The Influence of Advanced Battery Patents Funded by the U.S. Department of Energy's Vehicle Technologies Office and Other DOE Offices

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June 2021

DOE/EE Publication Number: 2370

Acknowledgements

This report, which traces the technological influence of DOE advanced batteries R&D broadly through the knowledge and innovation ecosystem, was prepared for the U.S. Department of Energy (DOE) under Purchase Order No. 7454233 with Lawrence Berkeley National Laboratory (LBNL), Berkeley, California, USA. LBNL is operated by The Regents of the University of California under Prime Contract No. DE-AC02-05CH11231.

Yaw O. Agyeman, Program Manager, Lawrence Berkeley National Laboratory, provided technical oversight of the project. Jeff Dowd of DOE's Office of Energy Efficiency and Renewable Energy (EERE), Strategic Analysis Office was the DOE Project Manager.

Patrick Thomas of 1790 Analytics, LLC was the principal researcher, analyst and author of the report. The author extends appreciation to the following EERE and LBNL staff who provided review comments of the draft study report:

- Yaw Agyeman, Lawrence Berkeley National Laboratory
- Mallory Clites, Vehicle Technologies Office
- Jeff Dowd, EERE Strategic Analysis Office
- Tien Duong, Vehicle Technologies Office

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 advanced batteries research funded by the Vehicle Technologies Office (VTO) in the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and its precursor programs – as well as advanced batteries research funded by other offices in DOE. The tracing 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 definition of "advanced batteries technology" used in this analysis is centered on the theme of "lithium-ion and beyond". That is, it focuses on lithium-ion batteries, plus related technologies. The analysis does not cover other battery chemistries that VTO (and DOE more generally) has funded, such as nickel metal hydride (NiMH) or zinc-air batteries. Also, the analysis is not restricted to patents that refer specifically to a vehicle application. Adding this restriction would exclude many relevant patents, since patent applicants typically claim as broad coverage as possible, rather than restricting their claims to a single application.

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

The main finding of this report is:

- Advanced batteries research funded by VTO, and by DOE in general, has had a significant influence on subsequent developments both within and beyond advanced batteries technology. This influence can be seen on innovations associated with leading companies in battery technology. It can also be traced to innovations in related technologies such as ultracapacitors, nanocomposites and electric vehicles.

More detailed findings from this report include:

- In advanced batteries technology, in the period 1976-2018, we identified a total of 35,655 patents (12,202 U.S. patents, 9,303 EPO patents and 14,150 WIPO patents). We grouped these patents into 22,644 patent families, with each family containing all patents resulting from the same initial application (named the 'priority application').

- 515 advanced batteries patents are confirmed to be associated with VTO funding (330 U.S. patents, 62 EPO patents, and 123 WIPO patents). We grouped these VTO-funded advanced batteries patents into 256 patent families.

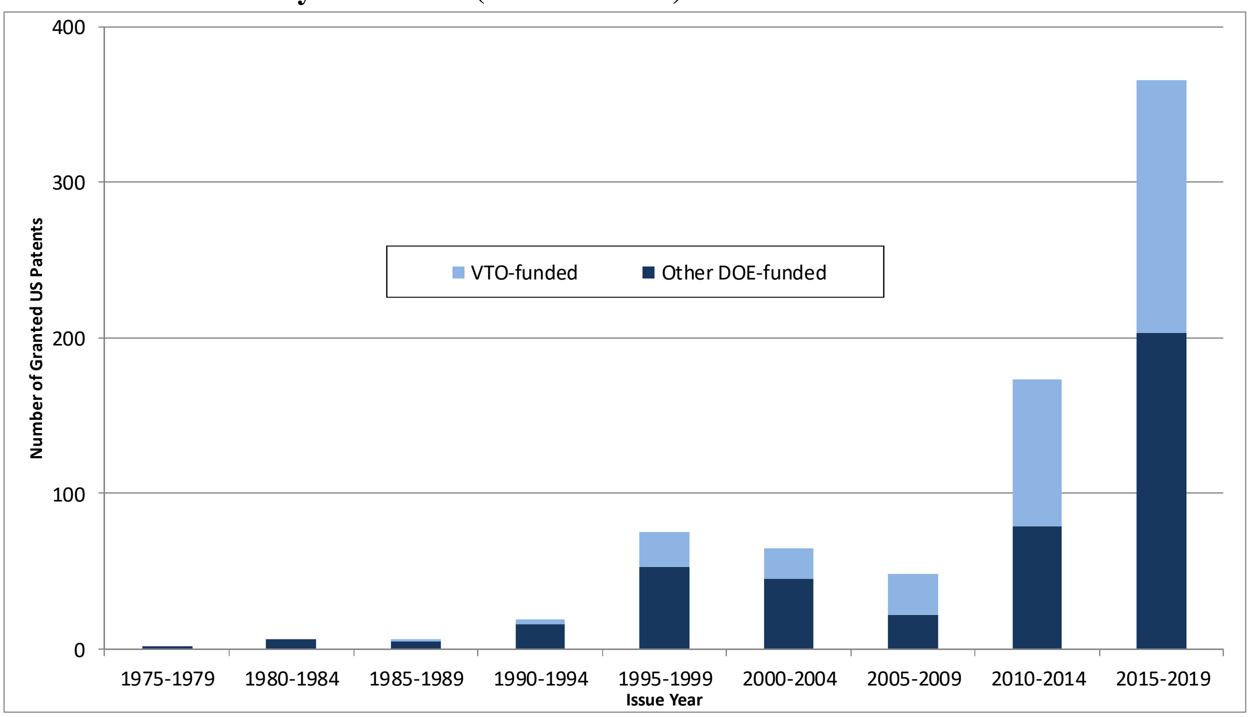
- In addition, we identified a further 603 advanced batteries patents (434 U.S. patents, 56 EPO patents and 113 WIPO patents) that are associated with DOE funding. These "Other DOE-funded" patents are grouped into 323 patent families. Out of these 323 Other DOE-funded patent families, 265 are definitely not VTO-funded. These patent families were either funded by a different DOE office, or marked as not VTO-funded by inventors or VTO technology managers, without specifying funding from another DOE source.

- The remaining 58 Other DOE-funded advanced batteries patent families could not be linked definitively to a specific DOE funding source, and may in fact have been funded by VTO. Hence, up to 18% (58 out of 323) of the Other DOE-funded advanced batteries patent families in this analysis may be VTO-funded. As such, the results presented in this report may understate the influence of VTO-funded advanced batteries research, relative to the influence of advanced batteries research funded by DOE in general.

- The total number of DOE-funded advanced batteries patents (VTO-funded plus Other DOE-funded) is 1,118, corresponding to 579 patent families. This represents 2.6% of the total number of advanced batteries patent families in the period 1976-2018. Note that 19 of these 579 VTO/Other DOE-funded patent families (three VTO-funded, 16 Other DOE-funded) specifically use the terms "vehicle" or "automobile" in their title or abstract.

- Figure E-1 reveals that there was very little DOE-funded advanced batteries (i.e. lithium-ion related) patenting through 1995. This is not surprising, given that the commercialization of lithium-ion batteries did not start until the early to mid-1990s.

Figure E-1 - Number of Advanced Batteries Granted U.S. Patents Funded by VTO and Other DOE Sources by Issue Year (5-Year Totals)



Note: The data collection period for this analysis ended with 2018. Any 2019 patents in the 2015-2019 column are additional patents that have been included because they are members of the same patent families as pre-2019 patents. No new patent search for 2019 was carried out.

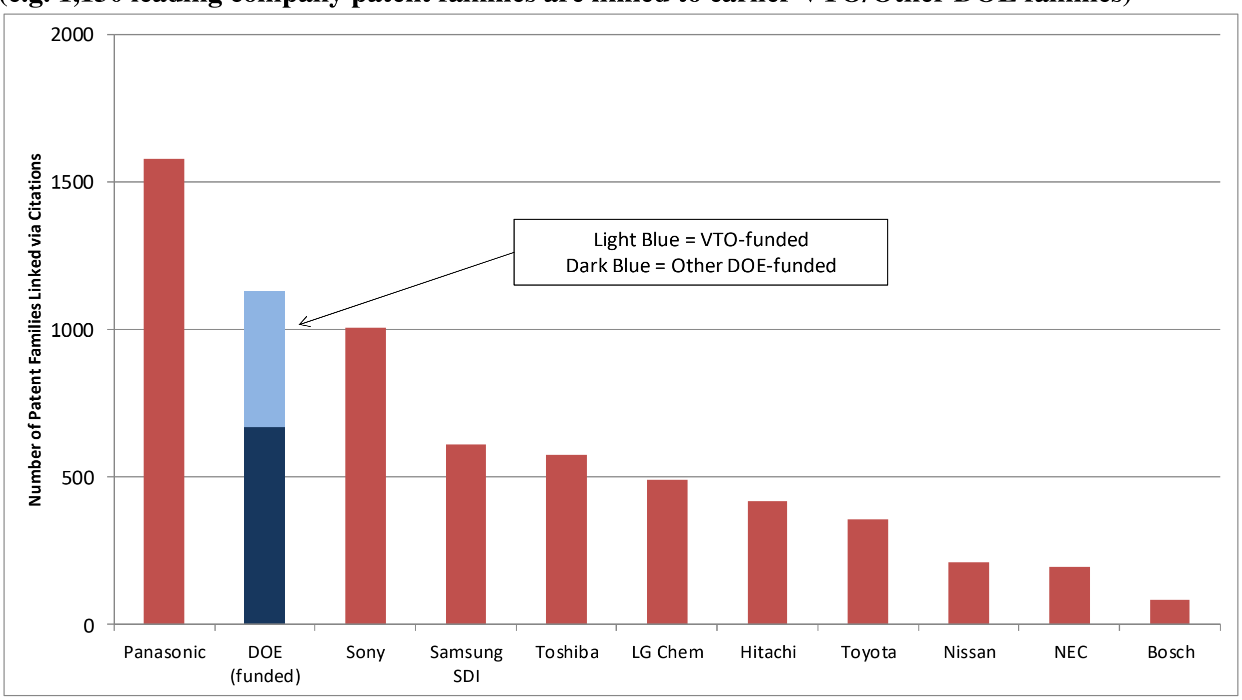
- After 1995, as shown in Figure E-1, there then followed an increase to 75 U.S. patents granted in 1995-1999, and then a decline to 48 patents in 2005-2009. Since 2009, there has been a sharp increase in the number of DOE-funded advanced batteries U.S. patents, with 173 granted in 2010-2014 (94 VTO-funded and 79 Other DOE-funded) and 366 granted in 2015-2019 (163 VTO-funded and 203 Other DOE-funded), even with data for 2019 being incomplete (see chart footnote).

- The ten companies with the largest number of advanced batteries patent families are: Samsung SDI (1,224); Panasonic (1,198); Toyota (1,127); LG Chem (1,120); Bosch (786); Hitachi (641); Sony (559); NEC (428); Nissan (405); and Toshiba (391). Nine of these ten companies are based in Asia, with the tenth (Bosch) based in Europe. The portfolio of 579 DOE-funded advanced batteries patent families would rank seventh among these leading patenting companies.

- VTO-funded advanced batteries patents have a particular focus on different electrode materials, notably manganese, titanium and nickel/cobalt/iron, plus the use of lithium-ion batteries in transport applications. Recent years have also seen an increase in VTO-funded patenting related to silicon-based and metal/alloy electrodes.

- A total of 1,130 advanced batteries patent families assigned to the leading companies are linked via citations to earlier DOE-funded advanced batteries patents (see Figure E-2). This places DOE in second place in this figure behind only Panasonic (which has twice as many patent families available to be cited). This is an impressive result, since VTO/Other DOE-funded patents represent only the seventh largest portfolio among the leading organizations. It suggests that patents funded by VTO/Other DOE have formed an important part of the foundation for technologies developed by leading advanced batteries companies.

Figure E-2 - Number of Leading Company Advanced Batteries Patent Families Linked via Citations to Earlier Advanced Batteries Families from Each Leading Company
(e.g. 1,130 leading company patent families are linked to earlier VTO/Other DOE families)

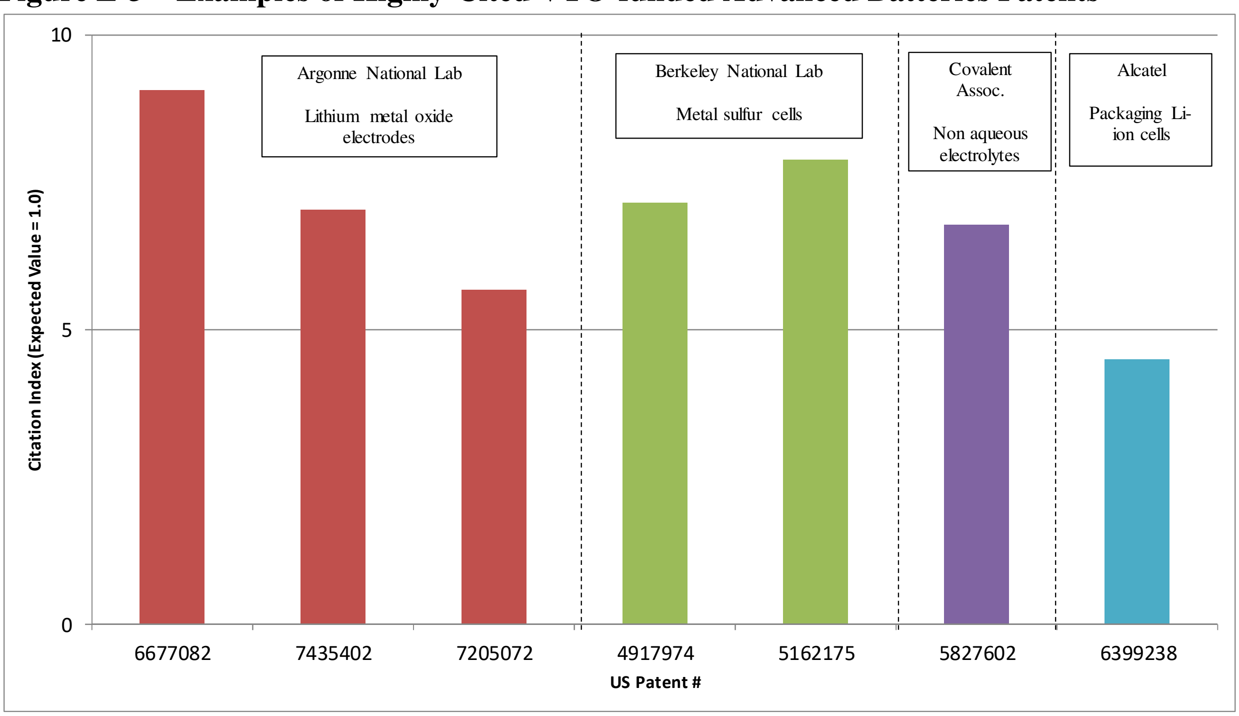


- Moving beyond the overall influence of VTO/Other DOE-funded patents on the leading companies, it is also instructive to examine which of these companies are linked particularly extensively via citations to earlier VTO/Other DOE-funded patents. The leading companies with the highest percentage of patent families linked via citations to VTO, and DOE overall are: Sony (17.7% overall; 6.4% to VTO), Samsung SDI (17.3% overall; 9.5% to VTO) and Toshiba (14.3% overall; 8.7% to VTO).

- VTO-funded advanced batteries patents have an average Citation Index value of 2.25 (the Citation Index is a normalized citation metric with an expected value of 1.0; a value of 2.25 shows that, based on their age and technology, VTO-funded advanced battery patents have been cited as prior art more than twice as frequently as expected by subsequent patents). Meanwhile, Other DOE-funded advanced batteries patents have an average Citation of 2.15 (i.e. they have also been cited more than twice as frequently as expected). The influence of VTO-funded and Other DOE-funded advanced batteries patents can be seen primarily within advanced batteries technology, although the influence also extends to related technologies such as ultracapacitors, nanocomposites and electric vehicles.

- There are a number of individual high-impact VTO-funded advanced batteries patents, examples of which are shown in Figure E-3. They include patents describing lithium metal oxide electrodes from Argonne National Laboratory; metal sulfur cells from Lawrence Berkeley National Laboratory; non-aqueous electrolytes from Covalent Associates; and methods for packaging lithium-ion cells from Alcatel.

Figure E-3 – Examples of Highly-Cited VTO-funded Advanced Batteries Patents



1.0 Introduction

This report focuses on advanced batteries technology.[1] Its objective is to trace the technological influence of advanced batteries research funded by the Vehicle Technologies Office (VTO) in the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and its precursor programs – as well as advanced batteries research funded by other offices in DOE. The purpose of the report is to:

(i) Locate patents awarded for key VTO-funded (and Other DOE-funded) innovations in advanced batteries technology; and

(ii) Determine the extent to which VTO-funded (and Other DOE-funded) advanced batteries research has influenced subsequent technological developments both within and beyond advanced batteries.

The primary focus of the report is on the influence of VTO-funded advanced batteries patents. That said, we also extend many elements of the analysis to DOE-funded advanced batteries patents that could not be definitively linked to VTO funding. 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 VTO itself upon the development of advanced batteries technology, while also tracing the influence of DOE more generally. Meanwhile, in practical terms, determining which patents were funded by VTO, 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 patent is via other data resources (e.g. iEdison), 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.

Rather than discard patents confirmed as DOE-funded, but that could not be definitively categorized as VTO-funded, we instead included these patents 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 others the source of funding within DOE is unknown. Many of these "unknown" patents may in fact have been funded by VTO, although a definitive link could not be established. Hence, the results reported here may underestimate the

[1] Following discussions with VTO technology managers, the definition of "advanced batteries technology" used in this analysis is centered on the theme of "lithium-ion and beyond". That is, it focuses on lithium-ion batteries, plus related technologies. The analysis does not cover other battery chemistries that VTO (and DOE more generally) has funded, such as nickel metal hydride (NiMH) or zinc-air batteries. Also, the analysis is not restricted to patents that refer specifically to a vehicle application. Adding this restriction would exclude many relevant patents, since patent applicants typically claim as broad coverage as possible, rather than restricting their claims to a single application.

influence of VTO-funded advanced batteries research, relative to the influence of advanced batteries research funded by the rest of DOE.

