8741258	2009	2014	UNIVERSITY OF MASSACHUSETTS	PRODUCTION OF HYDROGEN, LIQUID FUELS, AND CHEMICALS FROM CATALYTIC PROCESSING OF BIO-OILS
8754263	2013	2014	VIRENT ENERGY SYSTEMS INC.	METHODS AND SYSTEMS FOR GENERATING POLYOLS
8778058	2011	2014	COLORADO SCHOOL OF MINES	MULTILAYER SULFUR-RESISTANT COMPOSITE METAL MEMBRANES AND METHODS OF MAKING AND REPAIRING THE SAME
8834587	2012	2014	VIRENT ENERGY SYSTEMS INC.	METHOD OF PRODUCING GASEOUS PRODUCTS USING A DOWNFLOW REACTOR
8835153	2006	2014	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	PROCESS AND GENES FOR EXPRESSION AND OVEREXPRESSION OF ACTIVE [FEFE] HYDROGENASES
8863385	2011	2014	JOHNSON MATTHEY PUBLIC LIMITED COMPANY	STACKABLE STRUCTURAL REACTOR
8871078	2013	2014	UNIVERSITY OF NORTH CAROLINA	RUTHENIUM OR OSMIUM COMPLEXES AND THEIR USES AS CATALYSTS FOR WATER OXIDATION
WO2014007962	2013	2014	PRAXAIR TECHNOLOGY, INC.	METHOD OF MAKING A HYDROGEN TRANSPORT MEMBRANE AND ARTICLE
WO2014039879	2013	2014	NORTH CAROLINA STATE UNIVERSITY	SEQUESTRATION OF CARBON DIOXIDE WITH HYDROGEN TO USEFUL PRODUCTS
8939293	2012	2015	SYNKERA TECHNOLOGIES, INC.	COMPOSITE MEMBRANE WITH INTEGRAL RIM
8968432	2011	2015	BATTELLE MEMORIAL INSTITUTE	RAPID START FUEL REFORMING SYSTEMS AND TECHNIQUES
8974184	2012	2015	CONCEPTS ETI, INC.	TURBOMACHINERY HAVING SELF-ARTICULATING BLADES,

				SHUTTER VALVE, PARTIAL-ADMISSION SHUTTERS, AND/OR VARIABLE PITCH INLET NOZZLES
9005486	2011	2015	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	PROTON CONDUCTING CERAMICS IN MEMBRANE SEPARATIONS
9028720	2014	2015	AIR PRODUCTS AND CHEMICALS, INC.	ION TRANSPORT MEMBRANE REACTOR SYSTEMS AND METHODS FOR PRODUCING SYNTHESIS GAS
9057136	2006	2015	UNIVERSITY OF SOUTH CAROLINA	PRODUCTION OF LOW TEMPERATURE ELECTROLYTIC HYDROGEN
9067172	2014	2015	AIR PRODUCTS AND CHEMICALS, INC.	SOLID-STATE MEMBRANE MODULE
9079146	2010	2015	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION SYSTEMS UTILIZING SODIUM SILICIDE AND SODIUM SILICA GEL MATERIALS
9084970	2012	2015	PRAXAIR TECHNOLOGY, INC.	METHOD OF MAKING A HYDROGEN TRANSPORT MEMBRANE, AND ARTICLE
9093681	2011	2015	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION HAVING CO2 REMOVAL WITH STEAM REFORMING
9102528	2013	2015	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION SYSTEMS AND METHODS UTILIZING SODIUM SILICIDE AND SODIUM SILICA GEL MATERIALS
9133486	2013	2015	STANFORD UNIVERSITY	HYDROGENASE FUSION PROTEIN FOR IMPROVED HYDROGEN PRODUCTION
9139432	2012	2015	UNIVERSITY OF CENTRAL FLORIDA	APPARATUS FOR DECOMPOSING WATER AND RELEASING HYDROGEN
9156687	2012	2015	INTELLIGENT ENERGY, INC.	WATER REACTIVE HYDROGEN GENERATION SYSTEM AND METHOD WITH SEPARATION OF WASTE PRODUCTS FROM WATER REACTIVE MATERIALS
9174844	2013	2015	OHIO STATE UNIVERSITY	CALCIUM LOOPING PROCESS FOR HIGH PURITY HYDROGEN PRODUCTION INTEGRATED WITH CAPTURE OF CARBON DIOXIDE, SULFUR AND HALIDES
9199844	2013	2015	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	TWO STEP NOVEL HYDROGEN SYSTEM USING ADDITIVES TO ENHANCE

				HYDROGEN RELEASE FROM THE HYDROLYSIS OF ALANE AND ACTIVATED ALUMINUM
9216394	2014	2015	JOHNSON MATTHEY PUBLIC LIMITED COMPANY	STACKABLE STRUCTURAL REACTORS
9249440	2014	2016	UNIVERSITY OF GEORGIA	HYDROGENASE POLYPEPTIDE AND METHODS OF USE
9255646	2013	2016	AIR PRODUCTS AND CHEMICALS, INC.	EXCESS FLOW SHUTOFF VALVE
9316228	2010	2016	CONCEPTS NREC, LLC	HIGH-FLOW-CAPACITY CENTRIFUGAL HYDROGEN GAS COMPRESSION SYSTEMS, METHODS AND COMPONENTS THEREFOR
9359680	2014	2016	UNIVERSITY OF NORTH CAROLINA	RUTHENIUM OR OSMIUM COMPLEXES AND THEIR USES AS CATALYSTS FOR WATER OXIDATION
9399575	2013	2016	UNIVERSITY OF COLORADO	METHODS AND APPARATUS FOR GAS-PHASE REDUCTION/OXIDATION PROCESSES
9422160	2011	2016	ELEMENT ONE, INC.	METHOD OF MAKING A HYDROGEN SENSING PIGMENT
9476129	2013	2016	CALIFORNIA INSTITUTE OF TECHNOLOGY	SOLAR FUELS GENERATOR
9493349	2012	2016	PURDUE RESEARCH FOUNDATION	HIGH AND RAPID HYDROGEN RELEASE FROM THERMOLYSIS OF AMMONIA BORANE NEAR PEM FUEL CELL OPERATING TEMPERATURE
9506084	2013	2016	PURDUE RESEARCH FOUNDATION	PRODUCTION OF HYDROGEN USING AN ANAEROBIC BIOLOGICAL PROCESS
EP3047903	2010	2016	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION SYSTEMS AND METHODS UTILIZING SODIUM SILICIDE AND SODIUM SILICA GEL MATERIALS
9540741	2013	2017	CALIFORNIA INSTITUTE OF TECHNOLOGY	LIGHT-DRIVEN HYDROIODIC ACID SPLITTING FROM SEMICONDUCTIVE FUEL GENERATOR
9574276	2015	2017	UNIVERSITY OF SOUTH CAROLINA	PRODUCTION OF LOW TEMPERATURE ELECTROLYTIC HYDROGEN
9586190	2014	2017	SANDIA CORPORATION	THERMAL SWING REACTOR INCLUDING A MULTI-

				FLIGHT AUGER
9587256	2013	2017	UNIVERSITY OF GEORGIA	SEQUESTRATION OF CARBON DIOXIDE WITH HYDROGEN TO USEFUL PRODUCTS
9597675	2014	2017	UNIVERSITY OF CENTRAL FLORIDA	OXIDATION CATALYSTS ON ALKALINE EARTH SUPPORTS
9645108	2013	2017	CALIFORNIA INSTITUTE OF TECHNOLOGY	SCANNING DROP SENSOR
9657400	2008	2017	GENERAL ELECTRIC COMPANY	ELECTROLYZER ASSEMBLY METHOD AND SYSTEM
9669371	2015	2017	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION SYSTEMS UTILIZING SODIUM SILICIDE AND SODIUM SILICA GEL MATERIALS
9739418	2013	2017	UCHICAGO ARGONNE, LLC	ENHANCED METHODS FOR OPERATING REFUELING STATION TUBE-TRAILERS TO REDUCE REFUELING COST
9746211	2016	2017	EMERALD ENERGY NW, LLC	REFRIGERATION SYSTEM INCLUDING MICRO COMPRESSOR-EXPANDER THERMAL UNITS
9751073	2015	2017	JOHNSON MATTHEY PUBLIC LIMITED COMPANY	STACKABLE STRUCTURAL REACTORS
9815042	2014	2017	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	CASCADING PRESSURE REACTOR AND METHOD FOR SOLAR-THERMOCHEMICAL REACTIONS
9815747	2016	2017	BATTELLE ENERGY ALLIANCE, LLC	SYNGAS CONVERSION TO A LIGHT ALKENE AND RELATED METHODS
9845239	2015	2017	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATION SYSTEMS AND METHODS UTILIZING SODIUM SILICIDE AND SODIUM SILICA GEL MATERIALS
9868636	2013	2018	SANDIA CORPORATION	THERMOCHEMICALLY ACTIVE IRON TITANIUM OXIDE MATERIALS
9868671	2015	2018	PRAXAIR TECHNOLOGY, INC.	METHOD OF MAKING A HYDROGEN TRANSPORT MEMBRANE AND ARTICLE
9937484	2016	2018	BATTELLE MEMORIAL INSTITUTE	REACTOR, CO2 SORBENT SYSTEM, AND PROCESS OF MAKING H2 WITH SIMULTANEOUS CO2 SORPTION
9947816	2013	2018	CALIFORNIA INSTITUTE OF	SEMICONDUCTOR STRUCTURES FOR FUEL

			TECHNOLOGY	GENERATION
9975768	2016	2018	PURDUE RESEARCH FOUNDATION	HYDROGEN PURIFICATION SYSTEMS FOR PEM FUEL CELLS
10035121	2017	2018	SANDIA CORPORATION	THERMAL SWING REACTOR INCLUDING A MULTI-FLIGHT AUGER
10087535	2016	2018	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	DEVICES AND METHODS FOR PHOTOELECTROCHEMICAL WATER SPLITTING
10109874	2016	2018	FUELCELL ENERGY, INC.	SHIFT REACTOR FOR DIRECT FUEL CELL HYDROGEN SYSTEM
WO2018084923	2017	2018	FUELCELL ENERGY, INC.	SHIFT REACTOR FOR DIRECT FUEL CELL HYDROGEN SYSTEM
10227617	2017	2019	UNIVERSITY OF GEORGIA	SEQUESTRATION OF CARBON DIOXIDE WITH HYDROGEN TO USEFUL PRODUCTS
10246724	2016	2019	PURDUE RESEARCH FOUNDATION	PRODUCTION OF HYDROGEN USING AN ANAEROBIC BIOLOGICAL PROCESS
10344387	2016	2019	CALIFORNIA INSTITUTE OF TECHNOLOGY	SOLAR FUELS GENERATOR
10495352	2017	2019	EMERALD ENERGY NW, LLC	REFRIGERATION SYSTEM INCLUDING MICRO COMPRESSOR-EXPANDER THERMAL UNITS
10526964	2016	2020	CONCEPTS NREC, LLC	HIGH-FLOW-CAPACITY CENTRIFUGAL HYDROGEN GAS COMPRESSION SYSTEMS, METHODS AND COMPONENTS THEREFOR

Appendix PD-B. Hydrogen Production Patents in Families Associated with Other DOE Funding

Patent #	Application Year	Issue / Publication Year	Original Assignee	Title
3929980	1974	1975	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF PRODUCING HYDROGEN
3957956	1974	1976	UNITED STATES DEPARTMENT OF ENERGY	CLOSED CYCLE ION EXCHANGE METHOD FOR REGENERATING ACIDS, BASES AND SALTS
3969495	1975	1976	UNITED STATES DEPARTMENT OF ENERGY	THERMOCHEMICAL PRODUCTION OF HYDROGEN
3984530	1975	1976	UNITED STATES DEPARTMENT OF ENERGY	METHANE-METHANOL CYCLE FOR THE THERMOCHEMICAL PRODUCTION OF HYDROGEN
3996343	1976	1976	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR THERMOCHEMICALLY PRODUCING HYDROGEN
4002729	1976	1977	UNITED STATES DEPARTMENT OF ENERGY	METHOD FOR THERMOCHEMICAL DECOMPOSITION OF WATER
4005184	1975	1977	UNITED STATES DEPARTMENT OF ENERGY	THERMOCHEMICAL PROCESS FOR THE PRODUCTION OF HYDROGEN USING CHROMIUM AND BARIUM COMPOUND
4075312	1977	1978	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR RECOVERING EVOLVED HYDROGEN ENRICHED WITH AT LEAST ONE HEAVY HYDROGEN ISOTOPE
4078904	1976	1978	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR FORMING HYDROGEN AND OTHER FUELS UTILIZING MAGMA
4089940	1977	1978	GENERAL ATOMIC COMPANY	PROCESS FOR THE THERMOCHEMICAL PRODUCTION OF HYDROGEN
4169884	1978	1979	UNITED STATES DEPARTMENT OF ENERGY	HYDROGEN PRODUCTION FROM WATER USING COPPER AND BARIUM HYDROXIDE
4180555	1978	1979	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR PRODUCING HYDROGEN FROM WATER USING COBALT AND BARIUM COMPOUNDS
4207208	1978	1980	MOBIL CORP	METHOD FOR REGENERATION AND

				ACTIVITY IMPROVEMENT OF SYNGAS CONVERSION CATALYST
4230682	1979	1980	UNITED STATES DEPARTMENT OF ENERGY	CYCLIC THERMOCHEMICAL PROCESS FOR PRODUCING HYDROGEN USING CERIUM-TITANIUM COMPOUNDS
4237105	1979	1980	UNITED STATES DEPARTMENT OF ENERGY	THERMOCHEMICAL CYCLIC SYSTEM FOR SPLITTING WATER AND/OR CARBON DIOXIDE BY MEANS OF CERIUM COMPOUNDS AND REACTIONS USEFUL THEREIN
4244794	1979	1981	UNITED STATES DEPARTMENT OF ENERGY	HYDROGEN PRODUCTION BY THE DECOMPOSITION OF WATER
4276060	1979	1981	UNITED STATES DEPARTMENT OF ENERGY	CHROMATOGRAPHIC HYDROGEN ISOTOPE SEPARATION
4276279	1980	1981	UNITED STATES DEPARTMENT OF ENERGY	THERMOCHEMICAL GENERATION OF HYDROGEN AND OXYGEN FROM WATER
4309403	1980	1982	UNITED STATES DEPARTMENT OF ENERGY	THERMOCHEMICAL GENERATION OF HYDROGEN AND OXYGEN FROM WATER
4313925	1980	1982	UNITED STATES DEPARTMENT OF ENERGY	THERMOCHEMICAL CYCLIC SYSTEM FOR DECOMPOSING H2O AND/OR CO2 BY MEANS OF CERIUM-TITANIUM-SODIUM-OXYGEN COMPOUNDS
4330374	1979	1982	GENERAL ATOMIC COMPANY	RECOVERY OF ANHYDROUS HYDROGEN IODIDE
4331632	1980	1982	UNITED STATES DEPARTMENT OF ENERGY	CATALYTIC CARTRIDGE SO3 DECOMPOSER
4341618	1980	1982	EXXON RESEARCH AND ENGINEERING COMPANY	PROCESS FOR THE LIQUEFACTION OF SOLID CARBONACEOUS MATERIALS WHEREIN NITROGEN IS SEPARATED FROM HYDROGEN VIA AMMONIA SYNTHESIS
4351806	1981	1982	UNITED STATES DEPARTMENT OF ENERGY	CATALYTIC CARTRIDGE SO3 DECOMPOSER
4372833	1981	1983	UNIVERSITY OF GEORGIA	PHOTOGENERATION OF ACTIVE FORMATE

				DECOMPOSITION CATALYSTS TO PRODUCE HYDROGEN FROM FORMATE AND WATER
4396591	1982	1983	GA TECHNOLOGIES INC.	RECOVERY OF HYDROGEN IODIDE
4410505	1983	1983	GA TECHNOLOGIES INC.	HYDROGEN IODIDE DECOMPOSITION
EP0079423	1982	1983	WESTINGHOUSE ELECTRIC CORPORATION	CATALYTIC GAS REFORMER.
4430304	1981	1984	UNITED STATES DEPARTMENT OF ENERGY	SLAB REFORMER
4455286	1982	1984	UNITED STATES DEPARTMENT OF ENERGY	HIGH-TEMPERATURE SORBENT METHOD FOR REMOVAL OF SULFUR CONTAINING GASES FROM GASEOUS MIXTURES
4476105	1982	1984	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR PHOTOSYNTHETICALLY SPLITTING WATER
4504447	1983	1985	UNITED STATES DEPARTMENT OF ENERGY	SLAB REFORMER
4568435	1984	1986	UNITED STATES DEPARTMENT OF ENERGY	METHOD FOR IMPROVING PRODUCT YIELDS IN AN ANIONIC METALLOPORPHYRIN-BASED ARTIFICIAL PHOTOSYNTHESIS SYSTEM
4657646	1985	1987	UNITED STATES DEPARTMENT OF ENERGY	METHOD OF PRODUCING METALLIZED CHLOROPLASTS AND USE THEREOF IN THE PHOTOCHEMICAL PRODUCTION OF HYDROGEN AND OXYGEN
4693875	1986	1987	BATTELLE MEMORIAL INSTITUTE	PROCESS FOR RECOVERY OF HYDROGEN AND ABSTRACTION OF SULFUR
4696680	1985	1987	UNITED STATES DEPARTMENT OF ENERGY	METHOD AND APPARATUS FOR THE SELECTIVE SEPARATION OF GASEOUS COAL GASIFICATION PRODUCTS BY PRESSURE SWING ADSORPTION
EP0279853	1987	1988	BATTELLE MEMORIAL INSTITUTE	PROCESS FOR RECOVERY OF HYDROGEN AND ABSTRACTION OF SULFUR.
WO1988001535	1987	1988	BATTELLE MEMORIAL INSTITUTE	PROCESS FOR RECOVERY OF HYDROGEN AND ABSTRACTION OF SULFUR
4851151	1988	1989	TEXACO INC.	PROCESS FOR PRODUCTION OF SYNTHESIS GAS WITH

				REDUCED SULFUR CONTENT
4873214	1987	1989	TRW INC.	CARBONACEOUS MATERIAL FOR PRODUCTION OF HYDROGEN FROM LOW HEATING VALUE FUEL GASES
4876080	1988	1989	UNITED STATES DEPARTMENT OF ENERGY	HYDROGEN PRODUCTION WITH COAL USING A PULVERIZATION DEVICE
4885145	1987	1989	UNASSIGNED	METHOD FOR PROVIDING OXYGEN ION VACANCIES IN LANTHANIDE OXIDES
4909808	1987	1990	NASA	STEAM REFORMER WITH CATALYTIC COMBUSTOR
4946667	1988	1990	ENGELHARD CORPORATION	METHOD OF STEAM REFORMING METHANOL TO HYDROGEN
4976940	1989	1990	UNITED STATES DEPARTMENT OF ENERGY	METHOD FOR PRODUCING H2 USING A ROTATING DRUM REACTOR WITH A PULSE JET HEAT SOURCE
5057133	1990	1991	AIR PRODUCTS AND CHEMICALS, INC.	THERMALLY EFFICIENT MELTING AND FUEL REFORMING FOR GLASS MAKING
EP0464603	1991	1992	AIR PRODUCTS AND CHEMICALS, INC.	THERMALLY EFFICIENT MELTING AND FUEL REFORMING FOR GLASS MAKING
5198084	1989	1993	WESTERN RESEARCH INSTITUTE	LOW-COST PROCESS FOR HYDROGEN PRODUCTION
5211923	1991	1993	UNIVERSITY OF CHICAGO	HYDROGEN AND SULFUR RECOVERY FROM HYDROGEN SULFIDE WASTES
5217506	1992	1993	BEND RESEARCH, INC.	HYDROGEN-PERMEABLE COMPOSITE METAL MEMBRANE AND USES THEREOF
5221652	1991	1993	UNIVERSITY OF PITTSBURGH	METHANOL SYNTHESIS USING A CATALYST COMBINATION OF ALKALI OR ALKALINE EARTH SALTS AND REDUCED COPPER CHROMITE FOR METHANOL SYNTHESIS
WO1993025639	1993	1993	BATTELLE MEMORIAL INSTITUTE	METHOD FOR THE CATALYTIC CONVERSION OF ORGANIC MATERIALS INTO A PRODUCT GAS
5312597	1992	1994	UNITED STATES DEPARTMENT OF ENERGY	APPARATUS FOR SEPARATING AND RECOVERING HYDROGEN

				ISOTOPES
WO1994013579	1993	1994	UNIVERSITY OF CALIFORNIA	PROCESS FOR RECOVERY OF SULFUR FROM ACID GASES
5384335	1993	1995	UNIVERSITY OF PITTSBURGH	METHANOL SYNTHESIS USING A CATALYST COMBINATION OF ALKALI OR ALKALINE EARTH SALTS AND REDUCED COPPER CHROMITE
5397556	1992	1995	UNIVERSITY OF CALIFORNIA	PROCESS FOR RECOVERY OF SULFUR FROM ACID GASES
5451386	1993	1995	UNIVERSITY OF OREGON	HYDROGEN-SELECTIVE MEMBRANE
5453298	1994	1995	CALIFORNIA INSTITUTE OF TECHNOLOGY	METHOD FOR FORMING H2-PERMSELECTIVE OXIDE MEMBRANES
EP0643756	1993	1995	BATTELLE MEMORIAL INSTITUTE	METHOD FOR THE CATALYTIC CONVERSION OF ORGANIC MATERIALS INTO A PRODUCT GAS.
5494653	1993	1996	BATTELLE MEMORIAL INSTITUTE	METHOD FOR HOT GAS CONDITIONING
5498278	1994	1996	BEND RESEARCH, INC.	COMPOSITE HYDROGEN SEPARATION ELEMENT AND MODULE
5525322	1994	1996	UNIVERSITY OF CALIFORNIA	METHOD FOR SIMULTANEOUS RECOVERY OF HYDROGEN FROM WATER AND FROM HYDROCARBONS
5541486	1994	1996	ELSAG INTERNATIONAL N.V.	AUTOMATIC TUNING OF A POSITION CONTROL CIRCUIT FOR A SERVO DEVICE
EP0708396	1995	1996	ELSAG INTERNATIONAL N.V.	AUTOMATIC TUNING OF A POSITION CONTROL CIRCUIT FOR A SERVO DEVICE
EP0718031	1995	1996	BEND RESEARCH, INC.	COMPOSITE HYDROGEN SEPARATION ELEMENT AND MODULE
5616154	1994	1997	BATTELLE MEMORIAL INSTITUTE	METHOD FOR THE CATALYTIC CONVERSION OF ORGANIC MATERIALS INTO A PRODUCT GAS
5645626	1996	1997	BEND RESEARCH, INC.	COMPOSITE HYDROGEN SEPARATION ELEMENT AND MODULE
5652020	1996	1997	UNIVERSITY OF OREGON	HYDROGEN-SELECTIVE MEMBRANE
5669961	1994	1997	LOCKHEED MARTIN IDAHO TECHNOLOGIES	METHOD FOR THE PURIFICATION OF NOBLE GASES, NITROGEN AND

			COMPANY	HYDROGEN
EP0783919	1997	1997	BEND RESEARCH, INC.	COMPOSITE HYDROGEN SEPARATION ELEMENT AND MODULE
WO1997031858	1996	1997	BATTELLE MEMORIAL INSTITUTE	METHOD FOR HOT GAS CONDITIONING
WO1997041060	1996	1997	ELTRON RESEARCH, INC.	SOLID STATE OXYGEN ANION AND ELECTRON MEDIATING MEMBRANE AND CATALYTIC MEMBRANE REACTORS CONTAINING THEM
5814112	1996	1998	BATTELLE MEMORIAL INSTITUTE	NICKEL/RUTHENIUM CATALYST AND METHOD FOR AQUEOUS PHASE REACTIONS
5821111	1997	1998	BIOENGINEERING RESOURCES, INC.	BIOCONVERSION OF WASTE BIOMASS TO USEFUL PRODUCTS
5827903	1996	1998	UNITED STATES DEPARTMENT OF ENERGY	SEPARATION OF CATALYST FROM FISCHER-TROPSCH SLURRY
WO1998026869	1997	1998	BATTELLE MEMORIAL INSTITUTE	NICKEL/RUTHENIUM CATALYST AND METHOD FOR AQUEOUS PHASE REACTIONS
EP0896566	1996	1999	ELTRON RESEARCH, INC.	SOLID STATE OXYGEN ANION AND ELECTRON MEDIATING MEMBRANE AND CATALYTIC MEMBRANE REACTORS CONTAINING THEM
EP0931763	1999	1999	AIR PRODUCTS AND CHEMICALS, INC.	FLUID SEPARATION DEVICE COMPRISING A MIXED CONDUCTING MULTICOMPONENT METALLIC OXIDE MEMBRANE
WO1999034898	1999	1999	UNIVERSITY OF CALIFORNIA	APPARATUS AND METHOD FOR SIMULTANEOUS RECOVERY OF HYDROGEN FROM WATER AND FROM HYDROCARBONS
6033632	1996	2000	ELTRON RESEARCH, INC.	SOLID STATE OXYGEN ANION AND ELECTRON MEDIATING MEMBRANE AND CATALYTIC MEMBRANE REACTORS CONTAINING THEM
6056807	1998	2000	AIR PRODUCTS AND CHEMICALS, INC.	FLUID SEPARATION DEVICES CAPABLE OF OPERATING UNDER HIGH CARBON DIOXIDE PARTIAL PRESSURES WHICH UTILIZE CREEP-RESISTANT

				SOLID-STATE MEMBRANES FORMED FROM A MIXED CONDUCTING MULTICOMPONENT METALLIC OXIDE
6117808	1998	2000	UNIVERSITY OF CHICAGO	DENSE CERAMIC MEMBRANE MATERIAL FOR CONVERSION OF METHANE TO SYNGAS
6146549	1999	2000	ELTRON RESEARCH, INC.	CERAMIC MEMBRANES FOR CATALYTIC MEMBRANE REACTORS WITH HIGH IONIC CONDUCTIVITIES AND LOW EXPANSION PROPERTIES
6165438	1999	2000	UNIVERSITY OF CALIFORNIA	APPARATUS AND METHOD FOR SIMULTANEOUS RECOVERY OF HYDROGEN FROM WATER AND FROM HYDROCARBONS
WO2000069556	2000	2000	ELTRON RESEARCH, INC.	IMPROVED MIXED IONIC AND ELECTRONIC CONDUCTING CERAMIC MEMBRANES FOR HYDROCARBON PROCESSING
WO2000073247	2000	2000	BECHTEL BWXT IDAHO, LLC	THERMAL DEVICE AND METHOD FOR PRODUCTION OF CARBON MONOXIDE AND HYDROGEN BY THERMAL DISSOCIATION OF HYDROCARBON GASES
WO2000078434	2000	2000	UNIVERSITY OF CALIFORNIA	THERMALLY TOLERANT MULTILAYER METAL MEMBRANE
6187226	1999	2001	BECHTEL BWXT IDAHO, LLC	THERMAL DEVICE AND METHOD FOR PRODUCTION OF CARBON MONOXIDE AND HYDROGEN BY THERMAL DISSOCIATION OF HYDROCARBON GASES
6214090	1999	2001	UNIVERSITY OF CALIFORNIA	THERMALLY TOLERANT MULTILAYER METAL MEMBRANE
6214757	1999	2001	ELTRON RESEARCH, INC.	SOLID STATE OXYGEN ANION AND ELECTRON MEDIATING MEMBRANE AND CATALYTIC MEMBRANE REACTORS CONTAINING THEM
6309612	1998	2001	UNITED STATES DEPARTMENT OF ENERGY	CERAMIC MEMBRANE REACTOR WITH TWO REACTANT GASES AT