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 presents the results of our analysis. Results are presented at the organizational level for both VTO-funded and Other DOE-funded patents. These results show the distribution of VTO-funded (and Other DOE-funded) patents across advanced batteries technologies (as defined by Cooperative Patent Classifications). They also evaluate the extent of VTO's influence (and DOE's influence in general) on subsequent developments in advanced batteries and other technologies. Patent level results are then presented to highlight individual VTO-funded advanced batteries patents that have been particularly influential, as well as to reveal key patents from other organizations that build extensively on VTO-funded advanced batteries research.[2]

2.0 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 technologies developed by leading companies in the advanced batteries industry used VTO-funded research as a foundation. Meanwhile, the primary purpose of the forward tracing is to examine how VTO-funded advanced batteries (i.e. lithium-ion related) patents influenced subsequent technological developments more broadly, both within and outside advanced batteries technology. 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 advanced batteries companies.[3]

[2] This is one of a series of similar reports examining research portfolios across a range of DOE 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.

[3] The analyses described in this report were carried out separately for VTO-funded advanced batteries patents and Other DOE-funded advanced batteries patents. However, referring repeatedly to "VTO-funded/Other DOE-funded patents" or "VTO-funded/Other DOE-funded research" in describing the analyses is lengthy, so we instead use the collective terms "DOE-funded patents" and "DOE-funded research" in the Project Design and Methodology sections of the report.

Our 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, our analysis allows for a wide variety of possible linkages between DOE-funded advanced batteries research and subsequent technological developments. Examining all of these linkage types at the level of an entire technology 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]

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

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

technological and economic importance. 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.

Patent citation analysis has also been used extensively to trace technological developments over time. For example, in the analysis presented in this report, we use citations from patents to earlier patents to trace the influence of DOE-funded advanced batteries research. Specifically, we identify cases where patents cite DOE-funded advanced batteries patents as prior art. These represent first-generation links between DOE-funded patents and subsequent technological developments. We also identify cases where patents cite patents that in turn cite DOE-funded advanced batteries 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 advanced batteries research. By determining how frequently DOE-funded advanced batteries 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 advanced batteries.

Forward and Backward Tracing

As noted above, the purpose of this analysis is to trace the influence of DOE-funded advanced batteries research upon subsequent developments both within and beyond advanced batteries technology. 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, we first identify the leading advanced batteries organizations in terms of patent portfolio size. We then trace backwards from the patents owned by these organizations. This makes it possible to determine the extent to which innovations associated with these leading advanced batteries organizations build on earlier VTO-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 advanced batteries patents resulting from research funded by DOE (i.e. VTO plus Other DOE). The influence of these patents on later generations of technology is then evaluated. This tracing is not restricted to subsequent advanced batteries 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 advanced batteries patents upon developments both inside and outside this technology.

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.[5]

The backward tracing starts with patents assigned to the leading patenting organizations in advanced batteries technology. The first generation contains the patents that are cited as prior art by these starting patents. The second generation contains patents that are in turn cited as prior art by these first generation patents. In other words, the backward tracing starts with advanced batteries patents owned by leading organizations in this technology, and traces back through two generations of earlier patents to identify the technologies upon which they were built, including those funded by DOE.

The forward tracing starts with DOE-funded patents in advanced batteries technology. 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. In other words, the analysis starts with DOE-funded advanced batteries patents and traces forward for two generations of subsequent patents.

This means that we trace forward through two generations of citations starting from DOE-funded advanced batteries patents; and backward through two generations starting from the patents owned by leading advanced batteries organizations. Hence there are two types of links between DOE-funded patents and subsequent generations of patents:

1. **Direct Links**: where a patent cites a DOE-funded advanced batteries patent as prior art.

2. **Indirect Links**: where a patent cites an earlier patent, which in turn cites a DOE-funded advanced batteries patent. The DOE patent is thus linked indirectly to the subsequent 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 links of any other person in the world. By the same logic, if one

[5] As noted above, the forward and backward tracing were carried out separately for VTO-funded and Other DOE-funded advanced batteries 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 advanced batteries patents as a single portfolio.

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, we constructed patent families for DOE-funded advanced batteries patents, and also for the patents owned by leading advanced batteries organizations. We also assembled families for all patents linked via citations to DOE-funded advanced batteries patents.

To construct these patent families, we matched the priority documents of the U.S., EPO and WIPO patents, 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.

Metrics Used in the Analysis

Table 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.

[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.

Table 1 – List of Metrics Used in the Analysis

Metric
Trends
• Number of VTO/Other DOE-funded advanced batteries patent families by year of priority application
• Number of VTO/Other DOE-funded granted U.S. advanced batteries patents by issue year
• Overall number of advanced batteries patent families by priority year
• Percentage of advanced batteries patents families funded by VTO/Other DOE by priority year
Assignee Metrics
• Number of advanced batteries patent families for leading patenting organizations
• Assignees with largest number of advanced batteries patent families funded by VTO/Other DOE
Technology Metrics
• Patent classification (CPC) distribution for VTO-funded advanced batteries patent families (vs Other DOE-funded, leading advanced batteries companies, all advanced batteries)
Backward Tracing Metrics
• Total/Average number of leading company advanced batteries patent families linked via citations to earlier patent families from VTO/Other DOE and other leading companies
• Number of advanced batteries patent families for each leading company linked via citations to earlier VTO/Other DOE-funded patent families
• Total citation links from each leading company to VTO/Other DOE-funded patent families
• Percentage of leading company advanced batteries patent families linked via citations to earlier VTO/Other DOE-funded patent families
• VTO/Other DOE-funded advanced batteries patent families linked via citations to largest number of leading company advanced batteries patent families
• Leading company advanced batteries patent families linked via citations to largest number of VTO-funded advanced batteries patent families
• Highly cited leading company advanced batteries patent families linked via citations to earlier VTO-funded advanced batteries patent families
Forward Tracing Metrics
• Citation Index for advanced batteries patent portfolios owned by leading companies, plus portfolios of VTO/Other DOE-funded advanced batteries patents
• Number of patent families linked via citations to VTO/Other DOE-funded advanced batteries patents by patent classification
• Organizations (beyond leading advanced batteries companies) linked via citations to largest number of VTO/Other DOE funded advanced batteries patent families
• Highly cited VTO-funded advanced batteries U.S. patents
• VTO/Other DOE-funded advanced batteries patent families linked via citations to largest number of subsequent advanced batteries/non-advanced batteries patent families
• Highly cited patents (not owned by leading companies) linked via citations to earlier VTO-funded advanced batteries patents families

3.0 Methodology

The previous section of the report outlines the objective of our analysis – that is, to determine the influence of VTO-funded (and Other DOE-funded) advanced batteries research on subsequent developments both within and outside advanced batteries technology. 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 advanced batteries patents owned by leading patenting organizations in this technology. Meanwhile, the forward tracing starts from the sets of advanced batteries patents funded by VTO and Other DOE. We therefore had to define these various data sets – VTO-funded advanced batteries patents; Other DOE-funded advanced batteries patents; and advanced batteries patents assigned to the leading organizations in this technology.

Identifying VTO-funded and Other DOE-funded Advanced Batteries Patents

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

(i) Defining the universe of DOE-funded patents;
(ii) Determining which of these DOE-funded patents are relevant to advanced batteries; and
(iii) Categorizing these DOE-funded advanced batteries patents according to whether or not they can be linked definitively to VTO 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 take all of their patents and define 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.

We therefore constructed a database containing all DOE-funded patents. These include 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 us with 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 us with an output from its Visual Patent Finder tool. This tool takes DOE-funded patents and clusters them based on word occurrence patterns. In our case, the output was a flat file containing DOE-funded patents.

4. ***Patents assigned to DOE*** – in the USPTO database, we identified a small number of U.S. patents assigned to DOE itself that were 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. We identified all patents that refer to ‘Department of Energy’ or ‘DOE’ in their Government Interest field, including different variants of these strings. We also identified 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. We manually checked all of the patents containing these strings that were not already in any of the sources above, to make sure that they are indeed DOE-funded (e.g. ‘-ENG-’ is also used in a small number of NSF contracts). We then included any additional DOE funded patents 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 Advanced Batteries Patents

Having defined the universe of DOE-funded patents, the next step was to determine which of these patents are relevant to advanced batteries technology. We designed a custom patent filter to identify advanced batteries patents, consisting of a combination of Cooperative Patent Classifications (CPCs) and keywords. Details of the patent filter are shown in Table 2. The form of the filter is (Filter A OR Filter B), so patents that qualify under either of the filters in Table 2 were included in the initial patent set.

Table 2 – Filters used to Identify Advanced Batteries Patents

Filter A
Cooperative Patent Classification
H01M 10/0525 (Rocking chair batteries; lithium-ion batteries)
Y02E 60/122 (Lithium-ion batteries)
Y02T 10/7011 (Lithium-ion batteries)
Filter B
Cooperative Patent Classification
B05D 5/12 (Coatings with electrical properties)
B60L (Electrically-propelled vehicles)
H01M (Means, e.g. batteries, for converting chemical energy into electrical energy)
H02J 7 (Charging or depolarizing batteries)
Y02E 60/10 (Energy storage using batteries)
Y02E 60/12 (Batteries for climate change mitigation)
Y02E 60/128 (Hybrid battery/fuel cells)
Y02P 70/54 (Battery manufacturing)
Y02T 10/7005 (Electro-mobility batteries)
Y02T 10/7044-7094 (Controlling batteries)
Y02T 10/92 (Charging/discharging batteries)
Y02T 90/10-169 (Charging electric vehicles)
AND
Title/Abstract
Lithium(-)ion OR Li(-)ion OR Single(-)ion(-)conductor OR Lithium(-)rich OR Sodium(-)ion OR Lithium(-)metal OR Metallic(-)lithium OR Solid(-)state(-)electrolyte OR Ceramic(-)electrolyte* OR Lithiate*
where: (-) = zero or one characters, including a space; * = right truncation, unlimited characters

We then manually checked the resulting list of patents to determine which of them appear relevant to advanced batteries. Having constructed this draft patent list, we then sent it to VTO for review. Following this review, and based on feedback from VTO, the initial list of advanced batteries patents funded by DOE contained a total of 723 granted U.S. patents.

Defining VTO-funded vs. Other DOE-funded Advanced Batteries 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 723 DOE-funded advanced batteries patents in the initial list could be linked definitively to VTO 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 VTO technology managers to verify individual patents,
- (iv) Asking VTO 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 VTO, and
- (vi) Locating references to patents in available office annual project progress reports or patent disclosure documents with accomplishments reported by PIs.

Final List of VTO-funded and Other DOE-funded Advanced Batteries Patents

Based on the process described above, we divided the initial list of 723 DOE-funded advanced batteries U.S. patents into two categories – VTO-funded and Other DOE-funded. We then searched 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. We also searched for U.S. patents that are continuations, continuations-in-part, or divisional applications of each of the patents in the final set. We then grouped the patents into families by matching priority documents (see earlier discussion of patent families). Table 3 contains a summary of the number of VTO-funded and Other DOE-funded advanced batteries patents and patent families.

Table 3 – Number of VTO-funded and Other DOE-funded Advanced Batteries Patents and Patent Families

	# Patent Families	# U.S. Patents	# EPO Patents	# WIPO Patents
VTO-funded	256	330	62	123
Other DOE-funded	323	434	56	113
Total DOE-funded	579	764	118	236

Table 3 shows that we identified a total of 256 VTO-funded advanced batteries patent families, containing 330 U.S. patents, 62 EPO patents, and 123 WIPO patents (see Appendix A for patent list). We also identified 323 Other DOE-funded advanced batteries patent families, containing 434 U.S. patents, 56 EPO patents, and 113 WIPO patents (see Appendix B for patent list).[7] The bulk of these DOE-funded patents are from the mid-1990s onwards, corresponding to the commercialization of lithium-ion batteries.

[7] Referring back to the decision not to restrict the analysis to patents that refer specifically to a vehicle application, it is notable that out of 579 VTO/Other DOE-funded patent families, only 19 (three VTO-funded, 16 Other DOE-funded) use the term "vehicle*" or "automobile*" in their title or abstract.

As noted throughout this report, the approach used to define patents as VTO-funded was very stringent. Hence, a number of the 323 Other DOE-funded patent families may in fact have been funded by VTO, but are not categorized as such because a definite link could not be established. To get a better sense of how many of these Other DOE-funded patents (and patent families) may in fact be VTO-funded, we divided them into two groups.

The first group contains DOE-funded patent families that were definitely not funded by VTO. These include families linked specifically to funding from an office other than VTO, or that the inventor or VTO technology manager said were not funded by VTO (but without specifying funding from a different office). There are 265 such patent families. The second group contains DOE-funded patent families where the funding source within DOE could not be established, and inventors and VTO technology managers could not state categorically whether or not they were funded by VTO. There are 58 such patent families. Hence, up to 18% (58 out of 323) of the Other DOE-funded patent families in this analysis may in fact be VTO-funded. As a result, the findings reported may understate the influence of VTO-funded advanced batteries patents, relative to the influence of the remainder of DOE patents.

Identifying Advanced Batteries Patents Assigned to Leading Organizations

The purpose of the backward tracing element of our analysis is to evaluate the influence of VTO-funded (and Other DOE-funded) research upon advanced batteries innovations produced by leading organizations in this technology. To identify such organizations, we first defined the universe of advanced batteries patents in the period 1976-2018 using the patent filter detailed earlier in Table 2. Based on this filter, we identified a total of 12,202 advanced batteries U.S. patents; 14,150 advanced batteries WIPO patents; and 9,303 advanced batteries EPO patents. We grouped these patents into 22,644 patent families by matching priority documents. We then located the most prolific patenting organizations in this overall advanced batteries patent universe, based on number of patent families. The ten organizations with the largest number of advanced batteries patent families are shown in Table 4.[8]

Table 4 – Top 10 Patenting Advanced Batteries Companies

Company	# Advanced Batteries Patent Families
Samsung SDI Co Ltd	1224
Panasonic Corporation	1198
Toyota Motor Corp	1127
LG Chem Ltd.	1120
Bosch (Robert) GmbH	786
Hitachi Ltd	641
Sony Corp	559
NEC Corp	428
Nissan Motor Co. Ltd.	405
Toshiba Corp	391

[8] All ten of these organizations are companies. For clarity, they are referred to in the results section of the report as the leading advanced batteries 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 advanced batteries companies, but this is a cumbersome description to use throughout the results section of the report.

The number of patent families listed in Table 4 includes all variant names under which each company has patents, taking into account including all subsidiaries and acquisitions. The advanced batteries patent families of these companies – all of which are major technology and automotive companies – form the starting point for the backward tracing element of the analysis. As such, this analysis evaluates the influence of DOE-funded advanced batteries research on technologies developed by leading companies in the advanced batteries industry.

Constructing Citation Links

Through the processes described above, we constructed starting patent sets for both the backward forward tracing elements of the analysis. The patent set for the backward tracing consisted of patent families assigned to the leading patenting organizations in advanced batteries technology. The patent sets for the forward tracing consisted of VTO-funded (and, separately, Other DOE-funded) advanced batteries patent families.

Having defined these patent sets, we then traced backward through two generations of citations from the leading organizations' advanced batteries patents, and forward through two generations of citations from the VTO/Other DOE-funded advanced batteries 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.

4.0 Results

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

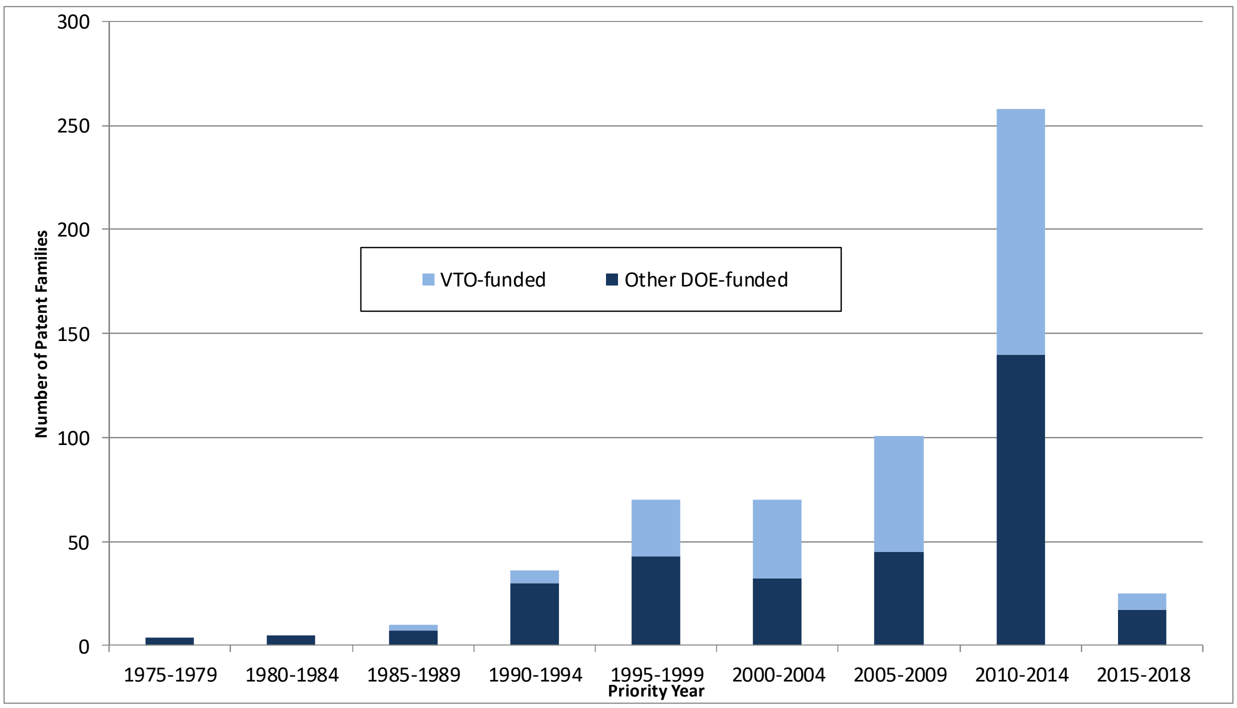
Overall Trends in Advanced Batteries Patenting

Trends in Advanced Batteries Patenting over Time

Figure 1 shows the number of DOE-funded advanced batteries patent families by priority year – i.e. the year of the first application in each patent family. This figure separates VTO-funded and Other DOE-funded patent families, and reveals an interesting pattern in terms of DOE-funded patent activity in advanced batteries technology. The earliest periods in the analysis saw very little DOE-funded patent activity in advanced batteries, which is not surprising given that lithium-ion batteries did not start to be commercialized until the 1990s. There were four patent families filed in 1975-1979 followed by five in 1980-1984, ten in 1985-1989, and 36 in 1990-1994. In total, 46 out of the 55 patent families in these earliest time periods are defined as Other DOE-funded, rather than VTO-funded.