				DIFFERENT PRESSURES
WO2001000310	2000	2001	BECHTEL BWXT IDAHO, LLC	PLASMA REFORMING AND PARTIAL OXIDATION OF HYDROCARBON FUEL VAPOR TO PRODUCE SYNTHESIS GAS AND/OR HYDROGEN GAS
WO2001010775	2000	2001	ELTRON RESEARCH, INC.	CERAMIC MEMBRANES FOR CATALYTIC MEMBRANE REACTORS WITH HIGH IONIC CONDUCTIVITIES AND LOW EXPANSION PROPERTIES
WO2001042132	2000	2001	UNIVERSITY OF CALIFORNIA	HYDROGEN PRODUCTION FROM CARBONACEOUS MATERIAL
WO2001046067	2000	2001	BECHTEL BWXT IDAHO, LLC	HYDROGEN AND ELEMENTAL CARBON PRODUCTION FROM NATURAL GAS AND OTHER HYDROCARBONS
WO2001053005	2001	2001	UNASSIGNED	METHOD FOR PREPARATION OF THERMALLY AND MECHANICALLY STABLE METAL/POROUS SUBSTRATE COMPOSITE MEMBRANES
6372156	1999	2002	BECHTEL BWXT IDAHO, LLC	METHODS OF CHEMICALLY CONVERTING FIRST MATERIALS TO SECOND MATERIALS UTILIZING HYBRID-PLASMA SYSTEMS
6395197	2000	2002	BECHTEL BWXT IDAHO, LLC	HYDROGEN AND ELEMENTAL CARBON PRODUCTION FROM NATURAL GAS AND OTHER HYDROCARBONS
6468499	2000	2002	ARGONNE NATIONAL LABORATORY	METHOD OF GENERATING HYDROGEN BY CATALYTIC DECOMPOSITION OF WATER
6471921	1999	2002	ELTRON RESEARCH, INC.	MIXED IONIC AND ELECTRONIC CONDUCTING CERAMIC MEMBRANES FOR HYDROCARBON PROCESSING
EP1224149	2000	2002	ELTRON RESEARCH, INC.	CERAMIC MEMBRANES FOR CATALYTIC MEMBRANE REACTORS WITH HIGH IONIC CONDUCTIVITIES AND

				LOW EXPANSION PROPERTIES
EP1240100	2000	2002	UNIVERSITY OF CALIFORNIA	HYDROGEN PRODUCTION FROM CARBONACEOUS MATERIAL
EP1251970	2001	2002	RESEARCH TRIANGLE INSTITUTE	METHOD FOR PREPARATION OF THERMALLY AND MECHANICALLY STABLE METAL/POROUS SUBSTRATE COMPOSITE MEMBRANES
WO2002018043	2001	2002	RESEARCH TRIANGLE INSTITUTE	ATTRITION RESISTANT BULK IRON CATALYSTS AND PROCESSES FOR PREPARING AND USING SAME
WO2002024437	2001	2002	PRAXAIR TECHNOLOGY, INC.	COLD ISOPRESSING METHOD
6524421	2000	2003	PRAXAIR TECHNOLOGY, INC.	COLD ISOPRESSING METHOD
6596423	2001	2003	BROOKHAVEN SCIENCE ASSOCIATES LLC	METHOD FOR LOW TEMPERATURE CATALYTIC PRODUCTION OF HYDROGEN
6606855	2000	2003	BECHTEL BWXT IDAHO, LLC	PLASMA REFORMING AND PARTIAL OXIDATION OF HYDROCARBON FUEL VAPOR TO PRODUCE SYNTHESIS GAS AND/OR HYDROGEN GAS
6641626	2002	2003	ELTRON RESEARCH, INC.	MIXED IONIC AND ELECTRONIC CONDUCTING CERAMIC MEMBRANES FOR HYDROCARBON PROCESSING
6668763	2002	2003	UNIVERSITY OF CHICAGO	PROCESS FOR IN-SITU PRODUCTION OF HYDROGEN (H2) BY ALCOHOL DECOMPOSITION FOR EMISSION REDUCTION FROM INTERNAL COMBUSTION ENGINES
EP1331992	2001	2003	RESEARCH TRIANGLE INSTITUTE	ATTRITION RESISTANT BULK IRON CATALYSTS AND PROCESSES FOR PREPARING AND USING SAME
EP1365909	2001	2003	PRAXAIR TECHNOLOGY, INC.	COLD ISOPRESSING METHOD
WO2003045841	2002	2003	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS

WO2003101588	2003	2003	UNIVERSITY OF WYOMING	MEMBRANE FOR HYDROGEN RECOVERY FROM STREAMS CONTAINING HYDROGEN SULFIDE
6699457	2001	2004	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS
6726893	2002	2004	UNIVERSITY OF CHICAGO	HYDROGEN PRODUCTION BY HIGH-TEMPERATURE WATER SPLITTING USING ELECTRON-CONDUCTING MEMBRANES
6761929	2002	2004	RESEARCH TRIANGLE INSTITUTE	METHOD FOR PREPARATION OF THERMALLY AND MECHANICALLY STABLE METAL/POROUS SUBSTRATE COMPOSITE MEMBRANES
6773692	2002	2004	IOWA STATE UNIVERSITY	METHOD OF PRODUCTION OF PURE HYDROGEN NEAR ROOM TEMPERATURE FROM ALUMINUM-BASED HYDRIDE MATERIALS
6790430	2000	2004	UNIVERSITY OF CALIFORNIA	HYDROGEN PRODUCTION FROM CARBONACEOUS MATERIAL
6793910	2002	2004	UNASSIGNED	PROCESS TO ACCOMPLISH AUTOTHERMAL OR STEAM REFORMING VIA A RECIPROCATING COMPRESSION DEVICE
6804950	2003	2004	BECHTEL BWXT IDAHO, LLC	PLASMA REFORMING AND PARTIAL OXIDATION OF HYDROCARBON FUEL VAPOR TO PRODUCE SYNTHESIS GAS AND/OR HYDROGEN GAS
EP1458645	2002	2004	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS
WO2004044095	2003	2004	UNIVERSITY OF MINNESOTA	CATALYTIC PARTIAL OXIDATION OF HYDROCARBONS
6964757	2002	2005	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS
6964758	2003	2005	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS
EP1562852	2003	2005	UNIVERSITY OF	CATALYTIC PARTIAL

			MINNESOTA	OXIDATION OF HYDROCARBONS
WO2005102915	2004	2005	BECHTEL BWXT IDAHO, LLC	METHOD OF PRODUCING HYDROGEN
6997012	2004	2006	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF LIQUIFYING A GAS
7022165	2003	2006	UNIVERSITY OF CALIFORNIA	TUBULAR HYDROGEN PERMEABLE METAL FOIL MEMBRANE AND METHOD OF FABRICATION
7078012	2003	2006	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF PRODUCING A HIGH PRESSURE GAS
7097675	2002	2006	BATTELLE ENERGY ALLIANCE, LLC	FAST-QUENCH REACTOR FOR HYDROGEN AND ELEMENTAL CARBON PRODUCTION FROM NATURAL GAS AND OTHER HYDROCARBONS
7153489	2004	2006	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF PRODUCING HYDROGEN
EP1713719	2004	2006	BECHTEL BWXT IDAHO, LLC	METHOD OF PRODUCING HYDROGEN
WO2006055263	2005	2006	BATTELLE ENERGY ALLIANCE, LLC	A CHEMICAL REACTOR AND METHOD FOR CHEMICALLY CONVERTING A FIRST MATERIAL INTO A SECOND MATERIAL
WO2006076023	2005	2006	BATTELLE MEMORIAL INSTITUTE	METHOD OF GENERATING HYDROCARBON REAGENTS FROM DIESEL, NATURAL GAS AND OTHER LOGISTICAL FUELS
7163670	2004	2007	UNIVERSITY OF WYOMING	MEMBRANE FOR HYDROGEN RECOVERY FROM STREAMS CONTAINING HYDROGEN SULFIDE
7176159	2002	2007	IOWA STATE UNIVERSITY	CATALYST AND SORBENT MATERIAL FOR THE PRODUCTION OF HYDROGEN
7255848	2003	2007	UNIVERSITY OF MINNESOTA	PRODUCTION OF HYDROGEN FROM ALCOHOLS
7259286	2003	2007	UNIVERSITY OF PITTSBURGH	ATTRITION RESISTANT BULK IRON CATALYSTS AND PROCESSES FOR PREPARING AND USING SAME
7262334	2003	2007	UNIVERSITY OF MINNESOTA	CATALYTIC PARTIAL OXIDATION OF HYDROCARBONS
7303657	2003	2007	BATTELLE ENERGY ALLIANCE, LLC	METHOD AND APPARATUS FOR CHEMICAL SYNTHESIS
EP1753843	2005	2007	BATTELLE	METHOD OF GENERATING

			MEMORIAL INSTITUTE	HYDROCARBON REAGENTS FROM DIESEL, NATURAL GAS AND OTHER LOGISTICAL FUELS
WO2007044009	2005	2007	MIDWEST RESEARCH INSTITUTE	ATTRITION RESISTANT FLUIDIZABLE REFORMING CATALYST
WO2007075476	2006	2007	VIRENT ENERGY SYSTEMS INC.	CATALYSTS AND METHODS FOR REFORMING OXYGENATED COMPOUNDS
WO2007127429	2007	2007	UNIVERSITY OF WYOMING	PROCESS AND CATALYST FOR PRODUCTION OF MIXED ALCOHOLS FROM SYNTHESIS GAS
WO2007134268	2007	2007	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	BIOHYDROGEN PRODUCTION BY AN ARTIFICIAL ENZYMATIC PATHWAY
WO2007149646	2007	2007	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF PRODUCING HYDROGEN, AND RENDERING A CONTAMINATED BIOMASS INERT
7338590	2005	2008	SANDIA CORPORATION	WATER-SPLITTING USING PHOTOCATALYTIC PORPHYRIN-NANOTUBE COMPOSITE DEVICES
7354561	2004	2008	BATTELLE ENERGY ALLIANCE, LLC	CHEMICAL REACTOR AND METHOD FOR CHEMICALLY CONVERTING A FIRST MATERIAL INTO A SECOND MATERIAL
7365102	2007	2008	DELPHI TECHNOLOGIES, INC.	PROCESS FOR PRE-REFORMING HYDROCARBON FUELS
7371907	2004	2008	LOS ALAMOS NATIONAL SECURITY, LLC	ICE METHOD FOR PRODUCTION OF HYDROGEN CLATHRATE HYDRATES
7435760	2005	2008	BATTELLE MEMORIAL INSTITUTE	METHOD OF GENERATING HYDROCARBON REAGENTS FROM DIESEL, NATURAL GAS AND OTHER LOGISTICAL FUELS
EP1945350	2005	2008	MIDWEST RESEARCH INSTITUTE	ATTRITION RESISTANT FLUIDIZABLE REFORMING CATALYST
EP1967490	2008	2008	DELPHI TECHNOLOGIES, INC.	PROCESS FOR PRE-REFORMING HYDROCARBON FUELS
EP1968887	2006	2008	VIRENT ENERGY SYSTEMS INC.	CATALYSTS AND METHODS FOR REFORMING OXYGENATED COMPOUNDS

WO2008109129	2008	2008	UNIVERSITY OF MINNESOTA	SOLID FUEL VOLATILIZATION TO PRODUCE SYNTHESIS
7534372	2007	2009	UNIVERSITY OF MINNESOTA	CATALYTIC PARTIAL OXIDATION OF HYDROCARBONS
7604771	2006	2009	UCHICAGO ARGONNE, LLC	THERMAL METHOD FOR FABRICATING A HYDROGEN SEPARATION MEMBRANE ON A POROUS SUBSTRATE
7611565	2006	2009	LOS ALAMOS NATIONAL SECURITY, LLC	DEVICE FOR HYDROGEN SEPARATION AND METHOD
7618612	2005	2009	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS
EP2018394	2007	2009	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	BIOHYDROGEN PRODUCTION BY AN ARTIFICIAL ENZYMATIC PATHWAY
EP2029276	2007	2009	UNIVERSITY OF WYOMING	PROCESS FOR PRODUCTION OF MIXED ALCOHOLS FROM SYNTHESIS GAS
WO2008127802	2008	2009	UNIVERSITY OF CALIFORNIA	METHOD AND APPARATUS AND FOR ELECTROKINETIC CO-GENERATION OF HYDROGEN AND ELECTRIC POWER FROM LIQUID WATER MICROJETS
WO2009045631	2008	2009	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	ELECTROCHEMICAL FORMATION OF HYDROXIDE FOR ENHANCING CARBON DIOXIDE AND ACID GAS UPTAKE BY A SOLUTION
WO2009079462	2008	2009	BATTELLE ENERGY ALLIANCE, LLC	METHODS AND SYSTEMS FOR THE PRODUCTION OF HYDROGEN
7665328	2006	2010	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF PRODUCING HYDROGEN, AND RENDERING A CONTAMINATED BIOMASS INERT
7666387	2007	2010	UT-BATTELLE, LLC	CARBONATE THERMOCHEMICAL CYCLE FOR THE PRODUCTION OF HYDROGEN
7666534	2006	2010	UNITED STATES DEPARTMENT OF ENERGY	ELECTRO-CATALYTIC OXIDATION DEVICE FOR REMOVING CARBON FROM A FUEL REFORMATE
7686856	2006	2010	PRAXAIR	METHOD AND APPARATUS

			TECHNOLOGY, INC.	FOR PRODUCING SYNTHESIS GAS
7767000	2007	2010	UNITED STATES DEPARTMENT OF ENERGY	REGENERABLE HYDROGEN CHLORIDE REMOVAL SORBENT AND REGENERABLE MULTI-FUNCTIONAL HYDROGEN SULFIDE AND HYDROGEN CHLORIDE REMOVAL SORBENT FOR HIGH TEMPERATURE GAS STREAMS
7818993	2007	2010	UCHICAGO ARGONNE, LLC	HIGH-PERFORMANCE FLEXIBLE HYDROGEN SENSORS
WO2010054357	2009	2010	UNIVERSITY OF GEORGIA	PHOTOCATALYTIC STRUCTURES, METHODS OF MAKING PHOTOCATALYTIC STRUCTURES, AND METHODS OF PHOTOCATALYSIS
WO2010107919	2010	2010	EMORY UNIVERSITY	POLYOXOMETALATE WATER OXIDATION CATALYSTS AND METHODS OF USE THEREOF
WO2010114924	2010	2010	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	SYSTEMS AND METHODS FOR SELECTIVE HYDROGEN TRANSPORT AND MEASUREMENT
7915196	2005	2011	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	ATTRITION RESISTANT FLUIDIZABLE REFORMING CATALYST
7939026	2007	2011	BATTELLE ENERGY ALLIANCE, LLC	APPARATUS FOR CHEMICAL SYNTHESIS
7959716	2009	2011	UCHICAGO ARGONNE, LLC	HYDROGEN SEPARATION MEMBRANE ON A POROUS SUBSTRATE
8048933	2007	2011	UNIVERSITY OF WYOMING	PROCESS AND CATALYST FOR PRODUCTION OF MIXED ALCOHOLS FROM SYNTHESIS GAS
WO2011071653	2010	2011	BATTELLE ENERGY ALLIANCE, LLC	METHOD AND SYSTEM FOR PRODUCING HYDROGEN USING SODIUM ION SEPARATION MEMBRANES
WO2011094391	2011	2011	YALE UNIVERSITY	CONDUCTIVITY BASED SELECTIVE ETCH FOR GAN DEVICES AND APPLICATIONS THEREOF
8101243	2007	2012	COLORADO SCHOOL OF MINES	METHOD OF MAKING SULFUR-RESISTANT COMPOSITE METAL MEMBRANES

8128735	2009	2012	UNITED STATES DEPARTMENT OF ENERGY	PROCESS FOR CO2 CAPTURE USING ZEOLITES FROM HIGH PRESSURE AND MODERATE TEMPERATURE GAS STREAMS
8132410	2007	2012	BATTELLE ENERGY ALLIANCE, LLC	METHODS AND SYSTEMS FOR THE PRODUCTION OF HYDROGEN
8133463	2009	2012	UNITED STATES DEPARTMENT OF ENERGY	PYROCHLORE-TYPE CATALYSTS FOR THE REFORMING OF HYDROCARBON FUELS
8142756	2010	2012	UNITED STATES DEPARTMENT OF ENERGY	METHODS OF REFORMING HYDROCARBON FUELS USING HEXAALUMINATE CATALYSTS
8177946	2008	2012	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	ELECTROCHEMICAL FORMATION OF HYDROXIDE FOR ENHANCING CARBON DIOXIDE AND ACID GAS UPTAKE BY A SOLUTION
8211681	2007	2012	VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.	BIOHYDROGEN PRODUCTION BY AN ARTIFICIAL ENZYMATIC PATHWAY
8231857	2006	2012	VIRENT ENERGY SYSTEMS INC.	CATALYSTS AND METHODS FOR REFORMING OXYGENATED COMPOUNDS
8241600	2011	2012	UNITED STATES DEPARTMENT OF ENERGY	PYROCHLORE CATALYSTS FOR HYDROCARBON FUEL REFORMING
8287814	2008	2012	BATTELLE ENERGY ALLIANCE, LLC	CHEMICAL REACTOR FOR CONVERTING A FIRST MATERIAL INTO A SECOND MATERIAL
8309049	2009	2012	BATTELLE ENERGY ALLIANCE, LLC	MOLTEN METAL REACTOR AND METHOD OF FORMING HYDROGEN, CARBON MONOXIDE AND CARBON DIOXIDE USING THE MOLTEN METAL REACTOR
EP2510135	2010	2012	BATTELLE ENERGY ALLIANCE, LLC	METHOD AND SYSTEM FOR PRODUCING HYDROGEN USING SODIUM ION SEPARATION MEMBRANES
EP2529394	2011	2012	YALE UNIVERSITY	CONDUCTIVITY BASED SELECTIVE ETCH FOR GAN DEVICES AND APPLICATIONS THEREOF
WO2012064712	2011	2012	OHIO STATE UNIVERSITY	CIRCULATING FLUIDIZED BED WITH MOVING BED

				DOWNCOMERS AND GAS SEALING BETWEEN REACTORS
WO2012078396	2011	2012	UT-BATTELLE, LLC	APPARATUS AND METHOD FOR THE ELECTROLYSIS OF WATER
WO2012145622	2012	2012	SUN CATALYTIX CORPORATION	NANOSTRUCTURES, SYSTEMS, AND METHODS FOR PHOTOCATALYSIS
8349214	2011	2013	PRAXAIR TECHNOLOGY, INC.	SYNTHESIS GAS METHOD AND APPARATUS
8349289	2008	2013	UNIVERSITY OF MINNESOTA	REACTIVE FLASH VOLATILIZATION OF FLUID FUELS
8372374	2008	2013	UNIVERSITY OF CALIFORNIA	METHOD AND APPARATUS FOR ELECTROKINETIC CO-GENERATION OF HYDROGEN AND ELECTRIC POWER FROM LIQUID WATER MICROJETS
8420032	2011	2013	SANDIA CORPORATION	MOVING BED REACTOR FOR SOLAR THERMOCHEMICAL FUEL PRODUCTION
8444846	2009	2013	BATTELLE ENERGY ALLIANCE, LLC	METHOD AND SYSTEM FOR PRODUCING HYDROGEN USING SODIUM ION SEPARATION MEMBRANES
8568582	2010	2013	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	SYSTEMS AND METHODS FOR SELECTIVE HYDROGEN TRANSPORT AND MEASUREMENT
8574327	2012	2013	BATTELLE ENERGY ALLIANCE, LLC	MOLTEN METAL REACTORS
8608829	2011	2013	UNITED STATES DEPARTMENT OF ENERGY	CU-PD-M HYDROGEN SEPARATION MEMBRANES
EP2586743	2002	2013	WISCONSIN ALUMNI RESEARCH FOUNDATION	LOW-TEMPERATURE HYDROGEN PRODUCTION FROM OXYGENATED HYDROCARBONS
EP2637777	2011	2013	OHIO STATE UNIVERSITY	CIRCULATING FLUIDIZED BED WITH MOVING BED DOWNCOMERS AND GAS SEALING BETWEEN REACTORS
WO2013009559	2012	2013	PRAXAIR TECHNOLOGY, INC.	METHOD AND APPARATUS FOR PRODUCING SYNTHESIS GAS
WO2013009560	2012	2013	PRAXAIR TECHNOLOGY, INC.	OXYGEN TRANSPORT MEMBRANE SYSTEM AND METHOD FOR TRANSFERRING HEAT TO CATALYTIC/PROCESS REACTORS

WO2013012473	2012	2013	BATTELLE ENERGY ALLIANCE, LLC	SYSTEM AND PROCESS FOR THE PRODUCTION OF SYNGAS AND FUEL GASSES
WO2013040013	2012	2013	BROOKHAVEN SCIENCE ASSOCIATES LLC	BIMETALLIC CATALYSTS FOR CO2 HYDROGENATION AND H2 GENERATION FROM FORMIC ACID AND/OR SALTS THEREOF
WO2013096813	2012	2013	UNIVERSITY OF FLORIDA	SOLAR THERMOCHEMICAL REACTOR, METHODS OF MANUFACTURE AND USE THEREOF AND THERMOGRAVIMETER
WO2013119303	2012	2013	UNIVERSITY OF MINNESOTA	THERMOCHEMICAL REACTOR SYSTEMS AND METHODS
WO2013122849	2013	2013	EVEREADY BATTERY COMPANY, INC.	HYDROGEN GAS GENERATOR
8623121	2011	2014	COLORADO SCHOOL OF MINES	STABLE CATALYST LAYERS FOR HYDROGEN PERMEABLE COMPOSITE MEMBRANES
8623241	2012	2014	PRAXAIR TECHNOLOGY, INC.	OXYGEN TRANSPORT MEMBRANE SYSTEM AND METHOD FOR TRANSFERRING HEAT TO CATALYTIC/PROCESS REACTORS
8679224	2011	2014	BABCOCK & WILCOX TECHNICAL SERVICES	HYDROGEN, LITHIUM, AND LITHIUM HYDRIDE PRODUCTION
8685281	2011	2014	BATTELLE ENERGY ALLIANCE, LLC	SYSTEM AND PROCESS FOR THE PRODUCTION OF SYNGAS AND FUEL GASSES
8764964	2011	2014	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	ELECTROCHEMICAL FORMATION OF HYDROXIDE FOR ENHANCING CARBON DIOXIDE AND ACID GAS UPTAKE BY A SOLUTION
8790546	2008	2014	UNIVERSITY OF MINNESOTA	SOLID FUEL VOLATILIZATION TO PRODUCE SYNTHESIS GAS
8822367	2010	2014	EMORY UNIVERSITY	POLYOXOMETALATE WATER OXIDATION CATALYSTS AND METHODS OF USE THEREOF
8920526	2011	2014	UNITED STATES DEPARTMENT OF ENERGY	PRODUCTION OF METHANE-RICH SYNGAS FROM HYDROCARBON FUELS USING MULTI-FUNCTIONAL

				CATALYST/CAPTURE AGENT
EP2729406	2012	2014	PRAXAIR TECHNOLOGY, INC.	METHOD AND APPARATUS FOR PRODUCING SYNTHESIS GAS
EP2729410	2012	2014	PRAXAIR TECHNOLOGY, INC.	OXYGEN TRANSPORT MEMBRANE SYSTEM AND METHOD FOR TRANSFERRING HEAT TO CATALYTIC/PROCESS REACTORS
EP2734467	2012	2014	BATTELLE ENERGY ALLIANCE, LLC	SYSTEM AND PROCESS FOR THE PRODUCTION OF SYNGAS AND FUEL GASSES
EP2755966	2012	2014	BROOKHAVEN SCIENCE ASSOCIATES LLC	BIMETALLIC CATALYSTS FOR CO2 HYDROGENATION AND H2 GENERATION FROM FORMIC ACID AND/OR SALTS THEREOF
EP2794086	2012	2014	UNIVERSITY OF FLORIDA	SOLAR THERMOCHEMICAL REACTOR, METHODS OF MANUFACTURE AND USE THEREOF AND THERMOGRAVIMETER
EP2815448	2013	2014	INTELLIGENT ENERGY, INC.	HYDROGEN GAS GENERATOR
WO2014018878	2013	2014	BATTELLE MEMORIAL INSTITUTE	SOLAR THERMOCHEMICAL PROCESSING SYSTEM AND METHOD
WO2014025770	2013	2014	EVEREADY BATTERY COMPANY, INC.	FUEL UNIT, REFILLABLE HYDROGEN GENERATOR AND FUEL CELL SYSTEM
WO2014077868	2013	2014	INTELLIGENT ENERGY, INC.	HEATER ASSEMBLY, HYDROGEN GENERATOR AND METHOD OF PROVIDING HYDROGEN GAS
WO2014077917	2013	2014	INTELLIGENT ENERGY, INC.	A HYDROGEN GENERATOR HAVING A THERMAL ACTUATOR
8956526	2012	2015	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HYBRID SULFUR CYCLE OPERATION FOR HIGH-TEMPERATURE GAS-COOLED REACTORS
8975205	2009	2015	UNIVERSITY OF GEORGIA	PHOTOCATALYTIC STRUCTURES, METHODS OF MAKING PHOTOCATALYTIC STRUCTURES, AND METHODS OF PHOTOCATALYSIS
9011651	2010	2015	UT-BATTELLE, LLC	APPARATUS AND METHOD FOR THE ELECTROLYSIS OF WATER
9011725	2014	2015	BATTELLE ENERGY	SYSTEM AND PROCESS

			ALLIANCE, LLC	FOR THE PRODUCTION OF SYNGAS AND FUEL GASSES
9017437	2012	2015	CERAMATEC, INC.	METHOD FOR FORMING SYNTHESIS GAS USING A PLASMA-CATALYZED FUEL REFORMER
9034618	2009	2015	INEOS BIO SA	METHOD FOR SUSTAINING MICROORGANISM CULTURE IN SYNGAS FERMENTATION PROCESS IN DECREASED CONCENTRATION OR ABSENCE OF VARIOUS SUBSTRATES
9044715	2008	2015	COLORADO SCHOOL OF MINES	UNSUPPORTED PALLADIUM ALLOY MEMBRANES AND METHODS OF MAKING SAME
9095846	2012	2015	BROOKHAVEN SCIENCE ASSOCIATES, LLC	BIMETALLIC CATALYSTS FOR CO2 HYDROGENATION AND H2 GENERATION FROM FORMIC ACID AND/OR SALTS THEREOF
9102691	2014	2015	TEXAS A&M UNIVERSITY SYSTEM	ALUMINUM METAL ORGANIC FRAMEWORK MATERIALS
9132416	2007	2015	UNITED STATES DEPARTMENT OF ENERGY	NANO-STRUCTURED NOBLE METAL CATALYSTS BASED ON HEXAMETALLATE ARCHITECTURE FOR THE REFORMING OF HYDROCARBON FUELS
9162201	2012	2015	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATOR HAVING LIQUID DELIVERY MEMBER
9180419	2012	2015	PRAXAIR TECHNOLOGY, INC.	SYNTHESIS GAS METHOD AND APPARATUS
9205420	2012	2015	HARVARD UNIVERSITY	NANOSTRUCTURES, SYSTEMS, AND METHODS FOR PHOTOCATALYSIS
9206524	2012	2015	YALE UNIVERSITY	CONDUCTIVITY BASED ON SELECTIVE ETCH FOR GAN DEVICES AND APPLICATIONS THEREOF
EP2876112	2014	2015	TEXAS A&M UNIVERSITY	MONOCRYSTALLINE IRON METAL ORGANIC FRAMEWORKS
EP2882682	2013	2015	INTELLIGENT ENERGY, INC.	REFILLABLE HYDROGEN GENERATOR
EP2920836	2013	2015	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATOR AND METHOD OF PROVIDING HYDROGEN GAS