The period between 1995 and 2009 saw a further increase in DOE-funded advanced batteries patenting. There were 70 patent families filed in each of 1995-1999 and 2000-2004, followed by 101 families in 2005-2009. Just over half of these patent families (121 out of 241) are defined as VTO-funded. The time period 2010-2014 then saw a sharp increase to 258 patent families, 118 defined as VTO-funded and 140 Other DOE-funded. The final time period in Figure 1 is 2015-2018, which contains only partial data due to associated time lags in the patenting process.

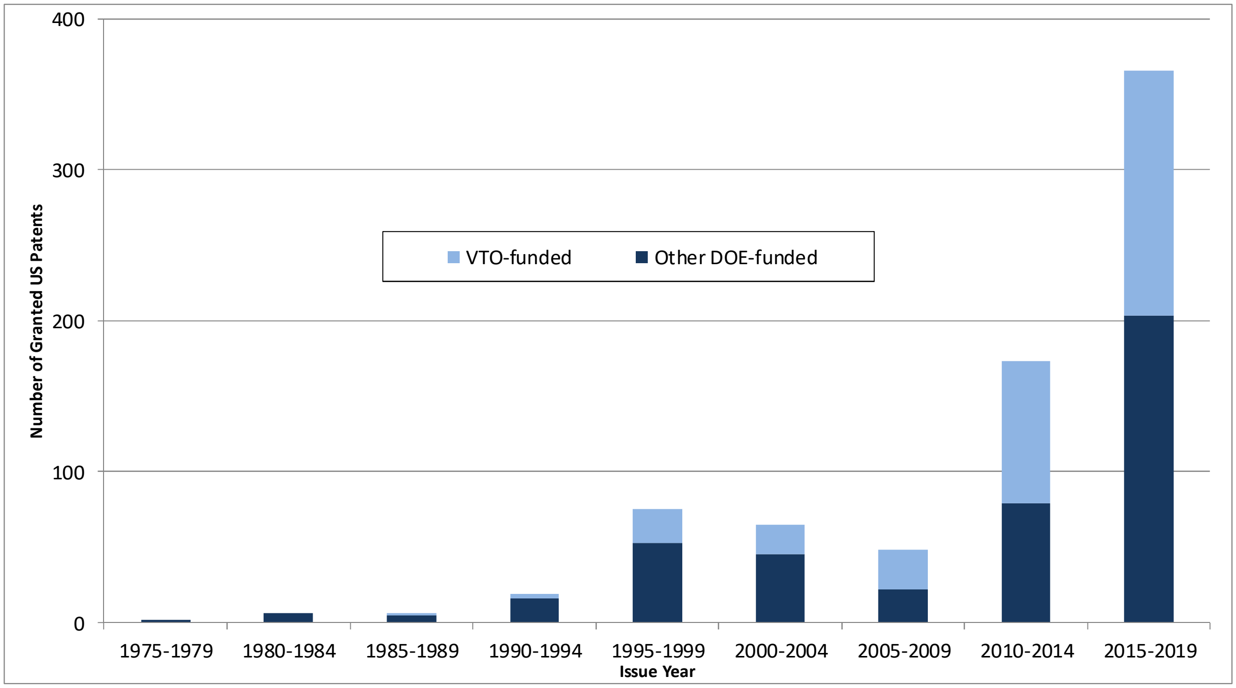
Figure 1 - Number of Advanced Batteries Patent Families funded by VTO and Other DOE Sources by Priority Year (5-Year Totals)



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

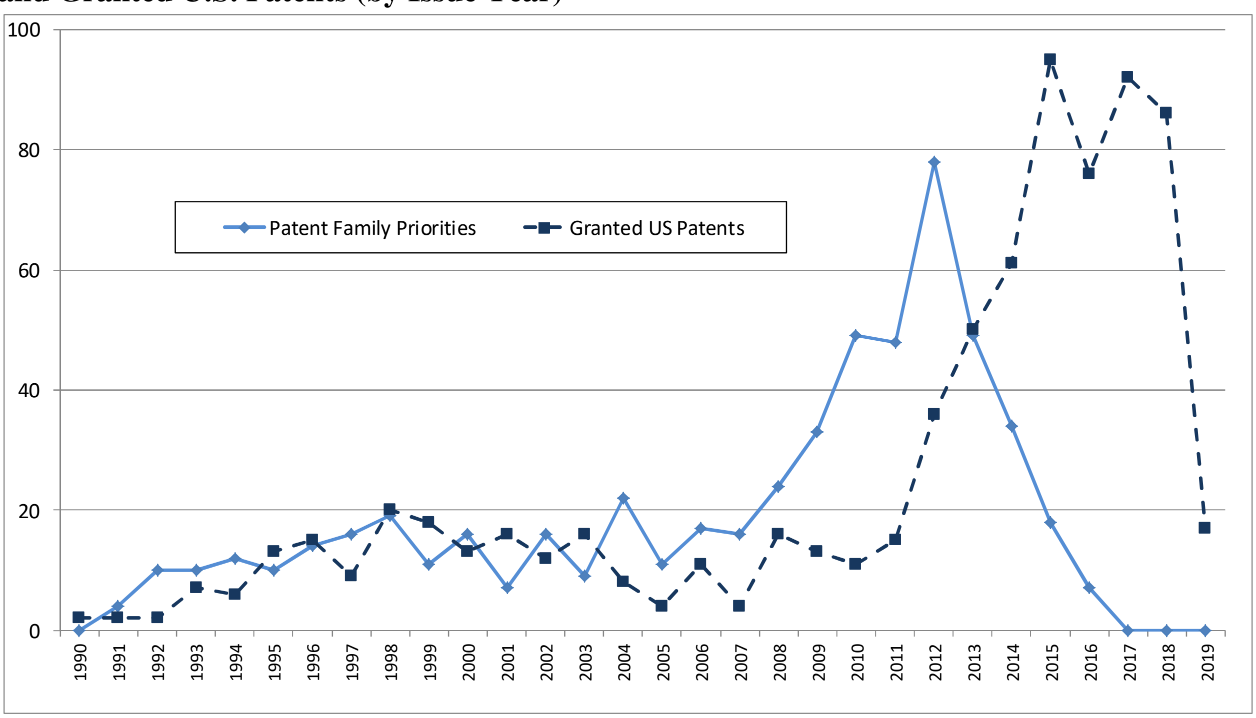
Figure 1 suggests that the bulk of DOE-funded advanced batteries patenting is in the most recent time periods in the analysis, with VTO funding being associated with a substantial proportion of these patents. This pattern is also reflected in Figure 2, which shows the number of advanced batteries granted U.S. patents funded by DOE since 1975. This figure shows very little patent activity through 1995, followed by an increase to 75 patents granted in 1995-1999. The number of patents then declined somewhat, totaling 48 in 2005-2009. Since then, there has been a sharp increase in the number of DOE-funded advanced battery U.S. patents, with 173 granted in 2010-2014 (94 VTO-funded and 79 Other DOE-funded) and 366 granted in 2015-2019 (163 VTO-funded and 203 Other DOE-funded).

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



Note: The data collection period for this analysis ended with 2018. Any 2019 patents in the 2015-2019 column are additional patents that have been included because they are members of the same patent families as pre-2019 patents. No new patent search for 2019 was carried out.

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

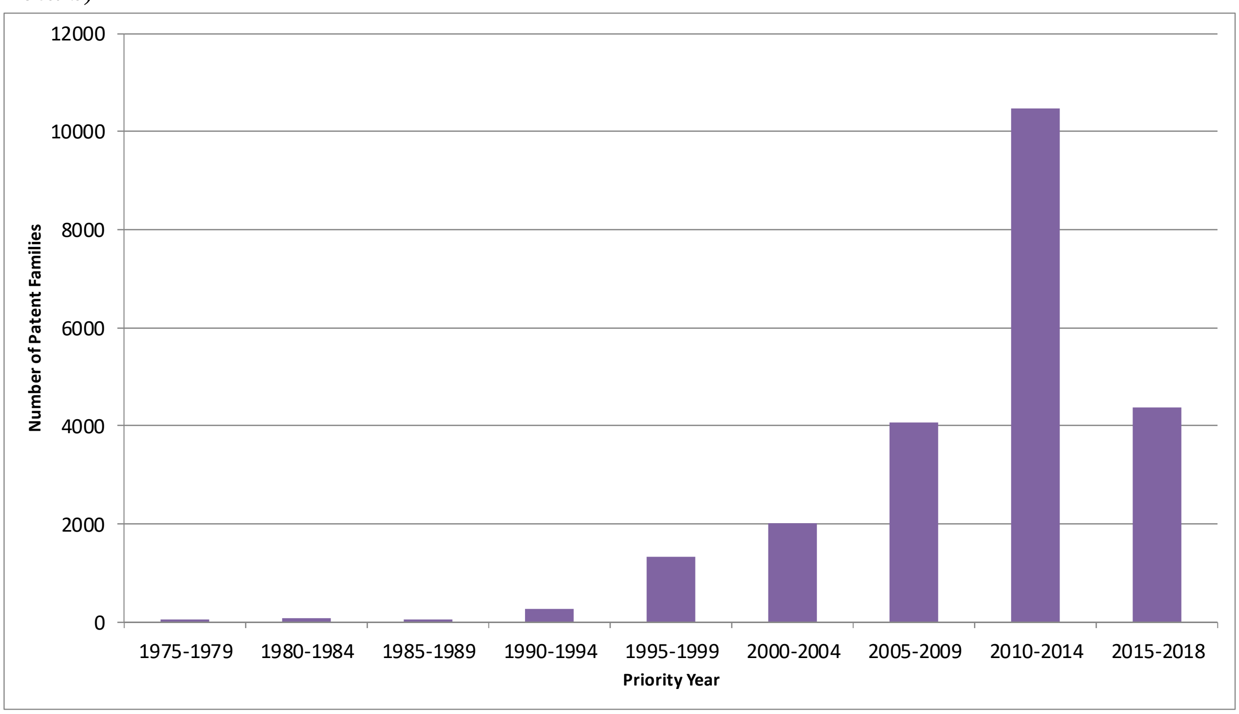


Note: The data collection period for this analysis ended with 2018. Any 2019 patents have been included because they are members of the same patent families as pre-2019 patents. No new patent search for 2019 was carried out.

Comparing Figures 1 and 2 shows the effect of time lags in the patenting process, with many of the patent families with priority dates in 2005-09 and 2010-14 (Figure 1) resulting in granted U.S. patents in 2010-14 and 2015-19 (Figure 2). These time lags can also be seen in Figure 3, which shows advanced batteries patent family priority years alongside issue years for granted U.S. advanced batteries patents (in this figure, VTO and Other DOE are combined, in order to simplify the presentation). In this figure, the peak in patent family priorities is in 2012, with the peak in granted U.S. patents occurring in 2015 and remaining high through 2018 (note that, due to the primary data collection for this analysis ending in 2018, the number granted U.S. patents declines sharply in 2019, and the number of patent families is zero).

Figures 1-3 focus on DOE-funded advanced batteries patent families. Figure 4 broadens the scope, and shows the overall number of advanced batteries patent families by priority year (based on USPTO, EPO, and WIPO filings). This chart follows a relatively similar pattern to Figure 1, which focused solely on DOE-funded advanced batteries patent families. Overall advanced batteries patenting started to increase in the 1990s, and continued to grow throughout the next two decades, peaking at 10,467 patent families in 2010-14. The overall number of patent families declined in 2015-18, although data for this period are incomplete. Hence, it appears that the trend in DOE-funded advanced batteries patenting is in line with the broader trend in this technology in general.

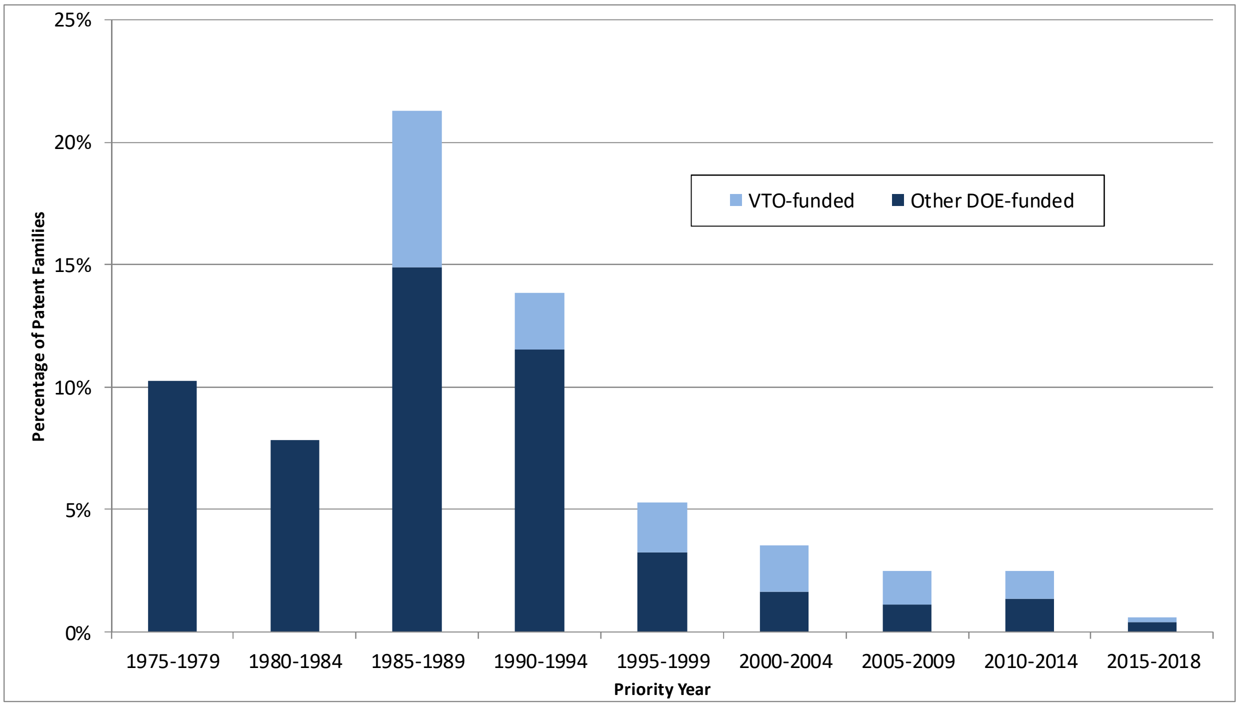
Figure 4 - Total Number of Advanced Batteries Patent Families by Priority Year (5-Year Totals)



Note: The final time period in this figure is 2015-2018. Data for this time period are incomplete. Due to time lags associated with the patenting process, only a fraction of the patent families from this time period will be included.

Figure 5 shows the percentage of advanced batteries patent families in each time period that were funded by DOE (VTO plus Other DOE). In the earliest time periods, this percentage is very high, peaking at over 21% in 1985-1989. However, it should be noted that the results for these early time periods are based on a very small number of patent families. For example, the 21% for 1985-1989 represents DOE funding 10 out of 47 total patent families (three funded by VTO, seven by Other DOE). As the overall number of advanced battery families has increased, the percentage funded by DOE has fallen. In 2010-2014, the most active time period overall, the 258 patent families funded by DOE (118 by VTO, 140 by Other DOE), represent 2.4% of the 10,467 patent families from this time period. This smaller percentage is not surprising, given the rapid growth in advanced battery patent activity associated with various very large companies. Overall, 2.6% of advanced battery patent families in the period 1976-2018 were funded by DOE.