EP2920837	2013	2015	INTELLIGENT ENERGY, INC.	A HYDROGEN GENERATOR HAVING A THERMAL ACTUATOR
WO2015054219	2014	2015	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
WO2015054223	2014	2015	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
WO2015054228	2014	2015	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
WO2015054363	2014	2015	PRAXAIR TECHNOLOGY, INC.	SYSTEM METHOD FOR TEMPERATURE CONTROL IN AN OXYGEN TRANSPORT MEMBRANE BASED REACTOR
WO2015079229	2014	2015	TEXAS A&M UNIVERSITY	PROCESS FOR PREPARING METAL ORGANIC FRAMEWORK MATERIALS
WO2015079230	2014	2015	TEXAS A&M UNIVERSITY	ALUMINIUM METAL ORGANIC FRAMEWORK MATERIALS
WO2015123246	2015	2015	PRAXAIR TECHNOLOGY, INC.	OXYGEN TRANSPORT MEMBRANE REACTOR BASED METHOD AND SYSTEM FOR GENERATING ELECTRIC POWER
9238201	2013	2016	PRAXAIR TECHNOLOGY, INC.	OXYGEN TRANSPORT MEMBRANE SYSTEM AND METHOD FOR TRANSFERRING HEAT TO CATALYTIC/PROCESS REACTORS
9243560	2012	2016	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATOR HAVING A THERMAL ACTUATOR
9295958	2013	2016	INTELLIGENT ENERGY, INC.	FUEL UNIT, REFILLABLE HYDROGEN GENERATOR AND FUEL CELL SYSTEM
9315909	2012	2016	UNIVERSITY OF CALIFORNIA	MOLECULAR MOLYBDENUM PERSULFIDE AND RELATED CATALYSTS FOR GENERATING HYDROGEN FROM WATER
9391334	2014	2016	INTELLIGENT ENERGY, INC.	HYDROGEN GAS GENERATOR
9452388	2014	2016	PRAXAIR TECHNOLOGY, INC.	SYSTEM AND METHOD FOR AIR TEMPERATURE CONTROL IN AN OXYGEN TRANSPORT MEMBRANE BASED REACTOR

9452401	2014	2016	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
9469908	2014	2016	UNIVERSITY OF PENNSYLVANIA	SYNERGISTIC OXYGEN EVOLVING ACTIVITY OF NON-STOICHIOMETRIC SURFACES
9486765	2014	2016	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
9499916	2015	2016	UNIVERSITY OF CALIFORNIA	MOLECULAR MOLYBDENUM PERSULFIDE AND RELATED CATALYSTS FOR GENERATING HYDROGEN FROM WATER
9504982	2012	2016	UNIVERSITY OF MINNESOTA	THERMOCHEMICAL REACTOR SYSTEMS AND METHODS
9517932	2015	2016	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATOR HAVING LIQUID DELIVERY MEMBER
EP3055052	2014	2016	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
EP3055053	2014	2016	PRAXAIR TECHNOLOGY, INC.	SYSTEM AND METHOD FOR TEMPERATURE CONTROL IN AN OXYGEN TRANSPORT MEMBRANE BASED REACTOR
EP3055054	2014	2016	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
EP3071579	2014	2016	TEXAS A&M UNIVERSITY	ALUMINIUM METAL ORGANIC FRAMEWORK MATERIALS
EP3106220	2016	2016	SOUTHERN RESEARCH INSTITUTE	SULFUR RESISTANT NICKEL ALUMINATE CATALYSTS, SOL-GEL PREPARATION METHOD AND USE IN METHANE REFORMING OF SUCH CATALYSTS
WO2016049061	2015	2016	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	ELECTROCHEMICAL FLOW-CELL FOR HYDROGEN PRODUCTION AND NICOTINAMIDE CO-FACTOR DEPENDENT TARGET REDUCTION, AND RELATED METHODS AND SYSTEMS
9562203	2014	2017	UNITED STATES	METHANE-RICH SYNGAS

			DEPARTMENT OF ENERGY	PRODUCTION FROM HYDROCARBON FUELS USING MULTI-FUNCTIONAL CATALYST/CAPTURE AGENT
9562472	2015	2017	PRAXAIR TECHNOLOGY, INC.	OXYGEN TRANSPORT MEMBRANE REACTOR BASED METHOD AND SYSTEM FOR GENERATING ELECTRIC POWER
9573094	2014	2017	PRAXAIR TECHNOLOGY, INC.	SYSTEM AND METHOD FOR TEMPERATURE CONTROL IN AN OXYGEN TRANSPORT MEMBRANE BASED REACTOR
9631284	2014	2017	COLORADO SCHOOL OF MINES	ELECTROCHEMICAL DEVICE FOR SYNGAS AND LIQUID FUELS PRODUCTION
9669379	2012	2017	UNIVERSITY OF FLORIDA	SOLAR THERMOCHEMICAL REACTOR, METHODS OF MANUFACTURE AND USE THEREOF AND THERMOGRAVIMETER
9682859	2014	2017	CONSOLIDATED NUCLEAR SECURITY LLC	HYDROGEN, LITHIUM, AND LITHIUM HYDRIDE PRODUCTION
9687775	2015	2017	UNIVERSITY OF SOUTH CAROLINA	CHEMICALLY STABLE CERAMIC-METAL COMPOSITE MEMBRANE FOR HYDROGEN SEPARATION
9724668	2016	2017	TEXAS A&M UNIVERSITY	IRON METAL ORGANIC FRAMEWORK MATERIALS
9776153	2014	2017	PRAXAIR TECHNOLOGY, INC.	CERAMIC OXYGEN TRANSPORT MEMBRANE ARRAY REACTOR AND REFORMING METHOD
9776860	2016	2017	JOHNS HOPKINS UNIVERSITY	METHOD OF CARBON DIOXIDE-FREE HYDROGEN PRODUCTION FROM HYDROCARBON DECOMPOSITION OVER METAL SALTS
9808755	2015	2017	AIR PRODUCTS AND CHEMICALS, INC.	SOUR PRESSURE SWING ADSORPTION PROCESS
9833777	2014	2017	EMORY UNIVERSITY	WATER OXIDATION CATALYSTS AND METHODS OF USE THEREOF
WO2017146800	2016	2017	PRAXAIR TECHNOLOGY, INC.	METHOD OF THERMALLY-STABILIZING AND OXYGEN TRANSPORT MEMBRANE-BASED REFORMING SYSTEM

WO2017147168	2017	2017	JOHNS HOPKINS UNIVERSITY	METHOD OF CARBON DIOXIDE-FREE HYDROGEN PRODUCTION FROM HYDROCARBON DECOMPOSITION OVER METAL SALTS
9944521	2015	2018	INTELLIGENT ENERGY, INC.	HYDROGEN GENERATOR HAVING A THERMAL ACTUATOR
9950305	2012	2018	BATTELLE MEMORIAL INSTITUTE	SOLAR THERMOCHEMICAL PROCESSING SYSTEM AND METHOD
9975080	2016	2018	UNITED STATES DEPARTMENT OF ENERGY	SULFUR TOLERANT HYDROPHOBIC IONIC LIQUID SOLVENT
9982353	2017	2018	DIOXIDE MATERIALS INC	WATER ELECTROLYZERS
10010847	2011	2018	OHIO STATE UNIVERSITY	CIRCULATING FLUIDIZED BED WITH MOVING BED DOWNCOMERS AND GAS SEALING BETWEEN REACTORS
10010876	2016	2018	PRAXAIR TECHNOLOGY, INC.	CATALYST FOR HIGH TEMPERATURE STEAM REFORMING
10106407	2017	2018	UNITED STATES DEPARTMENT OF ENERGY	METAL FERRITE OXYGEN CARRIERS/CATALYST FOR PARTIAL OXIDATION OF METHANE FOR PRODUCTION OF SYNTHESIS GAS
10113407	2011	2018	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	ELECTROCHEMICAL PRODUCTION OF METAL HYDROXIDE USING METAL SILICATES
10118823	2015	2018	PRAXAIR TECHNOLOGY, INC.	METHOD OF THERMALLY-STABILIZING AN OXYGEN TRANSPORT MEMBRANE-BASED REFORMING SYSTEM
10119197	2014	2018	UNIVERSITY OF NORTH CAROLINA	SOLAR WATER SPLITTING IN A MOLECULAR PHOTOELECTROCHEMICAL CELL
10144000	2016	2018	SOUTHERN RESEARCH INSTITUTE	SULFUR RESISTANT NICKEL BASED CATALYSTS, METHODS OF FORMING AND USING SUCH CATALYSTS
10151037	2015	2018	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	ELECTROCHEMICAL FLOW-CELL FOR HYDROGEN PRODUCTION AND NICOTINAMIDE DEPENDENT TARGET REDUCTION, AND RELATED METHODS AND

				SYSTEMS
EP3390275	2016	2018	PRAXAIR TECHNOLOGY, INC.	METHOD OF THERMALLY-STABILIZING AND OXYGEN TRANSPORT MEMBRANE-BASED REFORMING SYSTEM
WO2018098064	2017	2018	PRAXAIR TECHNOLOGY, INC.	CATALYST FOR HIGH TEMPERATURE STEAM REFORMING
10239035	2016	2019	UNIVERSITY OF FLORIDA	SOLAR THERMOCHEMICAL REACTOR, METHODS OF MANUFACTURE AND USE THEREOF AND THERMOGRAVIMETER
10259705	2016	2019	INTELLIGENT ENERGY, INC.	FUEL UNIT, REFILLABLE HYDROGEN GENERATOR AND FUEL CELL SYSTEM
10458038	2015	2019	YALE UNIVERSITY	CONDUCTIVITY BASED ON SELECTIVE ETCH FOR GAN DEVICES AND APPLICATIONS THEREOF
EP3514159	2014	2019	TEXAS A&M UNIVERSITY	ALUMINIUM METAL ORGANIC FRAMEWORK MATERIAL

Appendix ST-A. Hydrogen Storage Patents in Families Associated with HFTO Funding

Patent #	Application Year	Issue / Publication Year	Original Assignee	Title
5296438	1992	1994	UNITED STATES DEPARTMENT OF ENERGY	DIMENSIONALLY STABLE METALLIC HYDRIDE COMPOSITION
5411928	1993	1995	UNITED STATES DEPARTMENT OF ENERGY	COMPOSITION FOR ABSORBING HYDROGEN
5443616	1993	1995	UNITED STATES DEPARTMENT OF ENERGY	METAL HYDRIDE COMPOSITION AND METHOD OF MAKING
5460745	1994	1995	UNITED STATES DEPARTMENT OF ENERGY	HYDRIDE COMPOSITIONS
WO1995034918	1995	1995	OVONIC BATTERY COMPANY, INC.	ELECTROCHEMICAL HYDROGEN STORAGE ALLOYS AND BATTERIES FABRICATED FROM MG CONTAINING BASE ALLOYS
5506069	1994	1996	OVONIC BATTERY COMPANY, INC.	ELECTROCHEMICAL HYDROGEN STORAGE ALLOYS AND BATTERIES FABRICATED FROM MG CONTAINING BASE ALLOYS
5577630	1995	1996	THIOKOL CORPORATION	COMPOSITE CONFORMABLE PRESSURE VESSEL
WO1996023721	1996	1996	THIOKOL CORPORATION	COMPOSITE CONFORMABLE PRESSURE VESSEL
EP0765531	1995	1997	OVONIC BATTERY COMPANY, INC.	ELECTROCHEMICAL HYDROGEN STORAGE ALLOYS AND BATTERIES FABRICATED FROM MG CONTAINING BASE ALLOYS
EP0812293	1996	1997	THIOKOL CORPORATION	COMPOSITE CONFORMABLE PRESSURE VESSEL
WO1997036819	1997	1997	WESTINGHOUSE SAVANNAH RIVER COMPANY	APPARATUS AND METHODS FOR STORING AND RELEASING HYDROGEN
5798156	1996	1998	UNASSIGNED	LIGHTWEIGHT BLADDER LINED PRESSURE VESSELS
5958098	1997	1999	WESTINGHOUSE SAVANNAH RIVER COMPANY	METHOD AND COMPOSITION IN WHICH METAL HYDRIDE PARTICLES ARE EMBEDDED IN A SILICA NETWORK