Figure 5 - Percentage of Advanced Batteries Patent Families Funded by DOE by Priority Year



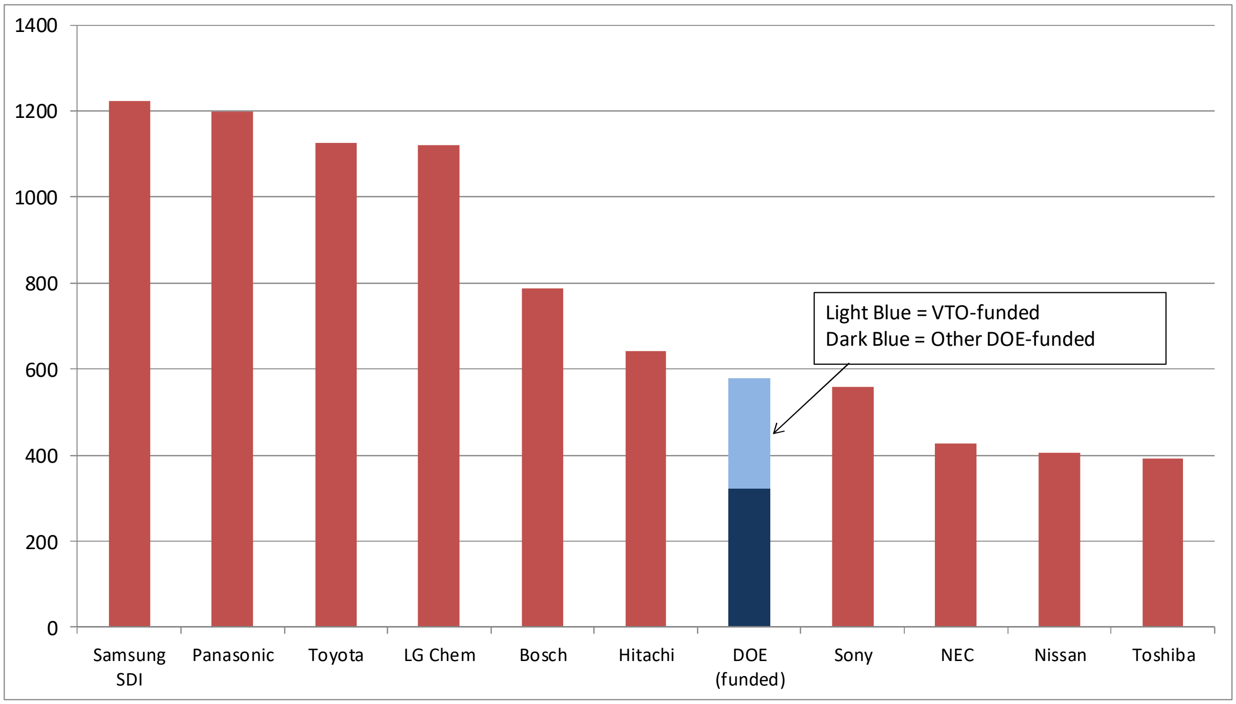
Note: The final time period in this figure is 2015-2018. Data for this time period are incomplete. Due to time lags associated with the patenting process, only a fraction of the patent families from this time period will be included.

Leading Advanced Batteries Assignees

The ten leading patenting companies in advanced batteries technology are listed above in Table 4, along with their number of advanced batteries patent families. These top ten companies are the basis for the backward tracing element of the analysis, as outlined below. Figure 6 shows the same information in graphical form, while also including DOE-funded patent families.

Figure 6 reveals that the DOE-funded advanced batteries patent portfolio ranks seventh in terms of number of patent families (579 families in total, of which 256 are VTO-funded and 323 are Other DOE-funded). It is just under half the size of the largest patent portfolios associated with Samsung SDI (1,224 patent families) and Panasonic (1,198 patent families). Another notable feature of Figure 6 is the lack of U.S. companies – out of the ten leading advanced battery companies, nine are from Asia and the other from Europe (Bosch). 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.

Figure 6 – Leading Advanced Batteries 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. Specifically, there are eight patent families that were funded by DOE (six by VTO, two by Other DOE) that were assigned to Seeo Inc. Seeo was acquired by Bosch in 2015 (Bosch subsequently announced that it is to sell off Seeo, but the patents still appear to be owned by Bosch). These eight patent families are counted in both the DOE column in Figure 6 (six for VTO, two for Other DOE), and in the Bosch column. This double-counting is appropriate, since these patent families are both funded by DOE and assigned to a leading company.

Assignees of VTO/Other DOE Advanced Batteries Patents

The DOE-funded advanced batteries patent portfolios are constructed somewhat differently from the portfolios of the top ten companies listed in Figure 6. Specifically, DOE's 579 patent families are those funded by DOE, but they are not necessarily assigned to the agency. For example, VTO (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 respective companies or DOE lab managers (as in the example of the Seeo/Bosch patent families discussed above).

Figure 7 shows the leading assignees on VTO-funded advanced batteries patent families. This chart is dominated by the University of Chicago, through its management of Argonne National Laboratory (ANL). There are a total of 99 VTO-funded advanced batteries patent families assigned to either the university itself, or to UChicago Argonne LLC. The remainder of Figure 7 also features numerous other DOE laboratory managers. These include: the University of

California (Lawrence Berkeley National Laboratory (LBNL)); Battelle Energy Alliance (Idaho National Laboratory (INL)); Battelle Memorial Institute (Pacific Northwest National Laboratory (PNNL)); UT-Battelle (Oak Ridge National Laboratory (ORNL)); and the Alliance for Sustainable Energy (National Renewable Energy Laboratory ((NREL)). This reflects the extent of VTO-funded advanced batteries research across a range of DOE laboratories. There are also two large companies in Figure 7 – 3M and W.R. Grace – although their numbers of VTO-funded advanced batteries patent families are relatively low.

Figure 7 - Assignees with Largest Number of VTO-Funded Advanced Batteries Patent Families

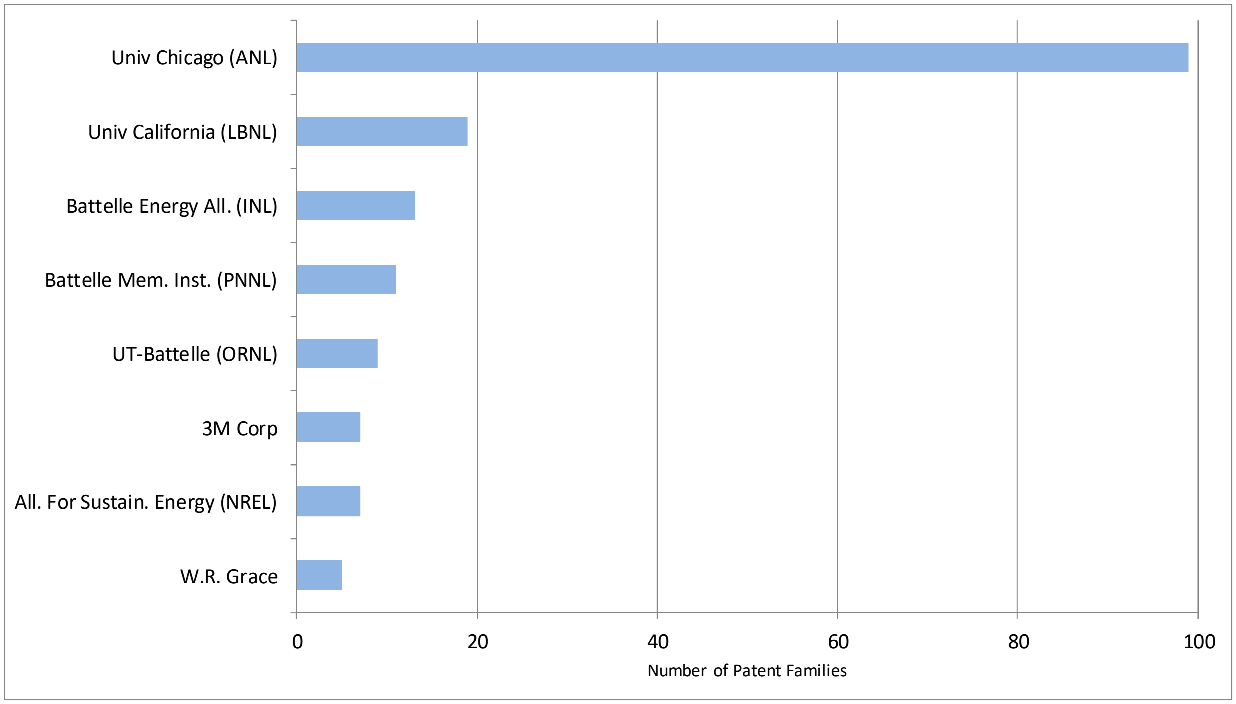
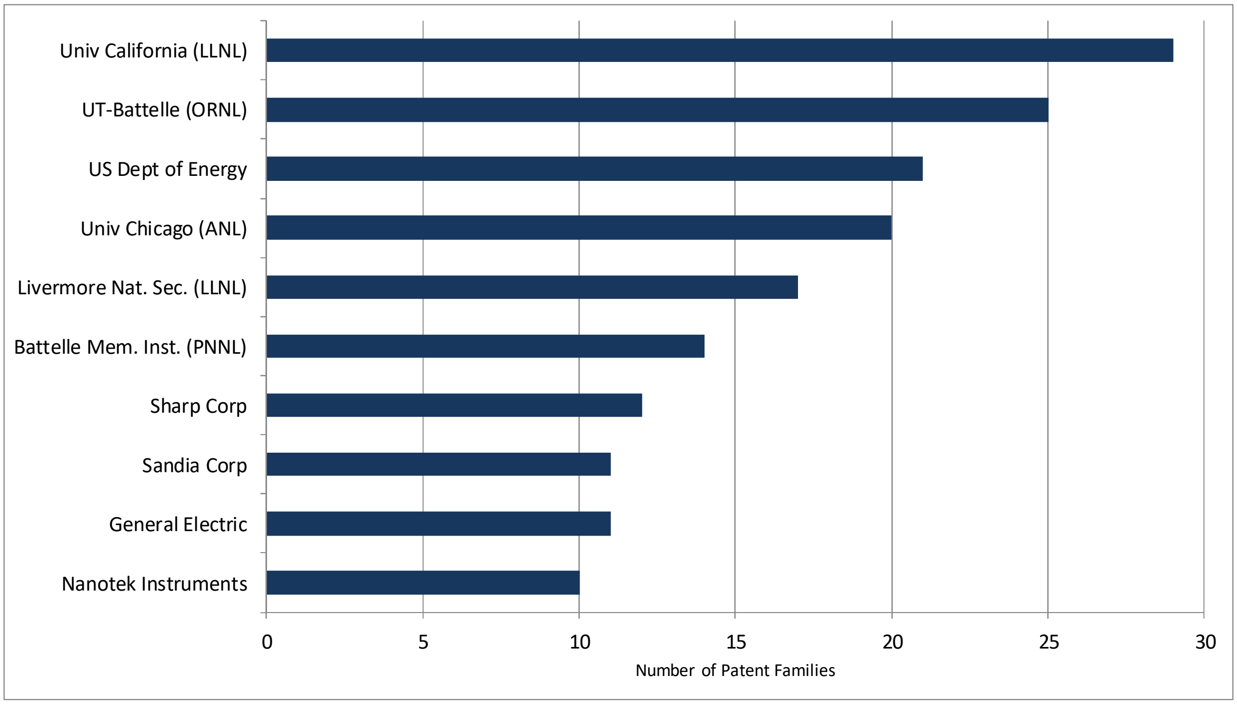


Figure 8 shows the leading assignees on Other DOE-funded advanced batteries patent families. This figure is again dominated by DOE laboratory managers. The most prolific assignee is the University of California, through its management of Lawrence Livermore National Laboratory (LLNL). Figure 8 also includes Lawrence Livermore National Security LLC, the current manager of LLNL. Between them, these LLNL-connected assignees are responsible for 46 Other DOE-funded advanced batteries patent families. Other DOE lab managers in Figure 8 include UT-Battelle (ORNL), University of Chicago (ANL) and Battelle Memorial Institute (PNNL). Figure 8 also includes a number of companies funded by Other DOE, including Sharp, General Electric and Nanotek Instruments. In addition, there are number of patent families assigned to DOE itself. This 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 8 - Assignees with Largest Number of Other DOE-funded Advanced Batteries Patent Families



Distribution of Advanced Batteries Patents across Patent Classifications

We analyzed the distribution of VTO-funded advanced batteries U.S. patents across Cooperative Patent Classifications (CPCs).[9] We then compared this distribution to those associated with Other DOE-funded advanced batteries patents; advanced batteries patents assigned to the ten leading companies; and the universe of all advanced batteries patents. This analysis provides insights into the technological focus of VTO funding in advanced batteries, versus the focus of the remainder of DOE, leading advanced batteries companies, and advanced batteries technology in general.

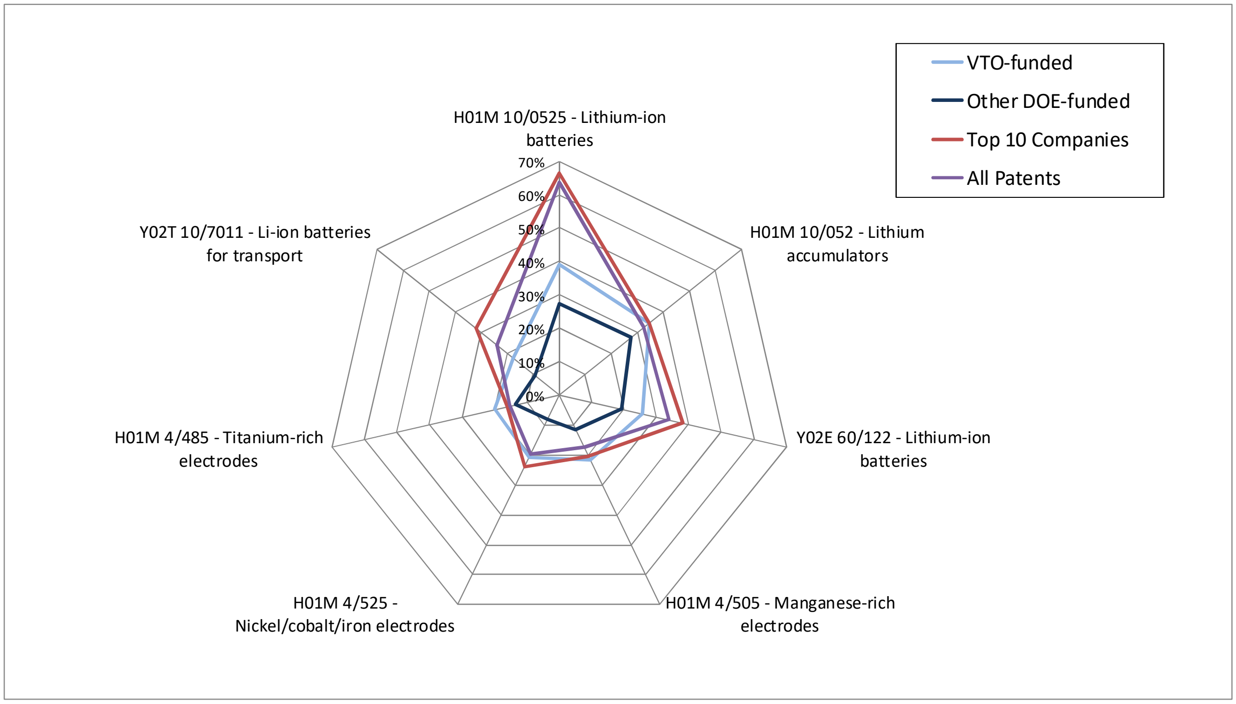
The results from this CPC analysis are shown in two separate charts, each from a different perspective. The first chart (Figure 9) is based on the seven CPCs that are most prevalent among VTO-funded advanced batteries patents. The purpose of this chart is thus to show the main focus areas of VTO-funded advanced batteries research, and the extent to which these areas translate to other portfolios (Other DOE-funded; leading advanced batteries companies; all advanced batteries).

This figure shows that VTO-funded research includes relatively balanced coverage across the seven CPCs (which is not particularly surprising, since the VTO-funded patent portfolio forms the basis for the CPCs included in the chart). The CPC H01M 10/0525, which is concerned with lithium-ion batteries, is the most common CPC among VTO-funded advanced batteries U.S.

[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.

patents. Over 39% of VTO-funded advanced batteries U.S. patents include this CPC. Other CPCs related to lithium-ion batteries are also prominent in Figure 9, notably H01M 10/052 (listed on 34% of VTO-funded patents) and Y02E 60/122 (26% of VTO-funded patents). There is also a CPC (Y02T 10/7011) specifically related to the use of lithium-ion batteries in transport applications. Figure 9 also contains CPCs concerned with different electrode materials, notably manganese, titanium and nickel/cobalt/iron. The percentage of VTO-funded patents with CPC H01M 4/485 (titanium-rich electrodes) is higher than for the other portfolios, but the difference is not substantial.

Figure 9 - Percentage of Advanced Batteries U.S. Patents in Most Common Cooperative Patent Classifications (Among VTO-Funded Patents)



The other three patent portfolios represented in Figure 9 (Other DOE-funded; leading advanced batteries companies; all advanced batteries patents) follow a similar distribution to VTO-funded patents across CPCs. The one notable exception is CPC H01M 10/0525 (lithium-ion batteries), with 64% of all advanced batteries patents, and 66% of advanced batteries patents assigned to the leading companies, containing this CPC. This suggests that this CPC is somewhat generic, and is attached routinely to patents describing lithium-ion battery technologies.

Figure 10 is similar to Figure 9, except that it is from the perspective of the most common CPCs among all advanced batteries patents. Hence, the purpose of this chart is to show the main research areas within advanced batteries as a whole, and how these areas are represented in selected advanced batteries portfolios (VTO-funded; Other DOE-funded; leading advanced batteries companies). Six out of the seven CPCs in Figure 9 also appear in Figure 10, reinforcing the idea that VTO-funded advanced batteries patents are generally aligned with the broader research themes in this technology. The one new CPC in Figure 10 is H01M 4/131, which is concerned with electrodes based on mixed oxides (such as lithium cobalt oxide). This CPC replaces H01M 4/485 (titanium-rich electrodes) from the list in Figure 9.

Figure 10 - Percentage of Advanced Batteries U.S. Patents in Most Common Cooperative Patent Classifications (Among All Advanced Batteries Patents)

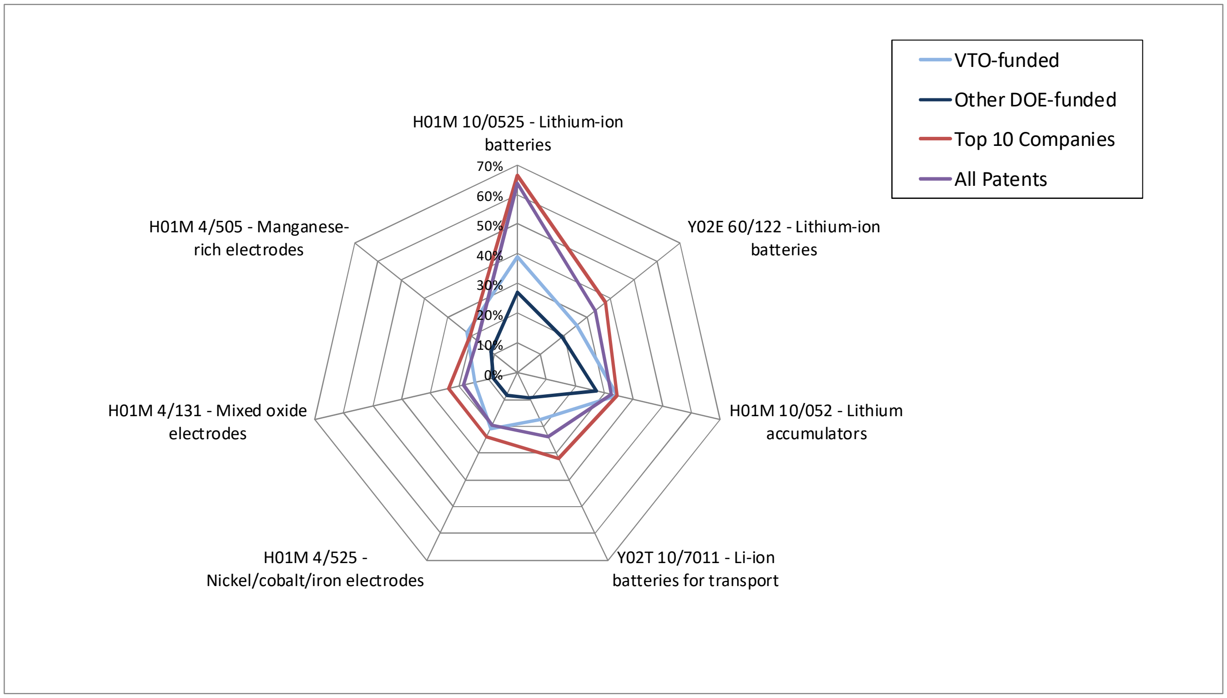


Figure 11 - Percentage of VTO-funded Advanced Batteries U.S. Patents in Most Common Cooperative Patent Classifications across Two Time Periods

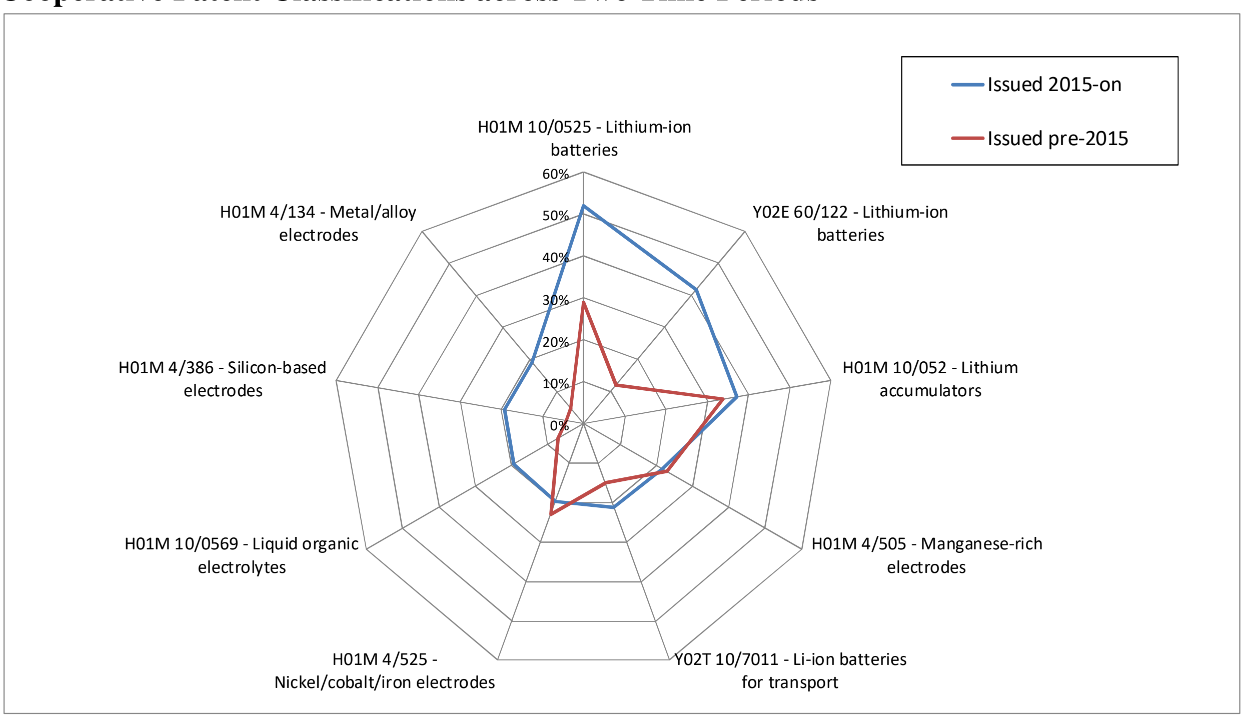


Figure 11 compares the CPC distribution of VTO-funded advanced batteries U.S. patents across two time periods – patents issued through 2014, and those issued from 2015 onwards. This figure reveals that, beyond the generic lithium-ion CPCs, the CPCs with the most substantial growth in recent years are concerned with silicon-based electrodes (H01M 4/386) and metal/alloy electrodes (H01M 4/134). This suggests that these are areas of increasing focus for recipients of VTO advanced batteries funding.

Tracing Backwards from Advanced Batteries Patents Owned by Leading Companies

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

Organizational Level Results

In the organizational level results, we first compare the influence of VTO-funded and Other DOE-funded advanced batteries research against the influence of leading companies in this technology. We then look at which of these leading companies build particularly extensively on DOE-funded advanced batteries research.

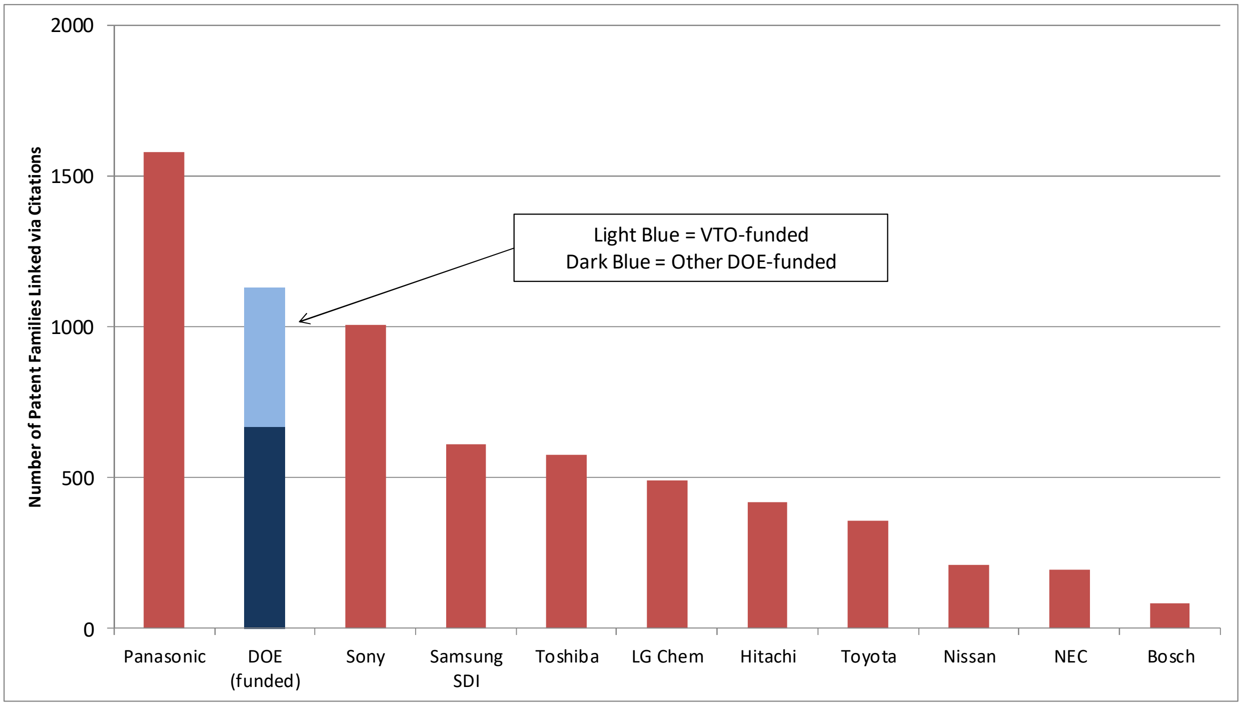
Figure 12 compares the influence of VTO-funded and Other DOE-funded advanced batteries research to the influence of research carried out by the top ten advanced batteries companies. Specifically, this figure shows the number of advanced batteries patent families owned by the leading companies that are linked via citations to earlier advanced batteries 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 developments made by leading companies in advanced batteries technology.[10]

In total, 1,130 leading company advanced batteries patent families (i.e. 14.8% of their 7,648 families) are linked via citations to earlier DOE-funded advanced batteries patents, out of which

[10] This figure compares the influence of patents *funded* by VTO/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, there is a small amount of double-counting in Figure 12, as some patent families assigned to Bosch were also funded by DOE. Also, in Figures 12-15, leading company patent families linked to both VTO-funded and Other DOE-funded patents are allocated to the VTO-funded segment of the DOE column, in order to avoid double-counting these families.

464 are linked to VTO-funded advanced batteries patents. This finding puts DOE-funded patents in second place in Figure 12. Only Panasonic is ahead of DOE in this figure, with 1,579 leading company patent families linked to its earlier patents. That said, Panasonic has more than twice as many advanced battery patent families as DOE (see Figure 6), and thus has many more patents available to be cited as prior art by subsequent generations of patents.

Figure 12 - Number of Leading Company Advanced Batteries Patent Families Linked via Citations to Earlier Advanced Batteries Patents from each Leading Company
e.g. 1,130 leading company families are linked to earlier VTO/Other DOE-funded families



The result in Figure 12 is very impressive from a DOE perspective, since it ranks second among the leading companies in terms of citation linkages despite only having the seventh largest patent portfolio. This suggests that the portfolio of DOE-funded advanced batteries patents has helped form an important part of the foundation for advanced batteries research carried out by the leading companies. Also, this figure may underestimate the influence of VTO-funded advanced batteries research (relative to Other DOE-funded research), since some of the Other DOE-funded advanced batteries patent families may in fact have been funded by VTO, as discussed earlier.

Figures 13 through 15 examine which of the leading companies build particularly extensively on earlier VTO-funded and Other DOE-funded advanced batteries patents. Figure 13 shows how many advanced batteries patent families owned by each of the leading companies are linked via citations to at least one earlier DOE-funded advanced batteries patent. Out of the ten leading advanced batteries companies, three are linked particularly strongly to earlier DOE-funded patents. As such, they build most extensively on earlier DOE-funded advanced batteries research. Samsung SDI heads this list, with 212 patent families linked via citations to DOE-funded patents, 116 of which are linked to VTO. LG Chem is second in Figure 13, with 152 patent families linked to DOE-funded patents (92 linked to VTO-funded patents), followed by Panasonic (147 families linked to DOE; 75 to VTO).

Figure 13 - Number of Patent Families Assigned to Leading Advanced Batteries Companies Linked via Citations to Earlier VTO/Other DOE-funded Advanced Batteries Patents

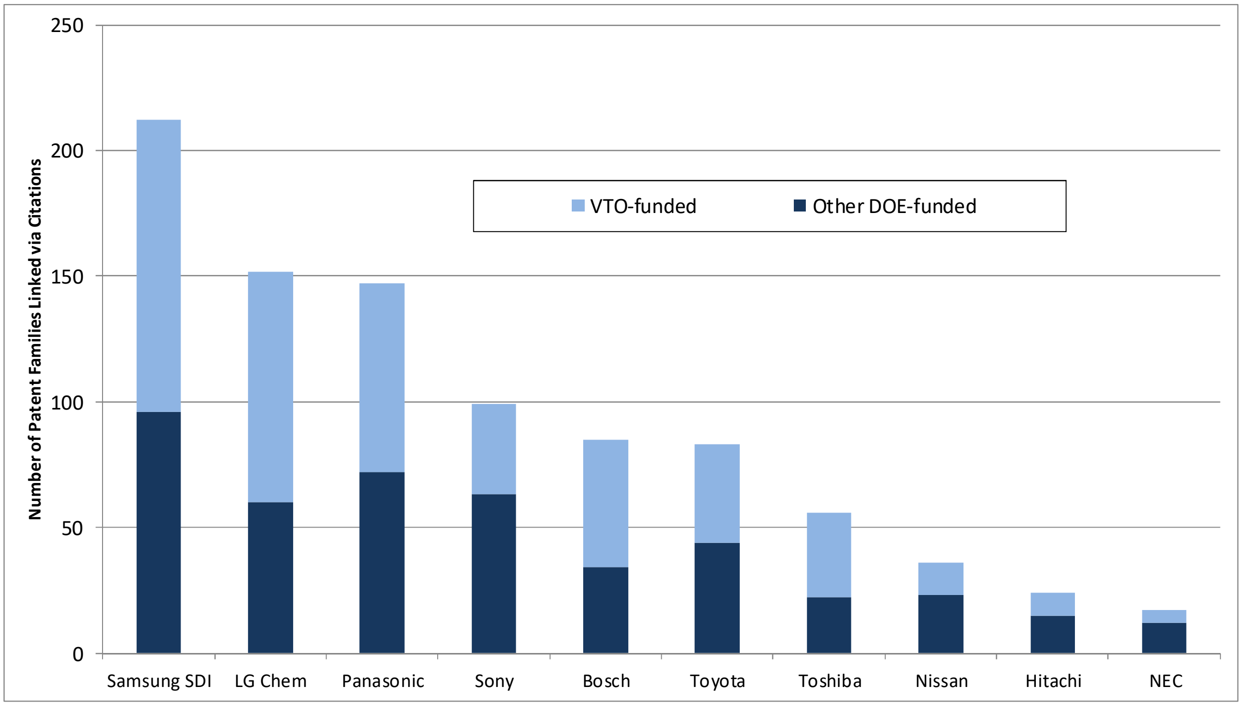


Figure 14 - Total Number of Citation Links from Leading Advanced Batteries Company Patent Families to Earlier VTO/Other DOE-funded Advanced Batteries Patents

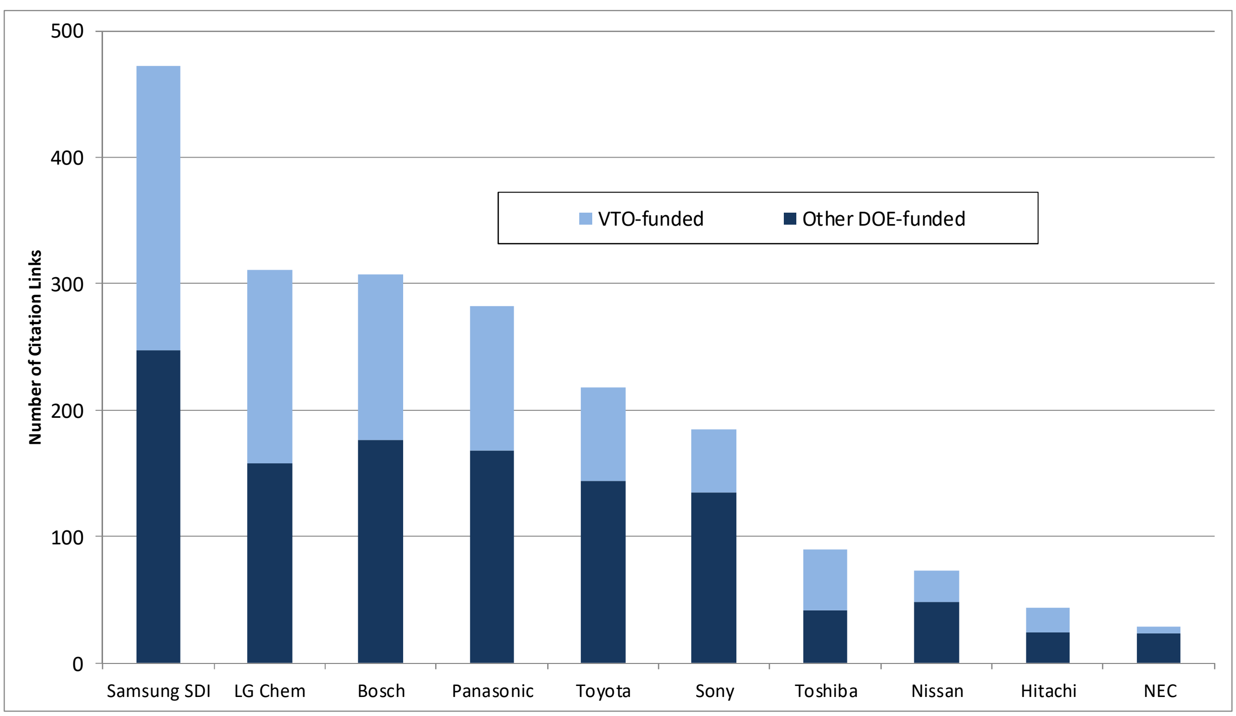
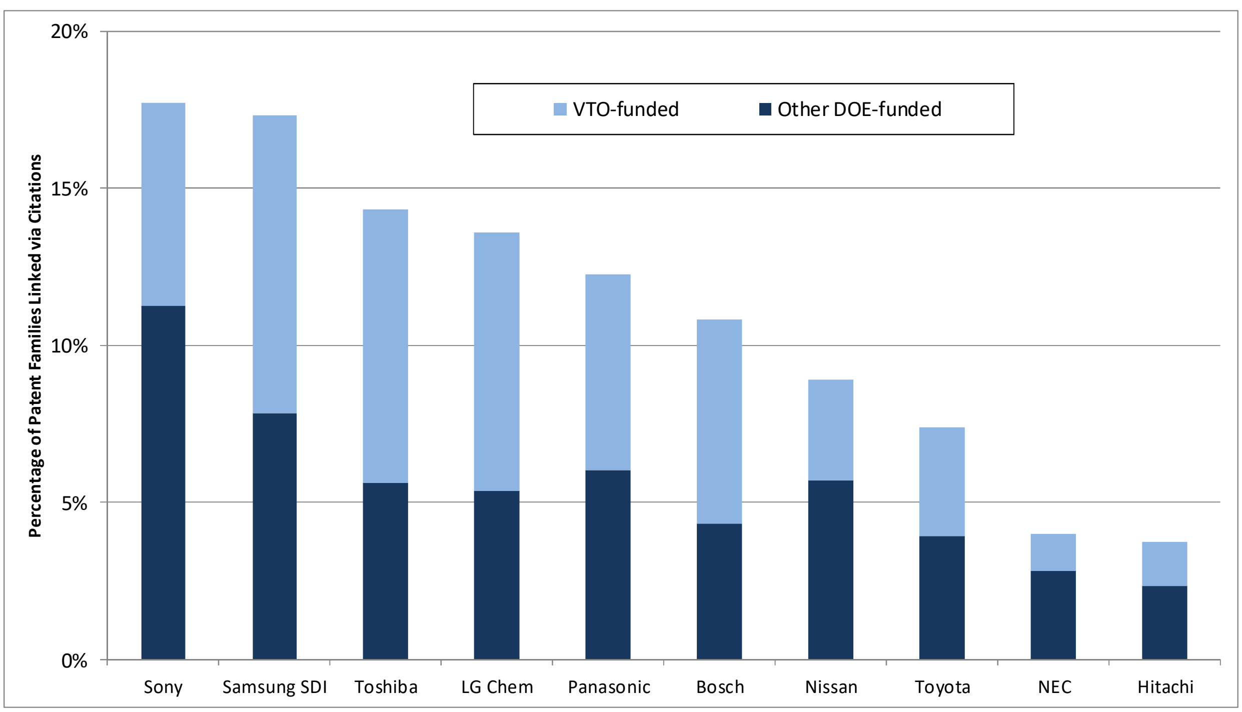