5965482	1998	1999	WESTINGHOUSE SAVANNAH RIVER COMPANY	COMPOSITION FOR ABSORBING HYDROGEN FROM GAS MIXTURES
EP0891294	1997	1999	WESTINGHOUSE SAVANNAH RIVER COMPANY	APPARATUS AND METHODS FOR STORING AND RELEASING HYDROGEN
6015041	1996	2000	WESTINGHOUSE SAVANNAH RIVER COMPANY	APPARATUS AND METHODS FOR STORING AND RELEASING HYDROGEN
6017600	1998	2000	UNIVERSITY OF CALIFORNIA	METHOD FOR FORMING A BLADDER FOR FLUID STORAGE VESSELS
6095367	1996	2000	CORDANT TECHNOLOGIES INC.	COMPOSITE CONFORMABLE PRESSURE VESSEL
EP1045464	1995	2000	OVONIC BATTERY COMPANY, INC.	ELECTROCHEMICAL HYDROGEN STORAGE ALLOYS
WO2000024608	1999	2000	JOHNS HOPKINS UNIVERSITY	COMPRESSED GAS FUEL STORAGE SYSTEM
WO2000024641	1999	2000	JOHNS HOPKINS UNIVERSITY	LOW COST, COMPRESSED GAS FUEL STORAGE SYSTEM
WO2000024669	1999	2000	JOHNS HOPKINS UNIVERSITY	COMPRESSED GAS MANIFOLD
6257360	1999	2001	JOHNS HOPKINS UNIVERSITY	COMPRESSED GAS FUEL STORAGE SYSTEM
6262328	1999	2001	WESTINGHOUSE SAVANNAH RIVER COMPANY	CONTAINER AND METHOD FOR ABSORBING AND REDUCING HYDROGEN CONCENTRATION
6267229	2000	2001	WESTINGHOUSE SAVANNAH RIVER COMPANY	APPARATUS AND METHODS FOR STORING AND RELEASING HYDROGEN
6321775	1999	2001	JOHNS HOPKINS UNIVERSITY	COMPRESSED GAS MANIFOLD
EP1133410	1999	2001	JOHNS HOPKINS UNIVERSITY	COMPRESSED GAS FUEL STORAGE SYSTEM
EP1152976	1999	2001	JOHNS HOPKINS UNIVERSITY	COMPRESSED GAS MANIFOLD
EP1161374	1999	2001	JOHNS HOPKINS UNIVERSITY	LOW COST, COMPRESSED GAS FUEL STORAGE SYSTEM
6418962	1999	2002	JOHNS HOPKINS UNIVERSITY	LOW COST, COMPRESSED GAS FUEL STORAGE SYSTEM
6432379	2000	2002	WESTINGHOUSE SAVANNAH RIVER COMPANY	APPARATUS AND METHODS FOR STORING AND RELEASING HYDROGEN
6471935	1999	2002	UNIVERSITY OF HAWAII	HYDROGEN STORAGE MATERIALS AND METHOD OF MAKING BY DRY

				HOMOGENATION
WO2002066369	2002	2002	SAFE HYDROGEN, LLC	STORAGE, GENERATION, AND USE OF HYDROGEN
6528441	1996	2003	WESTINGHOUSE SAVANNAH RIVER COMPANY	HYDROGEN STORAGE COMPOSITION AND METHOD
6593017	2002	2003	ENERGY CONVERSION DEVICES, INC.	HIGH CAPACITY CALCIUM LITHIUM BASED HYDROGEN STORAGE MATERIAL AND METHOD OF MAKING THE SAME
6616891	2002	2003	ENERGY CONVERSION DEVICES, INC.	HIGH CAPACITY TRANSITION METAL BASED HYDROGEN STORAGE MATERIALS FOR THE REVERSIBLE STORAGE OF HYDROGEN
EP1355849	2002	2003	SAFE HYDROGEN, LLC	STORAGE, GENERATION, AND USE OF HYDROGEN
WO2003064320	2003	2003	ENERGY CONVERSION DEVICES, INC.	HIGH CAPACITY CALCIUM LITHIUM BASED HYDROGEN STORAGE MATERIAL AND METHOD OF MAKING THE SAME
6708502	2002	2004	UNIVERSITY OF CALIFORNIA	LIGHTWEIGHT CRYOGENIC-COMPATIBLE PRESSURE VESSELS FOR VEHICULAR FUEL STORAGE
6746496	2002	2004	SANDIA CORPORATION	COMPACT SOLID SOURCE OF HYDROGEN GAS
6787007	2002	2004	BECHTEL BWXT IDAHO, LLC	POLYMERIC HYDROGEN DIFFUSION BARRIER, HIGH-PRESSURE STORAGE TANK SO EQUIPPED, METHOD OF FABRICATING A STORAGE TANK AND METHOD OF PREVENTING HYDROGEN DIFFUSION
6787229	2003	2004	UNIVERSITY OF CENTRAL FLORIDA	THREE-DIMENSIONAL CARBON FIBERS AND METHOD AND APPARATUS FOR THEIR PRODUCTION
6793909	2002	2004	SANDIA CORPORATION	DIRECT SYNTHESIS OF CATALYZED HYDRIDE COMPOUNDS
EP1470076	2003	2004	ENERGY CONVERSION DEVICES, INC.	HIGH CAPACITY CALCIUM LITHIUM BASED HYDROGEN STORAGE MATERIAL AND METHOD OF MAKING THE SAME
WO2004018852	2003	2004	ENERGY CONVERSION DEVICES, INC.	A HYDROGEN POWERED SCOOTER
WO2004026694	2003	2004	BECHTEL BWXT	POLYMERIC HYDROGEN

			IDAHO, LLC	DIFFUSION BARRIER, HIGH-PRESSURE STORAGE TANK SO EQUIPPED, METHOD OF FABRICATING A STORAGE TANK AND METHOD OF PREVENTING HYDROGEN DIFFUSION
WO2004027102	2003	2004	ENERGY CONVERSION DEVICES, INC.	HIGH CAPACITY TRANSITION METAL HYDROGEN STORAGE MATERIALS FOR THE REVERSIBLE STORAGE OF HYDROGEN
WO2004029503	2003	2004	UNIVERSITY OF CALIFORNIA	LIGHTWEIGHT CRYOGENIC-COMPATIBLE PRESSURE VESSELS FOR VEHICULAR FUEL STORAGE
WO2004041717	2003	2004	WESTINGHOUSE SAVANNAH RIVER COMPANY	COMPLEX HYDRIDES FOR HYDROGEN STORAGE
6918382	2002	2005	ENERGY CONVERSION DEVICES, INC.	HYDROGEN POWERED SCOOTER
EP1546601	2003	2005	UNIVERSITY OF CALIFORNIA	LIGHTWEIGHT CRYOGENIC-COMPATIBLE PRESSURE VESSELS FOR VEHICULAR FUEL STORAGE
EP1558520	2003	2005	WESTINGHOUSE SAVANNAH RIVER COMPANY	COMPLEX HYDRIDES FOR HYDROGEN STORAGE
EP1586536	2005	2005	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
WO2005015076	2004	2005	UNIVERSITY OF CALIFORNIA	STORAGE OF H2 BY ABSORPTION AND/OR MIXTURE WITHIN A FLUID MEDIUM
WO2005060620	2004	2005	ENERGY CONVERSION DEVICES, INC.	CATALYSTS AND HYDROGEN STORAGE MATERIALS EXHIBITING QUANTUM EFFECTS
7052671	2002	2006	SAFE HYDROGEN, LLC	STORAGE, GENERATION, AND USE OF HYDROGEN
7094387	2003	2006	WASHINGTON SAVANNAH RIVER COMPANY LLC	COMPLEX HYDRIDES FOR HYDROGEN STORAGE
EP1634016	2004	2006	UNIVERSITY OF CALIFORNIA	STORAGE OF H2 BY ABSORPTION IN LIQUID NITROGEN
EP1691918	2004	2006	ENERGY CONVERSION DEVICES, INC.	CATALYSTS AND HYDROGEN STORAGE MATERIALS EXHIBITING QUANTUM EFFECTS

WO2006009630	2005	2006	UNIVERSITY OF CALIFORNIA	METHOD AND SYSTEM FOR HYDROGEN EVOLUTION AND STORAGE
WO2006029027	2005	2006	UNASSIGNED	HYDROGEN STORAGE AND INTEGRATED FUEL CELL ASSEMBLY
7160530	2003	2007	MIDWEST RESEARCH INSTITUTE	METAL-DOPED SINGLE-WALLED CARBON NANOTUBES AND PRODUCTION THEREOF
7191602	2004	2007	UNIVERSITY OF CALIFORNIA	STORAGE OF H2 BY ABSORPTION AND/OR MIXTURE WITHIN A FLUID MEDIUM
7250386	2003	2007	ENERGY CONVERSION DEVICES, INC.	QUANTUM LIMIT CATALYSTS AND HYDROGEN STORAGE MATERIALS
7279077	2003	2007	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF FORMING A CHEMICAL COMPOSITION
7294323	2004	2007	BATTELLE ENERGY ALLIANCE, LLC	METHOD OF PRODUCING A CHEMICAL HYDRIDE
7297316	2005	2007	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
7306780	2004	2007	SANDIA CORPORATION	METHOD OF GENERATING HYDROGEN GAS FROM SODIUM BOROHYDRIDE
EP1784887	2005	2007	UNASSIGNED	HYDROGEN STORAGE AND INTEGRATED FUEL CELL ASSEMBLY
WO2007046881	2006	2007	UNIVERSITY OF MICHIGAN	CHEMICAL BRIDGES FOR ENHANCING HYDROGEN STORAGE BY SPILLOVER AND METHODS FOR FORMING THE SAME
WO2007050362	2006	2007	WASHINGTON SAVANNAH RIVER COMPANY LLC	HOLLOW POROUS-WALL GLASS MICROSPHERES FOR HYDROGEN STORAGE
WO2007092601	2007	2007	LOS ALAMOS NATIONAL SECURITY, LLC	ENERGY EFFICIENT SYNTHESIS OF BORANES
WO2007092602	2007	2007	LOS ALAMOS NATIONAL SECURITY, LLC	COMPOSITION AND METHOD FOR STORING AND RELEASING HYDROGEN
WO2007101241	2007	2007	UNIVERSITY OF MICHIGAN	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
WO2007106513	2007	2007	UNIVERSITY OF UTAH	HYDROGEN STORAGE IN A COMBINED MXAIH6/M'Y(NH2)Z SYSTEM AND A METHODS OF MAKING AND USING

				THE SAME
WO2007117858	2007	2007	SAFE HYDROGEN, LLC	STORING AND TRANSPORTING ENERGY
7384574	2004	2008	WESTINGHOUSE SAVANNAH RIVER COMPANY	HYDROGEN STORAGE MATERIAL AND PROCESS USING GRAPHITE ADDITIVE WITH METAL-DOPED COMPLEX HYDRIDES
7402234	2004	2008	BATTELLE ENERGY ALLIANCE, LLC	POLYMERIC HYDROGEN DIFFUSION BARRIER, HIGH-PRESSURE STORAGE TANK SO EQUIPPED, METHOD OF FABRICATING A STORAGE TANK AND METHOD OF PREVENTING HYDROGEN DIFFUSION
7427302	2007	2008	SANDIA CORPORATION	METHOD OF MANUFACTURING MICRO-DISPERSE PARTICLES OF SODIUM BOROHYDRIDE
7439369	2005	2008	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD AND SYSTEM FOR HYDROGEN EVOLUTION AND STORAGE
EP1914198	2005	2008	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
EP1945564	2006	2008	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HOLLOW POROUS-WALL GLASS MICROSPHERES FOR HYDROGEN STORAGE
EP1984406	2007	2008	LOS ALAMOS NATIONAL SECURITY, LLC	ENERGY EFFICIENT SYNTHESIS OF BORANES
EP1988996	2007	2008	UNIVERSITY OF MICHIGAN	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
EP1988997	2007	2008	LOS ALAMOS NATIONAL SECURITY, LLC	COMPOSITION AND METHOD FOR STORING AND RELEASING HYDROGEN
EP2002032	2007	2008	SAFE HYDROGEN, LLC	STORING AND TRANSPORTING ENERGY
WO2008058231	2007	2008	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
WO2008143780	2008	2008	LOS ALAMOS NATIONAL SECURITY, LLC	METAL AMINOBORANES
7521037	2007	2009	BROOKHAVEN SCIENCE ASSOCIATES LLC	REGENERATION OF ALUMINUM HYDRIDE
7544837	2006	2009	LOS ALAMOS NATIONAL SECURITY, LLC	BASE METAL DEHYDROGENATION OF AMINE-BORANES

7608233	2007	2009	SANDIA CORPORATION	DIRECT SYNTHESIS OF CALCIUM BOROHYDRIDE
7625547	2006	2009	FORD GLOBAL TECHNOLOGIES, LLC	HIGH DENSITY HYDROGEN STORAGE MATERIAL
EP2098479	2009	2009	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
EP2109868	2007	2009	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
WO2009005872	2008	2009	AIR PRODUCTS AND CHEMICALS, INC.	AUTOTHERMAL HYDROGEN STORAGE AND DELIVERY SYSTEMS
WO2009020745	2008	2009	UNIVERSITY OF CALIFORNIA	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
WO2009054874	2008	2009	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	ELECTROCHEMICAL PROCESS AND PRODUCTION OF ALUMINIUM HYDRIDE
WO2009091537	2009	2009	LOS ALAMOS NATIONAL SECURITY, LLC	REGENERATION OF POLYBORAZYLENE
WO2009105333	2009	2009	TOYOTA MOTOR CORP	GAS STORAGE MATERIALS, INCLUDING HYDROGEN STORAGE MATERIALS
WO2009142956	2009	2009	BATTELLE MEMORIAL INSTITUTE	PROCESS FOR SYNTHESIS OF AMMONIA BORANE FOR BULK HYDROGEN STORAGE
7645902	2006	2010	LOS ALAMOS NATIONAL SECURITY, LLC	ACID-CATALYZED DEHYDROGENATION OF AMINE-BORANES
7666807	2005	2010	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HOLLOW POROUS-WALL GLASS MICROSPHERES FOR HYDROGEN STORAGE
7678362	2006	2010	UOP LLC	HIGH DENSITY HYDROGEN STORAGE MATERIAL
7713506	2008	2010	LOS ALAMOS NATIONAL SECURITY, LLC	METAL AMINOBORANES
7736531	2007	2010	LOS ALAMOS NATIONAL SECURITY, LLC	COMPOSITION AND METHOD FOR STORING AND RELEASING HYDROGEN
7754641	2008	2010	GENERAL ELECTRIC COMPANY	HYDROGEN STORAGE MATERIAL AND RELATED PROCESSES
7781109	2004	2010	UNASSIGNED	HYDROGEN STORAGE AND INTEGRATED FUEL CELL ASSEMBLY
7790013	2006	2010	SAFE HYDROGEN, LLC	STORING AND TRANSPORTING ENERGY
7790133	2007	2010	UOP LLC	MULTI-COMPONENT