Figure 14 counts the total number of citation links from leading companies to earlier DOE-funded patents. This differs slightly from the count of linked families in Figure 13, since a single patent family may be linked to multiple earlier DOE-funded patents. Samsung SDI is again at the head of Figure 14, reinforcing its close links to earlier DOE-funded advanced batteries research. It has a total of 472 citation links to DOE-funded advanced batteries patents, 225 of which are links to VTO-funded patents. LG Chem is again in second place, with 311 citation links to DOE, 153 of which are links to VTO. Panasonic is still prominent, with 282 citation links to DOE, 113 of which are links to VTO. The biggest difference between Figures 13 and 14 is the high number of overall citation links from Bosch to DOE (307 in total; 131 to VTO), placing it in third place in Figure 14.

There is an element of portfolio size bias in the patent family counts in Figures 13 and 14. Companies with larger advanced batteries patent portfolios are likely to have more patent families linked to DOE, simply because they have more families overall. Figure 15 accounts for this portfolio size bias by calculating the percentage of each leading company's advanced batteries patent families that are linked via citations to earlier DOE-funded advanced batteries 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 15 reveals that two leading companies have more than 15% of their advanced batteries patent families linked via citations to earlier DOE-funded advanced batteries patents – Sony (17.7% overall; 6.4% to VTO) and Samsung SDI (17.3% overall; 9.5% to VTO). Toshiba also becomes more prominent in Figure 15, with 14.3% of its patent families linked to DOE (8.7% to VTO).

Figure 15 - Percentage of Leading Advanced Batteries Company Patent Families Linked via Citations to Earlier VTO/Other DOE-funded Advanced Batteries 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 advanced batteries patent families (in particular VTO-funded families) that have had a particularly strong influence on subsequent advanced batteries patents owned by leading companies in this technology. Looking in the opposite direction, it also identifies individual advanced batteries patents owned by leading companies that have extensive links to earlier VTO-funded research.

Table 5 shows the VTO-funded advanced batteries patent families linked via citations to the largest number of subsequent patent families owned by leading companies in this technology. Many of the patents in this table are relatively old. This is not surprising, since older patents have had a longer time period to become connected to subsequent generations of technology. As such, most of the patent families in Table 5 represent older foundational technologies that are linked to subsequent innovations associated with leading companies in the advanced batteries industry.

Table 5 - VTO Funded Advanced Batteries Patent Families Linked via Citations to Most Subsequent Leading Company Advanced Batteries Patent Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
27025104	5162175	1989	94	Univ California (LBNL)	Cell for making secondary batteries
23322874	4917974	1989	86	US Dept of Energy	Lithium/organosulfur redox cell having protective solid electrolyte barrier
26908237	6677082	2000	45	Univ Chicago (ANL)	Lithium metal oxide electrodes for lithium cells and batteries
26785372	6221531	1998	33	Univ Chicago (ANL)	Lithium-titanium-oxide anodes for lithium batteries
25311950	5766796	1997	24	EIC Laboratories	Passivation-free solid state battery
21940028	6045952	1998	22	US Dept of Energy	Electrochemical storage cell containing a substituted anisole or di-anisole redox shuttle additive for overcharge protection
24619784	5772934	1996	22	W.R. Grace & Co	Process to produce lithium-polymer batteries
27052452	5827602	1995	22	Covalent Associates	Hydrophobic ionic liquids
25428362	5965054	1997	21	Covalent Associates	Nonaqueous electrolyte for electrical storage devices
22985832	5558961	1994	18	Univ California (LBNL)	Secondary cell with orthorhombic alkali metal/manganese oxide phase active cathode material
23824853	6399238	1999	17	Alcatel	Module configuration
38801947	8563168	2006	17	Univ California (LBNL)	High elastic modulus polymer electrolytes
22796514	5376475	1994	14	Ovonic Battery Co	Aqueous lithium-hydrogen ion rechargeable battery

There are two VTO-funded patent families that stand out in terms of the number of leading company patent families linked to them via citations. The first is assigned to the University of

California, through its management of Lawrence Berkeley National Laboratory (LBNL). This LBNL patent family (whose representative patent[11] is US #5,162,175) describes a metal-sulfur cell. It is linked to 94 patent families owned by the ten leading companies, including families assigned to nine of these companies (the exception being NEC). The second patent family (representative patent US #4,917,974) is also from LBNL, and is assigned to DOE itself. This patent family describes a lithium organosulfur redox cell, and is linked via citations to 86 subsequent patent families owned the leading companies. Again, nine out of the ten leading companies are linked to this earlier VTO-funded patent family, the exception being NEC. Both of these VTO-funded patent families are associated with the same research group at LBNL, which included Steven Visco, who later founded PolyPlus Battery Company. Following these two LBNL patent families in Table 5 are two VTO-funded families from Argonne National Laboratory. These patent families (representative patents US #6,677,082 and US #6,221,531) describe lithium metal oxide electrodes, and are linked to 45 and 33 leading company patent families respectively. Table 5 also contains VTO-funded patent families from a range of other organizations, including EIC Laboratories, W.R. Grace, Covalent Associates and Alcatel.

Table 5 lists VTO-funded patents linked to large numbers of subsequent advanced batteries patent families owned by leading companies. Table 6 looks in the opposite direction, and lists advanced batteries patent families owned by leading companies that are linked particularly extensively to earlier patents funded by VTO.

Table 6 - Leading Company Advanced Batteries Patent Families Linked via Citations to Largest Number of VTO Funded Advanced Batteries Patent Families

Patent Family #	Representative Patent #	Priority Year	# VTO Fams	Assignee	Title
56165322	9979019	2014	10	Samsung SDI	Composite positive electrode active material, method of manufacturing the same
49758973	9368791	2012	9	Samsung SDI	Cathode active material, method for preparing the same, and lithium secondary batteries including the same
54071084	9711792	2014	9	Hitachi	Positive electrode active material for secondary batteries and lithium ion secondary battery using the same
41610764	9935333	2015	8	Bosch	High capacity anodes
55167436	9893337	2015	8	Bosch	Multi-phase electrolyte lithium batteries
54069953	9882241	2015	8	Bosch	High capacity cathode
57904406	10044064	2016	5	Bosch	Long cycle-life lithium sulfur solid state electrochemical cell
38087930	7883801	2005	5	Samsung SDI	Electrolyte for rechargeable lithium battery, and rechargeable lithium battery including the same
36177675	7595134	2005	5	Toshiba	Nonaqueous electrolyte battery, lithium-titanium composite oxide, battery pack and vehicle
58777353	10141762	2015	5	Toyota	All-solid-state battery system
34994311	7348102	2005	5	Toyota	Corrosion protection using carbon coated electron collector for lithium-ion battery with molten salt electrolyte
34994312	7468224	2005	5	Toyota	Battery having improved positive electrode and method of manufacturing the same

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

Many of the patent families in Table 6 are relatively new, and are examples of how VTO-funded advanced batteries research has helped form part of the foundation for recent advances made by leading companies. Samsung SDI has the two patent families at the head of this table (representative patents US #9,979,019 and US #9,368,791). These patent families describe composite electrode materials, and batteries containing these electrodes. They are linked via citations to a series of earlier VTO-funded patents from Argonne National Laboratory (ANL) describing lithium metal oxide electrodes. Hitachi also has a patent family near the head of Table 6 (representative patent US #9,711,792). This patent family describes a positive electrode with a layered crystalline structure, and is linked via citations to earlier VTO-funded patents outlining stabilized electrodes, again assigned to ANL. Also notable in Table 6 are three Bosch (Seeo) patent families describing batteries describing batteries with a solid polymer electrolyte containing embedded nanoparticles. These patent families are linked via citations to earlier VTO-funded patents related to hydrogel and polymer based electrolytes, assigned to a range of organizations including PolyPlus Battery and Arizona State University.

We also identified high-impact advanced batteries patents owned by leading companies that have citation links back to VTO-funded patents.[12] The idea is to highlight important technologies owned by leading companies that are linked to earlier advanced batteries research funded by VTO. Table 7 lists advanced batteries patents owned by leading companies that have Citation Index values of two or over (i.e. they have been cited at least twice as frequently as expected), and that are linked via citations to earlier VTO-funded advanced batteries patents.

The patents in Table 7 are listed in descending order according to their Citation Index values. The list is headed by a 2008 LG Chem patent (US #7,470,488) describing a composite film for a polymer electrolyte. This patent has been cited as prior art by 49 subsequent patents, which is more than seven times as many citations as expected for a patent of its age and technology. In turn, the LG Chem patent is linked via citations to earlier VTO-funded metal-sulfur cell patents from LBNL (which were highlighted in Table 5). Toyota has the patent in second place in Table 7 (US #7,348,102). This patent describes a battery with a molten salt electrolyte, and is linked via citations to earlier VTO-funded patents for non-aqueous electrolytes assigned to Covalent Associates. A number of other leading companies have highly-cited patents in Table 7, including Panasonic, Samsung SDI, Sony and Toshiba. This shows the influence of VTO research on high-impact technologies developed by various leading advanced batteries companies.

[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 H01M 10/0525 (Lithium-Ion Batteries) 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.

Table 7 - Highly Cited Leading Company Advanced Batteries Patents Linked via Citations to Earlier VTO-funded Advanced Batteries Patents

Patent	Issue Year	# Cites Received	Citation Index	Assignee	Title
7470488	2008	49	7.86	LG Chem	Multi-component composite film method for preparing the same
7348102	2008	38	6.16	Toyota	Corrosion protection using carbon coated electron collector for lithium-ion battery with molten salt electrolyte
7541114	2009	30	5.81	Panasonic	Anode active material, manufacturing method thereof, and non-aqueous electrolyte secondary battery
7662515	2010	31	4.52	Toshiba	Nonaqueous electrolyte battery, battery pack and vehicle
7157179	2007	32	4.26	Sony	Non-aqueous electrolyte cell and manufacturing method therefor
6605386	2003	51	3.43	Panasonic	Non-aqueous electrolyte secondary battery comprising composite particles
7521151	2009	20	3.23	Samsung SDI	Rechargeable lithium battery with specific surface roughness of positive electrode and/or negative electrode
6139815	2000	42	3.07	Sony	Hydrogen lithium titanate and manufacturing method therefor
6066417	2000	66	2.77	Samsung SDI	Glass-polymer composite electrolyte and a method of preparing the same
6528212	2003	36	2.44	Panasonic	Lithium battery
6423447	2002	41	2.26	Toshiba	Non-aqueous electrolyte secondary battery and method of production of the same
6372384	2002	41	2.20	Panasonic	Rechargeable lithium battery comprising substituted lithium titanate electrodes

While the patent-level results focus on VTO-funded advanced batteries patent families, we also identified Other DOE-funded advanced batteries 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 8.

The patent families in Table 8 are headed by a family assigned to Lockheed Martin, through its former management of Oak Ridge National Laboratory (ORNL). This patent family (representative patent US #5,314,765) describes a coating for lithium metal anodes, and is linked to 114 patent families owned by the leading batteries companies, with all ten of the companies represented among these linked families. It is one of a number of patent families in Table 8 associated with ORNL. Also near the head of Table 8 are Other DOE-funded patent families assigned to SRI International for non-flammable electrolytes (representative patent US #5,830,600) and to Associated Universities (Brookhaven National Laboratory) for thin film cells (representative patent US #5,441,831).

Table 8 - Other DOE Funded Advanced Batteries Patent Families Linked via Citations to Most Subsequent Leading Company Advanced Batteries Families

Patent Family #	Representative Patent #	Priority Year	# Linked Families	Assignee	Title
22476652	5314765	1993	114	Lockheed Martin (ORNL)	Protective lithium ion conducting ceramic coating for lithium metal anodes and associated method
24620996	5830600	1996	85	SRI International	Nonflammable/self-extinguishing electrolytes for batteries
26842654	5441831	1992	69	Associated Univs (BNL)	Cells having cathodes containing polycarbon disulfide materials
25445586	5338625	1992	65	Lockheed Martin (ORNL)	Thin film battery and method for making same
22659706	5569520	1994	58	Lockheed Martin (ORNL)	Rechargeable lithium battery for use in applications requiring a low to high power output
22632542	4340652	1980	42	US Dept of Energy	Ternary compound electrode for lithium cells
24577280	5219679	1991	40	EIC Laboratories	Solid electrolytes
23093045	5445906	1994	36	Lockheed Martin (ORNL)	Method and system for constructing a rechargeable battery and battery structures formed with the method
46248687	5470674	1993	34	Sandia Corp	Electrolyte salts for power sources
21961189	5426006	1993	32	Sandia Corp	Structural microporous carbon anode for rechargeable lithium-ion batteries
27487657	7026071	1996	31	MIT	Non-crosslinked, amorphous, block copolymer electrolyte for batteries

Overall, the backward tracing element of the analysis suggests that VTO-funded and Other DOE-funded advanced batteries patents have had a strong influence on subsequent innovations associated with the leading advanced batteries 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 of the leading companies.

Tracing Forwards from DOE-funded Advanced Batteries Patents

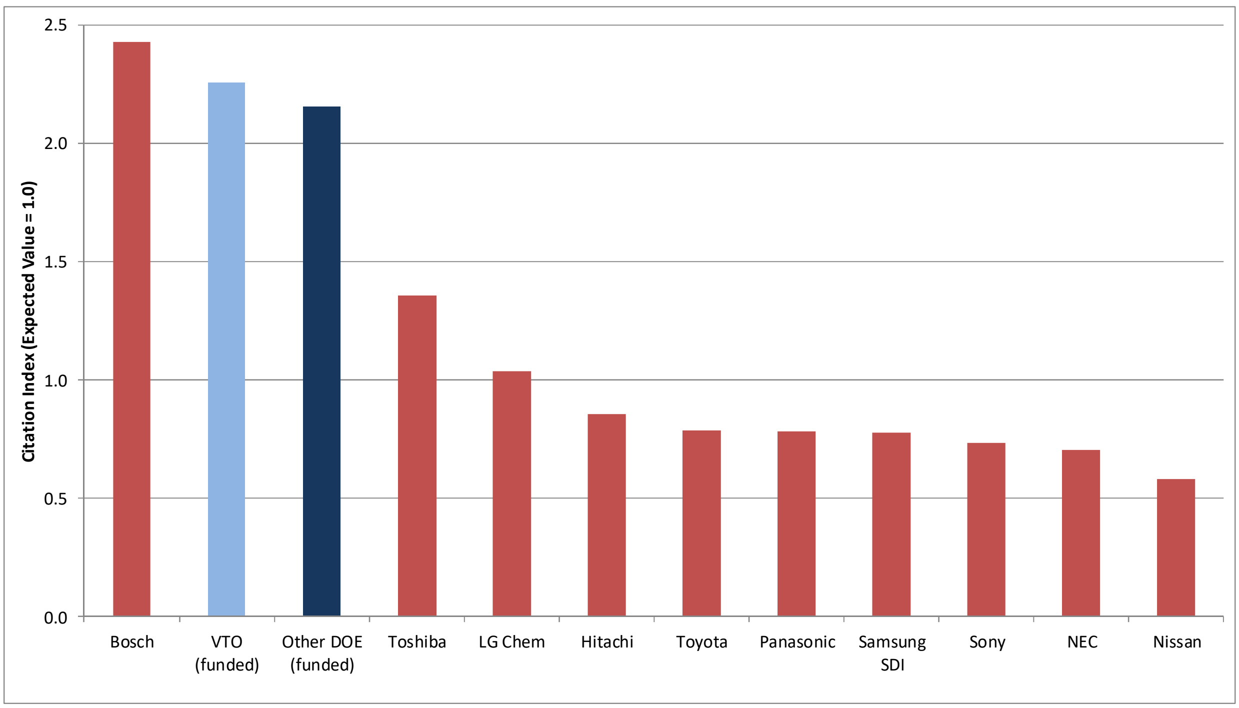
The previous section of the report examines the influence of DOE-funded advanced batteries research upon technological developments associated with leading advanced batteries companies. That analysis was based on tracing backwards from the patents of leading companies to previous generations of research. This section reports the results of an analysis tracing in the opposite direction – starting with VTO-funded (and Other DOE-funded) advanced batteries 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 advanced batteries companies), this section of the report focuses on the broader influence of VTO-funded (and Other DOE-funded) advanced batteries research, both within and beyond the advanced batteries industry. Also, in order to avoid repeating earlier results, the forward tracing concentrates primarily on patents that are linked to DOE-funded advanced batteries research, but are not owned by leading advanced batteries companies.

Organizational Level Results

We first generated Citation Index values for the portfolios of VTO-funded and Other DOE-funded advanced batteries patents. We then compared these Citation Indexes against those of the ten leading advanced batteries companies. The results are shown in Figure 16.

This figure reveals that VTO-funded advanced batteries patents have an average Citation Index of 2.25, showing they have been cited more than twice as frequently as expected by subsequent patents. The Citation Index for Other DOE-funded advanced batteries patents is slightly lower at 2.15, but this still means that these patents have been cited more than twice as frequently as expected. Overall, VTO ranks second in Figure 16, behind only Bosch, while Other DOE is third. There is then a substantial drop to the Citation Index of fourth-placed company (Toshiba with 1.36), suggesting that the portfolios of VTO-funded and Other DOE-funded patents have had a strong influence on subsequent technological developments, compared to the patent portfolios assigned to the leading companies.

Figure 16 - Citation Index for Leading Companies' Advanced Batteries Patents, plus VTO-funded and Other DOE-funded Advanced Batteries Patents



The Citation Index metric measures the overall influence of the DOE-funded advanced batteries patent portfolios, but does not necessarily address the breadth of this influence across technologies. We therefore identified the Cooperative Patent Classifications (CPCs) of the patent families linked via citations to earlier VTO-funded (and Other DOE-funded) advanced batteries patent families.[13] These CPCs reflect the influence of DOE-funded research across technologies.

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

Figure 17 shows the CPCs with the largest number of patent families linked to VTO-funded advanced batteries patents. The CPCs in this figure are shown in two different colors – i.e. dark green for CPCs related to advanced batteries technology and light green for CPCs beyond advanced batteries technology. In this figure, all but one of the CPCs are within battery technology, the only exception being CPC Y02E 60/122, which relates to capacitors. This suggests that advanced batteries is a relatively self-contained technology, with successive generations of technology building upon earlier batteries research. That said, there are a number of different batteries technologies represented in Figure 17, in particular different electrode materials and battery structures. This reflects the influence of VTO-funded patents across many different areas of batteries technology.

Figure 17 - Number of Patent Families Linked via Citations to Earlier VTO-Funded Advanced Batteries Patents by CPC

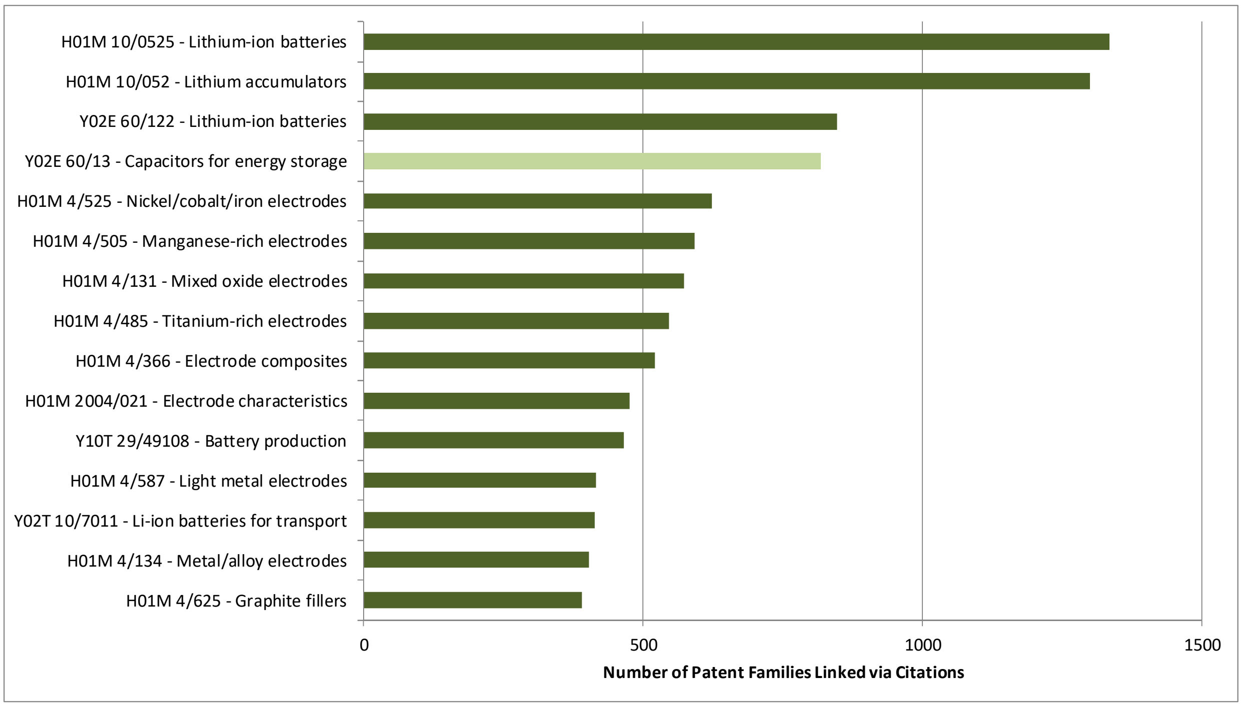


Figure 18 is similar to Figure 17, but is based on patent families linked to Other DOE-funded advanced batteries patents, rather than VTO-funded advanced batteries patents. Again, almost all of these CPCs are related to batteries, the exceptions being Y02E 60/122 (capacitors) and B82Y 30/00 (nanocomposites). These battery CPCs again cover various electrode materials, plus battery production and applications.

Figure 18 - Number of Patent Families Linked via Citations to Earlier Other DOE-Funded Advanced Batteries Patents by CPC

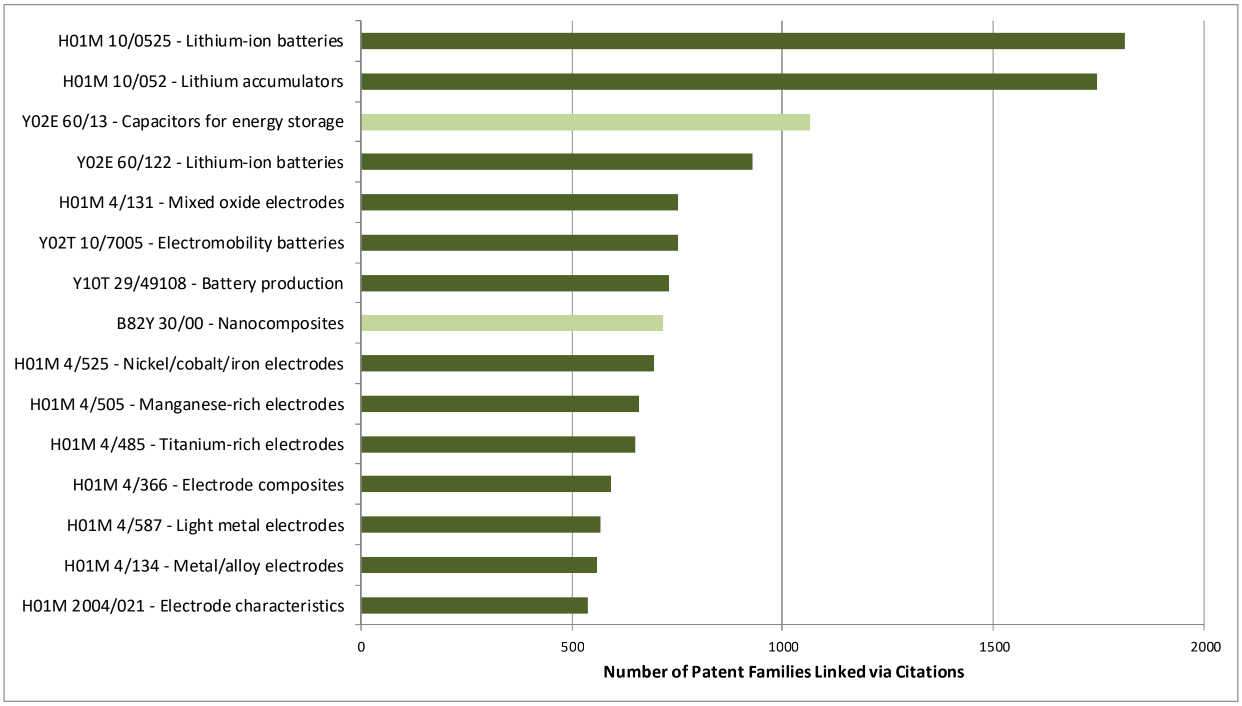
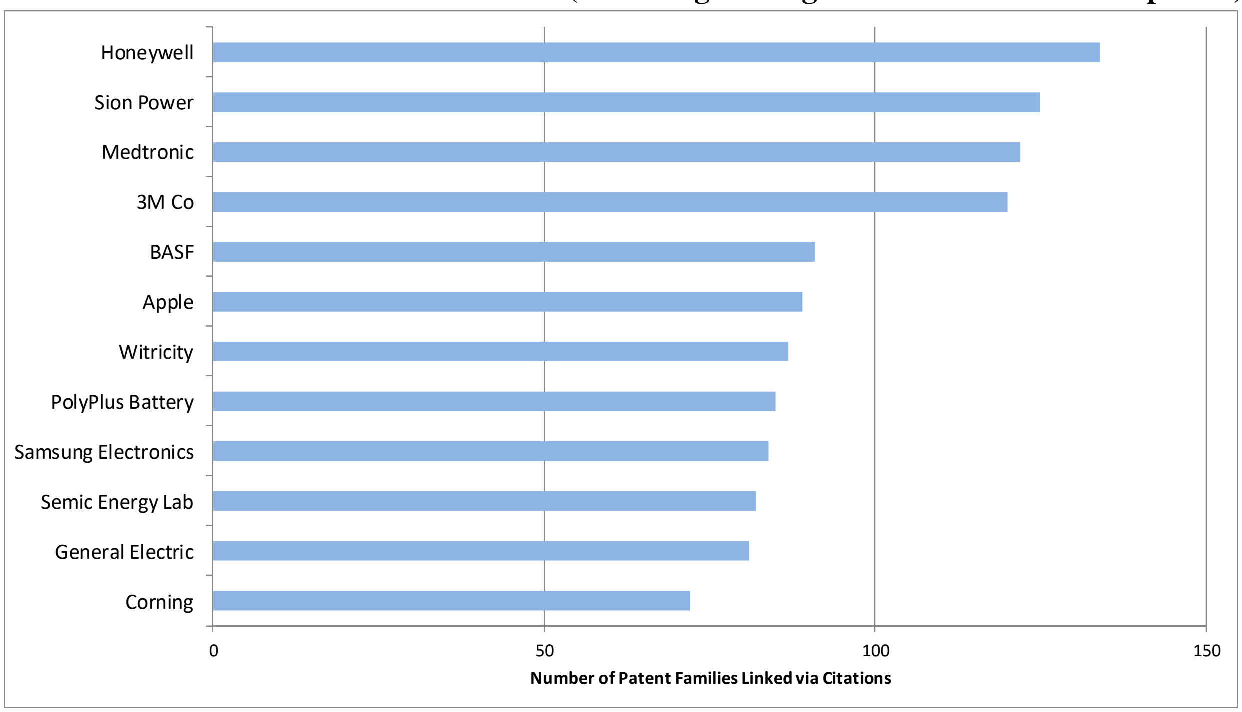


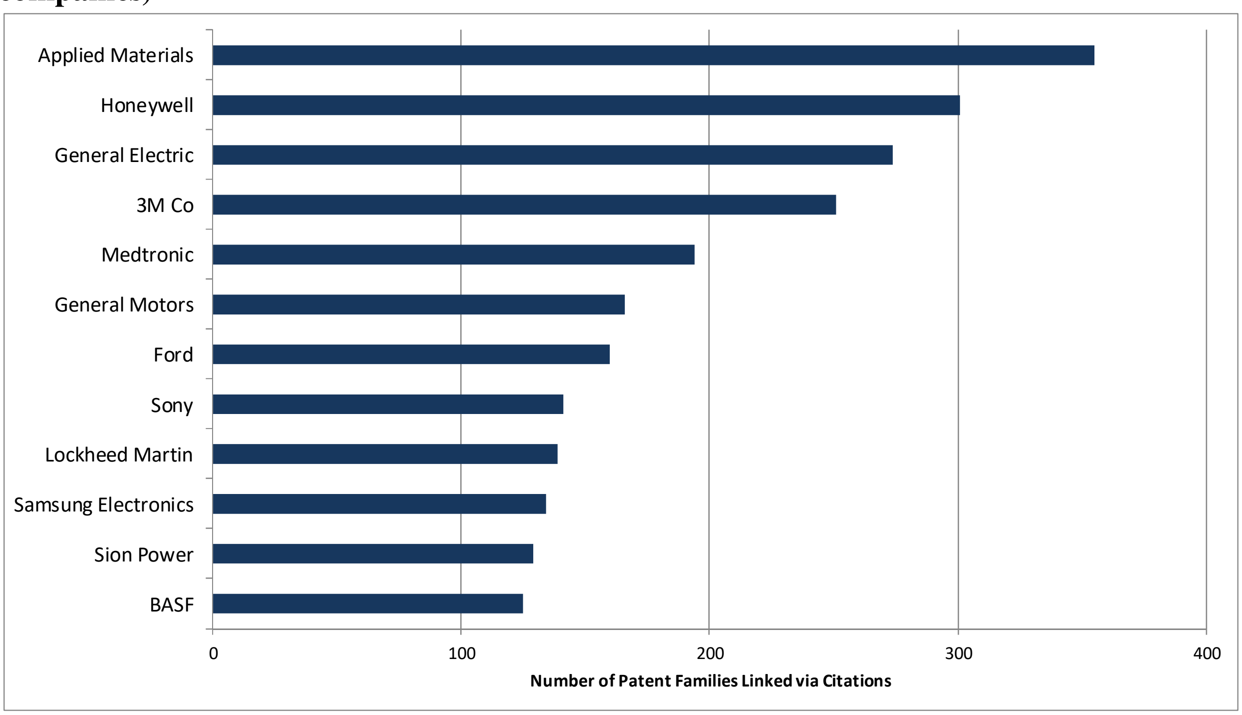
Figure 19 - Organizations with Largest Number of Patent Families Linked via Citations to VTO-funded Advanced Batteries Patents (excluding leading advanced batteries companies)



The organizations with the largest number of patent families linked via citations to earlier VTO-funded advanced batteries patents are shown in Figure 19. To avoid repeating the results from earlier, this figure excludes the ten leading advanced batteries companies used in the backward tracing element of the analysis. Also, note that Figure 19 includes all patent families assigned to these organizations, not just their patent families describing advanced batteries technology. This figure contains a mix of very large companies with interests in many technologies, plus specialist battery companies (beyond the leading companies included in the backward tracing element of the analysis). Examples of the former include Honeywell, 3M, BASF and Apple. Meanwhile, examples of the latter include Sion Power and PolyPlus Battery. This reflects the breadth of influence of VTO-funded advanced batteries research on technologies developed by a wide range of organizations. For instance, Honeywell is at the head of Figure 19, with a total of 134 patent families linked via citations to earlier VTO-funded advanced batteries patent families. These Honeywell patent families are directed to a variety of technologies, including batteries and materials, plus also imaging systems. Sion Power is in second place in Figure 19 with 125 patent families linked to earlier VTO-funded advanced battery patents. These Sion Power patents are more narrowly focused on battery technologies, as would be expected for a specialist battery company.

Figure 20 shows the organizations with the largest number of patent families linked via citations to earlier Other DOE-funded advanced batteries patents. This figure contains a number of the companies featured in Figure 19, which focused on patent families linked to earlier VTO-funded advanced batteries patents. These include Honeywell, 3M, Medtronic, General Electric and Sion Power. One notable difference between the two figures is the presence of large automakers Ford and General Motors in Figure 20. Both of these companies have numerous patent families related to batteries for hybrid electric vehicles that are linked via citations to earlier Other DOE-funded advanced batteries patents.

Figure 20 - Organizations with Largest Number of Patent Families Linked via Citations to Other DOE-funded Advanced Batteries Patents (excluding leading advanced batteries companies)



Patent Level Results

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

The simplest way of identifying high-impact VTO-funded advanced batteries patents is via overall Citation Indexes. The VTO-funded patents with the highest Citation Index values are shown in Table 9, with selected patents also presented in Figure 21. The patents in this table are a mix of 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.