				HYDROGEN STORAGE MATERIAL
7816004	2004	2010	UNIVERSITY OF CENTRAL FLORIDA	THREE-DIMENSIONAL CARBON FIBERS AND METHOD AND APPARATUS FOR THEIR PRODUCTION
7837852	2009	2010	LOS ALAMOS NATIONAL SECURITY, LLC	ENERGY EFFICIENT SYNTHESIS OF BORANES
7837976	2005	2010	BROOKHAVEN SCIENCE ASSOCIATES LLC	ACTIVATED ALUMINUM HYDRIDE HYDROGEN STORAGE COMPOSITIONS AND USES THEREOF
7846410	2009	2010	LOS ALAMOS NATIONAL SECURITY, LLC	REGENERATION OF POLYBORAZYLENE
EP2158156	2008	2010	LOS ALAMOS NATIONAL SECURITY, LLC	METAL AMINOBORANES
EP2167511	2008	2010	UNIVERSITY OF CALIFORNIA	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
EP2236824	2010	2010	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	NANOPOROUS CARBON ACTUATOR
EP2244975	2009	2010	LOS ALAMOS NATIONAL SECURITY, LLC	REGENERATION OF POLYBORAZYLENE
EP2254828	2009	2010	TOYOTA MOTOR CORP	GAS STORAGE MATERIALS, INCLUDING HYDROGEN STORAGE MATERIALS
RE041142	2002	2010	ALLIANT TECHSYSTEMS INC.	COMPOSITE CONFORMABLE PRESSURE VESSEL
WO2010036761	2009	2010	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	HYDROGEN-BASED ELECTROCHEMICAL ENERGY STORAGE
WO2010129598	2010	2010	BATTELLE MEMORIAL INSTITUTE	BULK-SCAFFOLDED HYDROGEN STORAGE AND RELEASING MATERIALS AND METHODS FOR PREPARING AND USING SAME
WO2010135159	2010	2010	QUANTUM FUEL SYSTEMS TECHNOLOGIES WORLDWIDE INC.	HIGH PRESSURE STORAGE DEVICE AND METHOD
7897129	2009	2011	BATTELLE MEMORIAL INSTITUTE	PROCESS FOR SYNTHESIS OF AMMONIA BORANE FOR BULK HYDROGEN STORAGE
7927507	2009	2011	HRL LABORATORIES, LLC	HYDROGEN STORAGE COMPOSITIONS
7951749	2007	2011	UNIVERSITY OF	ENHANCING HYDROGEN

			MICHIGAN	SPILLOVER AND STORAGE
7963116	2009	2011	BATTELLE MEMORIAL INSTITUTE	BULK-SCAFFOLDED HYDROGEN STORAGE AND RELEASING MATERIALS AND METHODS FOR PREPARING AND USING SAME
8003073	2008	2011	AIR PRODUCTS AND CHEMICALS, INC.	AUTOTHERMAL HYDROGEN STORAGE AND DELIVERY SYSTEMS
8076382	2008	2011	UCHICAGO ARGONNE, LLC	POROUS POLYMERIC MATERIALS FOR HYDROGEN STORAGE
8083907	2004	2011	UNIVERSITY OF SOUTH FLORIDA	HYDROGEN STORAGE NANO-FOIL AND METHOD OF MANUFACTURE
EP2368840	2011	2011	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A METAL HYDRIDE
EP2368841	2011	2011	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
EP2368893	2011	2011	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF AN ALUMINUM HYDRIDE COMPOUND
WO2011006071	2010	2011	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGH CAPACITY STABILIZED COMPLEX HYDRIDES FOR HYDROGEN STORAGE
WO2011017129	2010	2011	UNIVERSITY OF OREGON	SUBSTITUTED 1,2-AZABORINE HETEROCYCLES
8101786	2010	2012	LOS ALAMOS NATIONAL SECURITY, LLC	ENERGY EFFICIENT SYNTHESIS OF BORANES
8105974	2009	2012	TOYOTA MOTOR CORP	DESTABILIZED AND CATALYZED BOROHYDRIDE FOR REVERSIBLE HYDROGEN STORAGE
8119198	2010	2012	UNIVERSITY OF CENTRAL FLORIDA	THREE-DIMENSIONAL CARBON FIBERS AND METHOD AND APPARATUS FOR THEIR PRODUCTION
8124559	2009	2012	TOYOTA MOTOR CORP	DESTABILIZED AND CATALYZED BOROHYDRIDE FOR REVERSIBLE HYDROGEN STORAGE
8147788	2009	2012	SANDIA CORPORATION	DIRECT SYNTHESIS OF MAGNESIUM BOROHYDRIDE
8147796	2007	2012	UNIVERSITY OF UTAH	HYDROGEN STORAGE IN A COMBINED

				MXALH6/M'Y(NH2)Z SYSTEM AND METHODS OF MAKING AND USING THE SAME
8153020	2009	2012	UNIVERSITY OF SOUTH FLORIDA	HYDROGEN-STORING HYDRIDE COMPLEXES
8153554	2007	2012	UNIVERSITY OF SOUTH CAROLINA	REVERSIBLE HYDROGEN STORAGE MATERIALS
8193113	2010	2012	GENERAL ELECTRIC COMPANY	HYDROGEN STORAGE MATERIAL AND RELATED PROCESSES
8231770	2010	2012	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	NANOPOROUS CARBON ACTUATOR AND METHODS OF USE THEREOF
8236196	2009	2012	MICROBES UNLIMITED, LLC	SYSTEMS AND METHODS FOR FACILITATING HYDROGEN STORAGE USING NATURALLY OCCURRING NANOSTRUCTURE ASSEMBLIES
8268288	2009	2012	BROOKHAVEN SCIENCE ASSOCIATES, LLC	REGENERATION OF ALUMINUM HYDRIDE
8303883	2006	2012	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	FORMING FOAM STRUCTURES WITH CARBON FOAM SUBSTRATES
8314245	2007	2012	UNIVERSITY OF CALIFORNIA	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
8329140	2008	2012	LOS ALAMOS NATIONAL SECURITY, LLC	METHOD AND SYSTEM FOR HYDROGEN EVOLUTION AND STORAGE
8338330	2006	2012	UNIVERSITY OF MICHIGAN	CHEMICAL BRIDGES FOR ENHANCING HYDROGEN STORAGE BY SPILLOVER AND METHODS FOR FORMING THE SAME
EP2433045	2010	2012	QUANTUM FUEL SYSTEMS TECHNOLOGIES WORLDWIDE INC.	HIGH PRESSURE STORAGE DEVICE AND METHOD
EP2454189	2010	2012	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGH CAPACITY STABILIZED COMPLEX HYDRIDES FOR HYDROGEN STORAGE
EP2459573	2010	2012	UNIVERSITY OF OREGON	SUBSTITUTED 1,2-AZABORINE HETEROCYCLES
WO2012082213	2011	2012	UNIVERSITY OF CALIFORNIA	CONDUCTIVE OPEN FRAMEWORKS
WO2012096976	2012	2012	BATTELLE MEMORIAL	COMBINED ON-BOARD HYDRIDE SLURRY

			INSTITUTE	STORAGE AND REACTOR SYSTEM AND PROCESS FOR HYDROGEN POWERED VEHICLES AND DEVICES
8372369	2011	2013	UNIVERSITY OF MICHIGAN	ENHANCING HYDROGEN SPILLOVER AND STORAGE
8377405	2009	2013	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
8377415	2011	2013	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	METHODS FOR SYNTHESIZING ALANE WITHOUT THE FORMATION OF ADDUCTS AND FREE OF HALIDES
8377416	2009	2013	PURDUE RESEARCH FOUNDATION	METHOD FOR RELEASING HYDROGEN FROM AMMONIA BORANE
8377555	2008	2013	TOYOTA MOTOR CORP	GAS STORAGE MATERIALS, INCLUDING HYDROGEN STORAGE MATERIALS
8410185	2011	2013	UCHICAGO ARGONNE, LLC	POROUS POLYMERIC MATERIALS FOR HYDROGEN STORAGE
8426337	2009	2013	UNIVERSITY OF MICHIGAN	METAL SALT CATALYSTS FOR ENHANCING HYDROGEN SPILLOVER
8440100	2012	2013	UNIVERSITY OF SOUTH FLORIDA	METHOD OF GENERATING HYDROGEN-STORING HYDRIDE COMPLEXES
8449650	2010	2013	LOS ALAMOS NATIONAL SECURITY, LLC	GAS STORAGE AND SEPARATION BY ELECTRIC FIELD SWING ADSORPTION
8470156	2007	2013	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	ELECTROCHEMICAL PROCESS AND PRODUCTION OF NOVEL COMPLEX HYDRIDES
8480792	2008	2013	UNIVERSITY OF CALIFORNIA	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
8501137	2011	2013	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF AN ALUMINUM HYDRIDE COMPOUND
8501349	2009	2013	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	HYDROGEN-BASED ELECTROCHEMICAL ENERGY STORAGE
8517206	2009	2013	QUANTUM FUEL SYSTEMS TECHNOLOGIES WORLDWIDE INC.	HIGH PRESSURE STORAGE VESSEL
EP2614067	2011	2013	UNIVERSITY OF CALIFORNIA	CONDUCTIVE OPEN FRAMEWORKS
WO2013112212	2012	2013	UNIVERSITY OF CALIFORNIA	METAL-ORGANIC FRAMEWORKS WITH

				EXCEPTIONALLY LARGE PORE APERATURES
8691177	2011	2014	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
8715583	2010	2014	SAFE HYDROGEN, LLC	STORING AND TRANSPORTING ENERGY
8758715	2011	2014	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	POROUS WALL HOLLOW GLASS MICROSPHERES AS A MEDIUM OR SUBSTRATE FOR STORAGE AND FORMATION OF NOVEL MATERIALS
8802051	2011	2014	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A METAL HYDRIDE
8808662	2011	2014	ROHM AND HAAS COMPANY	PROCESS FOR PRODUCTION OF A BOROHYDRIDE COMPOUND
8809230	2011	2014	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	POROUS SUBSTRATES FILLED WITH NANOMATERIALS
8809546	2012	2014	UNIVERSITY OF CALIFORNIA	PREPARATION OF FUNCTIONALIZED ZEOLITIC FRAMEWORKS
8881932	2013	2014	QUANTUM FUEL SYSTEMS TECHNOLOGIES WORLDWIDE INC.	ADAPTERLESS CLOSURE ASSEMBLY FOR COMPOSITE PRESSURE VESSELS
8883109	2010	2014	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGH CAPACITY STABILIZED COMPLEX HYDRIDES FOR HYDROGEN STORAGE
8889097	2012	2014	BATTELLE MEMORIAL INSTITUTE	COMBINED ON-BOARD HYDRIDE SLURRY STORAGE AND REACTOR SYSTEM AND PROCESS FOR HYDROGEN-POWERED VEHICLES AND DEVICES
8895146	2013	2014	TOYOTA MOTOR CORP	GAS STORAGE MATERIALS, INCLUDING HYDROGEN STORAGE MATERIALS
8921554	2010	2014	UNIVERSITY OF OREGON	SUBSTITUTED 1,2-AZABORINE HETEROCYCLES
EP2766046	2012	2014	UNIVERSITY OF CALIFORNIA	METAL-ORGANIC FRAMEWORKS WITH EXCEPTIONALLY LARGE PORE APERATURES
WO2014150691	2014	2014	LAWRENCE LIVERMORE NATIONAL	THREADED INSERT FOR COMPACT CRYOGENIC-CAPABLE PRESSURE

			SECURITY, LLC	VESSELS
WO2014210154	2014	2014	QUANTUM FUEL SYSTEMS TECHNOLOGIES WORLDWIDE INC.	ADAPTERLESS CLOSURE ASSEMBLY FOR COMPOSITE PRESSURE VESSELS
8926932	2007	2015	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
8945500	2011	2015	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGH CAPACITY HYDROGEN STORAGE NANOCOMPOSITE MATERIALS
9006137	2013	2015	FORD GLOBAL TECHNOLOGIES, LLC	ADSORBENT MATERIAL WITH ANISOTROPIC LAYERING
9057483	2014	2015	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	THREADED INSERT FOR COMPACT CRYOGENIC-CAPABLE PRESSURE VESSELS
9078922	2012	2015	UNIVERSITY OF CALIFORNIA	METAL-ORGANIC FRAMEWORKS WITH EXCEPTIONALLY LARGE PORE APERATURES
WO2015066693	2014	2015	UNIVERSITY OF CALIFORNIA	METAL-ORGANIC FRAMEWORKS WITH A HIGH DENSITY OF HIGHLY CHARGED EXPOSED METAL CATION SITES
9234626	2014	2016	BATTELLE MEMORIAL INSTITUTE	CONFORMABLE PRESSURE VESSEL FOR HIGH PRESSURE GAS STORAGE
9266642	2012	2016	WIRETOUGH CYLINDERS LLC	STEEL WRAPPED PRESSURE VESSEL
9269473	2011	2016	UNIVERSITY OF CALIFORNIA	CONDUCTIVE OPEN FRAMEWORKS
9321638	2013	2016	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	USE OF TRIPHENYL PHOSPHATE AS RISK MITIGANT FOR METAL AMIDE HYDROGEN STORAGE MATERIALS
9325030	2012	2016	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGH ENERGY DENSITY BATTERY BASED ON COMPLEX HYDRIDES
9340677	2014	2016	UT-BATTELLE, LLC	APPARATUS AND PROCESS FOR THE SURFACE TREATMENT OF CARBON FIBERS
9365685	2012	2016	UT-BATTELLE, LLC	METHOD OF IMPROVING ADHESION OF CARBON FIBERS WITH A POLYMERIC MATRIX
9440850	2008	2016	SOUTHWEST RESEARCH INSTITUTE	CARBON MATERIAL FOR HYDROGEN STORAGE
9517445	2013	2016	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS

				FOR ITS PRODUCTION
9562646	2013	2017	UT-BATTELLE, LLC	HYDROGEN STORAGE CONTAINER
9568150	2014	2017	QUANTUM FUEL SYSTEMS TECHNOLOGIES WORLDWIDE INC.	METHOD OF FABRICATING A PRESSURIZED-GAS STORAGE ASSEMBLY
9580308	2014	2017	SAFE HYDROGEN, LLC	STORING AND TRANSPORTING ENERGY
9604847	2014	2017	DELAWARE STATE UNIVERSITY	RUBIDIUM HYDRIDE CATALYZED ALLOYS
9669098	2015	2017	UNIVERSITY OF CALIFORNIA	METAL-ORGANIC FRAMEWORKS WITH EXCEPTIONALLY LARGE PORE APERATURES
9677713	2015	2017	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	COMPACT INSERT DESIGN FOR CRYOGENIC PRESSURE VESSELS
9683704	2014	2017	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HEATING AND COOLING SYSTEM FOR AN ON-BOARD GAS ADSORBENT STORAGE VESSEL
9809380	2013	2017	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HEAT TRANSFER UNIT AND METHOD FOR PREFABRICATED VESSEL
9840412	2014	2017	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HIGH CAPACITY HYDROGEN STORAGE NANOCOMPOSITE MATERIALS
9850585	2011	2017	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	ENHANCING ELECTROCHEMICAL METHODS FOR PRODUCING AND REGENERATING ALANE BY USING ELECTROCHEMICAL CATALYTIC ADDITIVE
9957103	2015	2018	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HEAT TRANSFER UNIT AND METHOD FOR PREFABRICATED VESSEL
9978474	2016	2018	UNIVERSITY OF CALIFORNIA	CONDUCTIVE OPEN FRAMEWORKS
10000377	2016	2018	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	NANOSTRUCTURED METAL AMIDES AND NITRIDES FOR HYDROGEN STORAGE
10035127	2014	2018	UNIVERSITY OF CALIFORNIA	METAL-ORGANIC FRAMEWORKS WITH A HIGH DENSITY OF HIGHLY CHARGED EXPOSED METAL CATION SITES
10082246	2017	2018	LAWRENCE LIVERMORE NATIONAL	CRYOGENIC PRESSURIZED STORAGE WITH HUMP-REINFORCED VACUUM

			SECURITY, LLC	JACKET
RE046771	2016	2018	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	POROUS SUBSTRATES FILLED WITH NANOMATERIALS
WO2018148225	2018	2018	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CRYOGENIC PRESSURIZED STORAGE WITH HUMP-REINFORCED VACUUM JACKET
10351683	2016	2019	UT-BATTELLE, LLC	METHOD OF IMPROVING ADHESION OF CARBON FIBERS WITH A POLYMERIC MATRIX
10422481	2017	2019	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	HEATING AND COOLING SYSTEM FOR AN ON-BOARD GAS ADSORBENT STORAGE VESSEL
10457785	2016	2019	UT-BATTELLE, LLC	METHOD OF IMPROVING ADHESION OF CARBON FIBERS WITH A POLYMERIC MATRIX
10501590	2016	2019	UT-BATTELLE, LLC	SOLID COMPOSITES CONTAINING POLYMERIC MATRIX WITH CARBON FIBERS EMBEDDED THEREIN
EP3580491	2018	2019	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CRYOGENIC PRESSURIZED STORAGE WITH HUMP-REINFORCED VACUUM JACKET
10549990	2017	2020	SAFE HYDROGEN, LLC	STORING AND TRANSPORTING ENERGY

Appendix ST-B. Hydrogen Storage Patents in Families Associated with Other DOE Funding

Patent #	Application Year	Issue / Publication Year	Original Assignee	Title
4079523	1976	1978	THE INTERNATIONAL NICKEL COMPANY, INC.	IRON-TITANIUM-MISCHMETAL ALLOYS FOR HYDROGEN STORAGE
4292265	1980	1981	UNITED STATES DEPARTMENT OF ENERGY	METHOD FOR PREPARING POROUS METAL HYDRIDE COMPACTS
4360569	1980	1982	UNITED STATES DEPARTMENT OF ENERGY	POROUS METAL HYDRIDE COMPOSITE AND PREPARATION AND USES THEREOF
4497775	1982	1985	UNITED STATES DEPARTMENT OF ENERGY	APPARATUS FOR STORING HYDROGEN ISOTOPES
4769225	1985	1988	UNITED STATES DEPARTMENT OF ENERGY	SYSTEM FOR EXCHANGE OF HYDROGEN BETWEEN LIQUID AND SOLID PHASES
4960450	1989	1990	SYRACUSE UNIVERSITY	SELECTION AND PREPARATION OF ACTIVATED CARBON FOR FUEL GAS STORAGE
5198207	1991	1993	TH. GOLDSCHMIDT AG	METHOD FOR THE PREPARATION OF ACTIVE MAGNESIUM HYDRIDE-MAGNESIUM HYDROGEN STORAGE SYSTEMS, WHICH REVERSIBLY ABSORB HYDROGEN
5248649	1992	1993	UNASSIGNED	PALLADIUM/KIESELGUHR COMPOSITION AND METHOD
EP0490156	1991	1993	TH. GOLDSCHMIDT AG	PROCESS FOR MANUFACTURING ACTIVE, REVERSIBLE, H2 ACCEPTING MAGNESIUM HYDRIDE-MAGNESIUM-HYDROGEN STORAGE SYSTEM.
6074453	1997	2000	IOWA STATE UNIVERSITY	ULTRAFINE HYDROGEN STORAGE POWDERS
6494191	2002	2002	BECHTEL BWXT IDAHO, LLC	SYSTEMS AND METHOD FOR DELIVERING LIQUIFIED GAS TO AN ENGINE
6554015	2001	2003	UNITED STATES DEPARTMENT OF ENERGY	SINGLE PIECE SILVER/PALLADIUM CELL FOR ADJUSTING OR MEASURING A LEVEL OF HYDROGEN AND METHODS THEREFOR
6619273	2002	2003	BECHTEL BWXT IDAHO, LLC	SYSTEMS AND METHOD FOR DELIVERING LIQUIFIED GAS TO AN ENGINE
6953028	2003	2005	BATTELLE	METHOD FOR DELIVERING

			ENERGY ALLIANCE, LLC	LIQUIFIED GAS TO AN ENGINE
WO2005080256	2005	2005	BATTELLE MEMORIAL INSTITUTE	MATERIALS FOR HYDROGEN STORAGE AND METHODS FOR PREPARING AND USING SAME
7044113	2005	2006	BATTELLE ENERGY ALLIANCE, LLC	SYSTEMS FOR DELIVERING LIQUIFIED GAS TO AN ENGINE
EP1713717	2005	2006	BATTELLE MEMORIAL INSTITUTE	MATERIALS FOR HYDROGEN STORAGE AND METHODS FOR PREPARING AND USING SAME
WO2006091293	2006	2006	CARNEGIE INSTITUTION OF WASHINGTON	MIXTURE INCLUDING HYDROGEN AND HYDROCARBON HAVING PRESSURE-TEMPERATURE STABILITY
7303736	2005	2007	UNIVERSITY OF CALIFORNIA	NANOSTRUCTURED MATERIALS FOR HYDROGEN STORAGE
EP1838816	2006	2007	CARNEGIE INSTITUTION OF WASHINGTON	MIXTURE INCLUDING HYDROGEN AND HYDROCARBON HAVING PRESSURE-TEMPERATURE STABILITY
7316788	2004	2008	BATTELLE MEMORIAL INSTITUTE	MATERIALS FOR STORAGE AND RELEASE OF HYDROGEN AND METHODS FOR PREPARING AND USING SAME
7340937	2005	2008	JEFFERSON SCIENCE ASSOCIATES LLC	METHOD FOR DETERMINING HYDROGEN MOBILITY AS A FUNCTION OF TEMPERATURE IN SUPERCONDUCTING NIOBIUM CAVITIES
7361213	2005	2008	UT-BATTELLE, LLC	BORAZINE-BORON NITRIDE HYBRID HYDROGEN STORAGE SYSTEM
7471010	2004	2008	ALLIANCE FOR SUSTAINABLE ENERGY, LLC	WIND TURBINE TOWER FOR STORING HYDROGEN AND ENERGY
7574868	2006	2009	CARNEGIE INSTITUTION OF WASHINGTON	MIXTURE INCLUDING HYDROGEN AND HYDROCARBON HAVING PRESSURE-TEMPERATURE STABILITY
7781111	2008	2010	SANDIA CORPORATION	HYDROGEN STORAGE AND GENERATION SYSTEM
7816044	2010	2010	SANDIA CORPORATION	FUEL CELL USING A HYDROGEN GENERATION SYSTEM
7824473	2008	2010	NORTHWESTERN UNIVERSITY	METAL-ORGANIC FRAMEWORK MATERIALS BASED ON ICOSAHEDRAL BORANES AND CARBORANES
WO2010042948	2009	2010	NORTHWESTERN UNIVERSITY	TETRATOPIC PHENYL COMPOUNDS, RELATED METAL-ORGANIC

				FRAMEWORK MATERIALS AND POST-ASSEMBLY ELABORATION
8076034	2008	2011	LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	CONFINEMENT OF HYDROGEN AT HIGH PRESSURE IN CARBON NANOTUBES
8124558	2005	2012	SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC	CATALYZED BOROHYDRIDES FOR HYDROGEN STORAGE
8262775	2009	2012	NORTHWESTERN UNIVERSITY	TETRATOPIC PHENYL COMPOUNDS, RELATED METAL-ORGANIC FRAMEWORK MATERIALS AND POST-ASSEMBLY ELABORATION
WO2012119069	2012	2012	BATTELLE MEMORIAL INSTITUTE	METHODS FOR ASSOCIATING OR DISSOCIATING GUEST MATERIALS WITH A METAL ORGANIC FRAMEWORK, SYSTEMS FOR ASSOCIATING OR DISSOCIATING GUEST MATERIALS WITHIN A SERIES OF METAL ORGANIC FRAMEWORKS, THERMAL ENERGY TRANSFER ASSEMBLIES, AND METHODS FOR TRANSFERR
8470075	2012	2013	NORTHWESTERN UNIVERSITY	TETRATOPIC PHENYL COMPOUNDS, RELATED METAL-ORGANIC FRAMEWORK MATERIALS AND POST-ASSEMBLY ELABORATION
8534058	2010	2013	SOUTHWEST RESEARCH INSTITUTE	ENERGY STORAGE AND PRODUCTION SYSTEMS, APPARATUS AND METHODS OF USE THEREOF
8615812	2010	2013	ADVANCED FUEL RESEARCH, INC.	HIGH-STRENGTH POROUS CARBON AND ITS MULTIFUNCTIONAL APPLICATIONS
WO2013192146	2013	2013	NORTHWESTERN UNIVERSITY	METAL-ORGANIC FRAMEWORK MATERIALS WITH ULTRAHIGH SURFACE AREAS
8795412	2012	2014	BATTELLE MEMORIAL INSTITUTE	METHODS FOR ASSOCIATING OR DISSOCIATING GUEST MATERIALS WITH A METAL ORGANIC FRAMEWORK, SYSTEMS FOR ASSOCIATING OR DISSOCIATING GUEST MATERIALS WITHIN A SERIES OF METAL ORGANIC FRAMEWORKS, THERMAL ENERGY TRANSFER

				ASSEMBLIES, AND METHODS FOR TRANSFERRING THERMAL ENERGY
8900352	2012	2014	NORTHWESTERN UNIVERSITY	SYSTEM AND METHOD FOR GENERATING AND/OR SCREENING POTENTIAL METAL-ORGANIC FRAMEWORKS
WO2014059392	2013	2014	SRI INTERNATIONAL	MONOLITHIC NATURAL GAS STORAGE DELIVERY SYSTEM BASED ON SORBENTS
9012368	2012	2015	NORTHWESTERN UNIVERSITY	SYSTEM AND METHOD FOR GENERATING AND/OR SCREENING POTENTIAL METAL-ORGANIC FRAMEWORKS
9216939	2013	2015	NORTHWESTERN UNIVERSITY	METAL-ORGANIC FRAMEWORK MATERIALS WITH ULTRAHIGH SURFACE AREAS
WO2015195179	2015	2015	UNIVERSITY OF CALIFORNIA	METAL ORGANIC FRAMEWORKS COMPRISING A PLURALITY OF SBUS WITH DIFFERENT METAL IONS AND/OR A PLURALITY OF ORGANIC LINKING LIGANDS WITH DIFFERENT FUNCTIONAL GROUPS.
9370765	2014	2016	BLACKPAK, INC.	SPACE-FILLING POLYHEDRAL SORBENTS
9403686	2014	2016	BATTELLE MEMORIAL INSTITUTE	METHODS FOR ASSOCIATING OR DISSOCIATING GUEST MATERIALS WITH A METAL ORGANIC FRAMEWORK, SYSTEMS FOR ASSOCIATING OR DISSOCIATING GUEST MATERIALS WITHIN A SERIES OF METAL ORGANIC FRAMEWORKS, THERMAL ENERGY TRANSFER ASSEMBLIES, AND METHODS FOR TRANSFERRING THERMAL ENERGY
9415996	2014	2016	BLACKPAK, INC.	SORPTION PUMPS AND STORAGE FOR GASES
9452380	2015	2016	SRI INTERNATIONAL	MONOLITHIC NATURAL GAS STORAGE DELIVERY SYSTEM BASED ON SORBENTS
WO2016028731	2015	2016	BLACKPAK, INC.	SORPTION PUMPS AND STORAGE FOR GASES
WO2016053799	2015	2016	BLACKPAK, INC.	SPACE-FILLING POLYHEDRAL SORBENTS
EP3200900	2015	2017	BLACKPAK, INC.	SPACE-FILLING POLYHEDRAL SORBENTS
10087205	2015	2018	UNIVERSITY OF CALIFORNIA	METAL ORGANIC FRAMEWORKS COMPRISING

		A PLURALITY OF SBUS WITH DIFFERENT METAL IONS AND/OR A PLURALITY OF ORGANIC LINKING LIGANDS WITH DIFFERENT FUNCTIONAL GROUPS

The Influence of Hydrogen and Fuel Cell Patents Funded by HFTO and Other DOE Offices

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