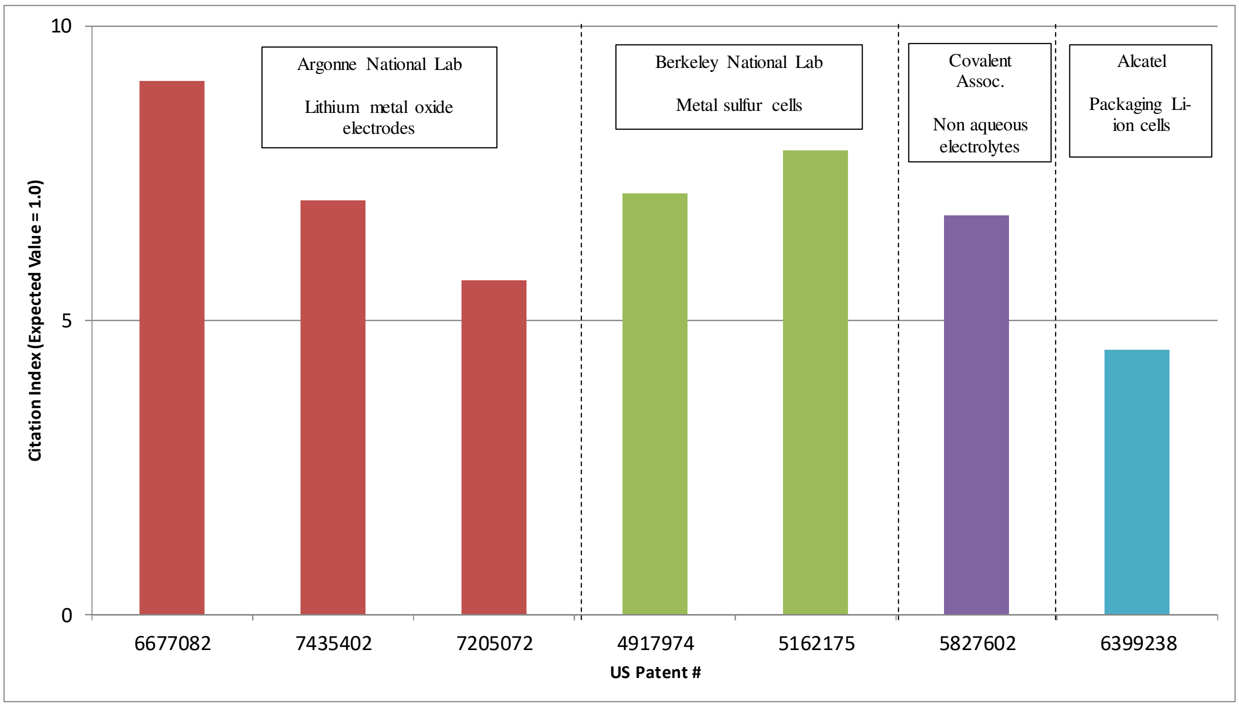
Table 9 – List of Highly Cited VTO-Funded Advanced Batteries Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
6677082	2004	117	9.05	Univ Chicago (ANL)	Lithium metal oxide electrodes for lithium cells and batteries
5162175	1992	194	7.88	Univ California (LBNL)	Cell for making secondary batteries
4917974	1990	158	7.14	US Dept of Energy	Lithium/organosulfur redox cell having protective solid electrolyte barrier
7435402	2008	48	7.02	Univ Chicago (ANL)	Method and apparatus for preparation of spherical metal carbonates and lithium metal oxides for lithium rechargeable batteries
5827602	1998	197	6.78	Covalent Associates	Hydrophobic ionic liquids
7205072	2007	63	5.67	Univ Chicago (ANL)	Layered cathode materials for lithium ion rechargeable batteries
6399238	2002	86	4.48	Alcatel	Module configuration
7026074	2006	32	4.01	Univ Chicago (ANL)	Lithium ion battery with improved safety
6221531	2001	72	3.66	Univ Chicago (ANL)	Lithium-titanium-oxide anodes for lithium batteries
5965054	1999	48	3.42	Covalent Associates	Nonaqueous electrolyte for electrical storage devices
7303840	2007	36	3.24	Univ Chicago (ANL)	Manganese oxide composite electrodes for lithium batteries
7390472	2008	21	3.16	NEI Corp	Method of making nanostructured lithium iron phosphate--based powders with an olivine type structure
6730429	2004	32	2.65	Univ Chicago (ANL)	Intermetallic negative electrodes for non-aqueous lithium cells and batteries
5858573	1999	47	2.56	EIC Laboratories	Chemical overcharge protection of lithium and lithium-ion secondary batteries
6297293	2001	40	2.35	TDA Research	Mesoporous carbons and polymers

The patent at the head of Table 9 (US #6,677,082) was issued in 2004, and is assigned to the University of Chicago, through its management of Argonne National Laboratory (ANL). This patent describes a lithium metal oxide electrode, and has been cited as prior art by 117 subsequent patents, more than nine times as many citations as expected. The second and third patents in Table 9 are the LBNL metal-sulfur cell patents (US #5,162,175 and US #4,917,974) discussed earlier in the backward tracing element of the analysis, showing that the influence of these patents extends beyond just the leading advanced batteries companies.

In terms of raw citation counts, the most highly-cited patent in Table 9 is US #5,827,602. This patent is assigned to Covalent Associates and describes ionic liquids for use as non-aqueous electrolytes. It has been cited by 197 subsequent patents, almost seven times as many citations as expected given its age and technology. Table 9 also contains a number of more recent VTO-funded advanced batteries patents. These include ANL patents (US #7,435,402 and US #7,205,072) describing cathode materials with improved capacity and thermal safety.

Figure 21 – Examples of Highly-Cited VTO-funded Advanced Batteries Patents



The Citation Indexes in Table 9 are based on a single generation of citations to VTO-funded advanced batteries patents. Tables 10 and 11 extend this by examining a second generation of citations – i.e. they show the VTO-funded advanced batteries patents linked directly or indirectly 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 advanced batteries technology (i.e. whether they are in the battery universe constructed in the initial step of this project). This provides insights into which VTO-funded patent families have been particularly influential within advanced batteries technology, and which have had a broader impact beyond advanced batteries.

[14] The VTO-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 10 contains older VTO-funded advanced batteries patent families (i.e. with priority dates prior to 2000) linked to the largest number of subsequent patent families. The three patent families at the head of this figure contain the LBNL and Covalent Associates patents with the highest Citation Indexes in Table 9. It is interesting to note that, while the LBNL patent families are linked extensively to subsequent batteries patents, the Covalent family has stronger links to patents families beyond battery technology. The latter is also true of the fourth-place patent family in Table 9. This Alcatel patent family (representative patent US #6,399,238) describes a method for packaging lithium-ion cells, especially for use in electric vehicles. It is linked to 517 subsequent patent families, only 77 of which are related to batteries.

Table 10 - Pre-2000 VTO-funded Advanced Batteries Patent Families Linked via Citations to Largest Number of Subsequent Advanced Batteries/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Battery Fams	Assignee	Title
27025104	1989	5162175	1204	540	Univ California (LBNL)	Cell for making secondary batteries
27052452	1995	5827602	1018	117	Covalent Associates	Hydrophobic ionic liquids
23322874	1989	4917974	990	498	US Dept of Energy	Lithium/organosulfur redox cell having protective solid electrolyte barrier
23824853	1999	6399238	517	77	Alcatel	Module configuration
25428369	1997	5973913	503	104	Covalent Associates	Nonaqueous electrical storage device
22901490	1999	6136476	415	197	3M Co	Methods for making lithium vanadium oxide electrode materials
26785372	1998	6221531	389	261	Univ Chicago (ANL)	Lithium-titanium-oxide anodes for lithium batteries
22985832	1994	5558961	353	101	Univ California (LBNL)	Secondary cell with orthorhombic alkali metal/manganese oxide phase active cathode material
27377167	1998	6528208	266	150	Univ Chicago (ANL)	Anodes for rechargeable lithium batteries
23566622	1999	6297293	263	10	TDA Research	Mesoporous carbons and polymers
22851419	1988	4849309	240	121	US Dept of Energy	Overcharge tolerant high-temperature cells and batteries
24619784	1996	5772934	197	116	W.R. Grace & Co	Process to produce lithium-polymer batteries
24825938	1996	5858573	187	135	EIC Laboratories	Chemical overcharge protection of lithium and lithium-ion secondary batteries

Table 11 contains newer VTO-funded patent families, with priority dates from 2000 onwards. One notable feature of this table is that many of the patent families linked via citations to these VTO-funded families are related to battery technology. In turn, this suggests that these more recent VTO-funded advanced batteries patent families have had a particularly strong influence within battery technology.

The patent family at the head of Table 11 is assigned to the University of Chicago through its management of ANL, and describes lithium metal oxide electrodes. This family contains the VTO-funded patent with the highest Citation Index in Table 9 (US #6,677,082). The family is linked via citations to 340 subsequent patent families, 236 of which are related to battery technology. It is one of numerous ANL patents in Table 11. Other organizations with patent families in this table include Arizona State University (for polymeric electrolytes), Johnson Controls (for a lithium-based vehicle battery) and Envia (for high-capacity anode materials).

Table 11 - Post-1999 VTO-funded Advanced Batteries Patent Families Linked via Citations to Largest Number of Subsequent Advanced Batteries/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Battery Fams	Assignee	Title
26908237	2000	6677082	340	236	Univ Chicago (ANL)	Lithium metal oxide electrodes for lithium cells and batteries
46205005	2002	7205072	137	88	Univ Chicago (ANL)	Layered cathode materials for lithium ion rechargeable batteries
27732681	2002	7026074	107	65	Univ Chicago (ANL)	Lithium ion battery with improved safety
26906914	2000	7504473	91	56	Arizona State Univ	Conductive polymeric compositions for lithium batteries
36588383	2004	7507503	81	40	Univ Chicago (ANL)	Long life lithium batteries with stabilized electrodes
28677817	2002	7498102	77	31	Univ Chicago (ANL)	Nonaqueous liquid electrolyte
34549396	2003	8632898	76	30	Johnson Controls	Battery system including batteries that have a plurality of positive terminals and a plurality of negative terminals
43970717	2009	9190694	66	46	Envia Systems	High capacity anode materials for lithium ion batteries
39529966	2002	7390472	50	36	NEI Corp	Method of making nanostructured lithium iron phosphate--based powders with an olivine type structure
41415096	2007	8323820	41	30	PolyPlus Battery	Catholytes for aqueous lithium/air battery cells
38801947	2006	8563168	35	25	Univ California (LBNL)	High elastic modulus polymer electrolytes

The tables above identify VTO-funded patent families linked particularly strongly to subsequent technological developments. Table 12 looks in the opposite direction, and identifies highly-cited patents linked to earlier VTO-funded advanced batteries patents. As such, these are examples where VTO-funded advanced batteries research has formed part of the foundation for subsequent high-impact technologies. This table focuses on patent families not owned by the leading advanced batteries companies, since those families were examined in the backward tracing element of the analysis.

The patent at the head of Table 12 (US #7,939,218) is assigned to Nanosys, and describes carbon-based nanowires with a wide range of applications, including in batteries and fuel cells. This Nanosys patent has been cited as prior art by 90 subsequent patents, more than twenty times more citations than expected given its age and technology. Most of the other patents in Table 12 are related to different aspects of battery technology, including electrode coatings (PolyPlus Battery), electrode arrays (BioSource), layered electrodes (Sion Power) and electrode materials (MIT). Two patents in Table 12 from technologies beyond batteries are assigned to Xebec Adsorption (for fuel cells) and Georgia Tech (for supercapacitors). These are examples of VTO-funded advanced batteries patents influencing developments in other technologies.

Table 12 - Highly Cited Patents (not from leading advanced batteries companies) Linked via Citations to Earlier VTO-funded Advanced Batteries Patents

Patent #	Issue Year	# Cites Received	Citation Index	Assignee	Title
7939218	2011	90	20.19	Nanosys	Nanowire structures comprising carbon
7368191	2008	92	16.05	BioSource	Electrode array for use in electrochemical cells
7097925	2006	120	13.58	Xebec Adsorption	High temperature fuel cell power plant
7338734	2008	92	13.57	MIT	Conductive lithium storage electrode
7247408	2007	139	12.50	Sion Power	Lithium anodes for electrochemical cells
7282295	2007	105	12.27	PolyPlus Battery	Protected active metal electrode and battery cell structures with non-aqueous interlayer architecture
7061749	2006	133	10.71	Georgia Inst Tech	Supercapacitor having electrode material comprising single-wall carbon nanotubes and process for making the same
7033406	2006	102	10.10	Eestor Inc	Electrical-energy-storage unit (EESU) utilizing ceramic and integrated-circuit technologies for replacement of electrochemical batteries
6025094	2000	257	9.63	PolyPlus Battery	Protective coatings for negative electrodes

As with the backward tracing element of the analysis, the patent-level results from the forward tracing focus on VTO-funded advanced batteries patents. However, within the forward tracing, we did also identify Other DOE-funded advanced batteries patent families linked to the largest number of subsequent patent families within and beyond advanced batteries technology. These Other DOE-funded advanced batteries families are shown in Table 13.

Lockheed Martin has a number of Other DOE-funded patent families in Table 13, through its management of Oak Ridge National Laboratory (ORNL). These include the patent family at the head of this table (representative patent US #5,338,625) which describes a thin film battery. It is linked via citations to 2,195 subsequent patent families, 635 of which are related to batteries. Other ORNL patent families in Table 13 are related to electrode coatings (representative patent US #5,314,765), thin film battery production (representative patent US #5,445,906), and electrodes with improved temperature resistance (representative patent US #5,705,293). Other organizations with patent families in Table 13 include General Electric (for batteries and ultracapacitors in electric vehicles), Los Alamos National Laboratory (for molten salt lithium cells), and Associated Universities (Brookhaven National Laboratory) for thin film batteries.

Table 13 - Other DOE-funded Advanced Batteries Patent Families Linked via Citations to Largest Number of Subsequent Advanced Batteries/Other Patent Families

Family #	Priority Year	Rep. Patent #	# Linked Families	# Linked Battery Fams	Assignee	Title
25445586	1992	5338625	2195	635	Lockheed Martin (ORNL)	Thin film battery and method for making same
24625016	1996	5710699	1784	91	General Electric	Power electronic interface circuits for batteries and ultracapacitors in electric vehicles and battery storage systems
22476652	1993	5314765	1488	669	Lockheed Martin (ORNL)	Protective lithium ion conducting ceramic coating for lithium metal anodes and associate method
23093045	1994	5445906	1274	383	Lockheed Martin (ORNL)	Method and system for constructing a rechargeable battery and battery structures formed with the method
26865884	1980	4405416	1054	160	Los Alamos Natl Lab	Molten salt lithium cells
26842654	1992	5441831	814	421	Associated Univ (BNL)	Cells having cathodes containing polycarbon disulfide materials
25011229	1991	5219673	808	62	Argonne Natl Lab	Cell structure for electrochemical devices and method of making same
25121345	1997	5705293	726	255	Lockheed Martin (ORNL)	Solid state thin film battery having a high temperature lithium alloy anode
22330747	1993	5932185	720	32	Univ California (LLNL)	Method for making thin carbon foam electrodes
21925940	1997	6242132	588	233	UT-Battelle (ORNL)	Silicon-tin oxynitride glassy composition and use as anode for lithium-ion battery
22240687	1987	4832463	581	163	Tufts College	Thin film ion conducting coating
24620996	1996	5830600	494	288	SRI International	Nonflammable/self-extinguishing electrolytes for batteries
25343921	1992	5252413	464	228	EIC Laboratories	Solid polymer electrolyte lithium batteries

Overall, the forward tracing element of the analysis shows that VTO-funded and Other DOE-funded advanced batteries research has had a strong influence on subsequent technologies. This influence can be seen most strongly within advanced batteries technology, with batteries patents from a range of companies linked to earlier DOE-funded patents. The influence also extends into related technologies, including ultracapacitors, nanocomposites, and electric vehicles.

5.0 Conclusions

This report describes the results of an analysis tracing links between advanced batteries research funded by DOE (VTO plus Other DOE) and subsequent developments both within and beyond advanced batteries technology. This tracing is carried out both backwards and forwards in time. The purpose of the backward tracing is to determine the extent to which VTO-funded (and Other DOE-funded) research forms a foundation for the technologies developed by leading advanced batteries companies. The purpose of the forward tracing is to examine the influence of VTO-funded (and Other DOE-funded) advanced batteries patents upon subsequent developments, both within and outside advanced batteries technology.

The backward tracing element of the analysis shows that VTO-funded and Other DOE-funded advanced batteries patents have had a strong influence on subsequent innovations associated with the leading advanced batteries companies. This influence can be seen both over time, and across these leading companies. Meanwhile, the forward tracing shows that this influence can be seen both within advanced batteries technology, and in related technologies such as ultracapacitors, nanocomposites, and electric vehicles.

Overall, the analysis presented in this report reveals that advanced batteries research funded by VTO, and by DOE in general, has had a significant influence on subsequent developments, both within and beyond advanced batteries technology. This influence can be seen on innovations associated with the leading advanced batteries companies, plus innovations associated with large companies across a range of other technologies.

Appendix A. VTO-funded Advanced Batteries Patents used in the Analysis

Patent #	Application Year	Issue / Publication Year	Original Assignees	Title
4849309	1988	1989	US DEPT OF ENERGY	OVERCHARGE TOLERANT HIGH-TEMPERATURE CELLS AND BATTERIES
4917974	1989	1990	US DEPT OF ENERGY	LITHIUM/ORGANOSULFUR REDOX CELL HAVING PROTECTIVE SOLID ELECTROLYTE BARRIERFORMED ON ANODE AND METHOD OF MAKING SAME
WO1990013150	1990	1990	UNIV CALIFORNIA	LITHIUM/ORGANOSULFUR REDOX CELL HAVING PROTECTIVE SOLID ELECTROLYTE BARRIER FORMED ON ANODE AND METHOD OF MAKING SAME
5162175	1991	1992	UNIV CALIFORNIA	CELL FOR MAKING SECONDARY BATTERIES
5376475	1994	1994	OVONIC BATTERY CO	AQUEOUS LITHIUM-HYDROGEN ION RECHARGEABLE BATTERY
5403787	1994	1995	CORNING INC	EXTRUDED CERAMIC HONEYCOMB AND METHOD
EP0669294	1995	1995	CORNING INC	EXTRUDED CERAMIC HONEYCOMB AND METHOD.
WO1995025355	1995	1995	OVONIC BATTERY CO	AN AQUEOUS LITHIUM-HYDROGEN ION RECHARGEABLE BATTERY
5529858	1994	1996	SAFT AMERICA INC	HERMETICALLY SEALED THERMOCOMPRESSION FEEDTHROUGH AND PERIPHERAL SEAL FOR HIGH TEMPERATURE LITHIUM BASED BATTERY APPLICATIONS
5558961	1994	1996	UNIV CALIFORNIA	SECONDARY CELL WITH ORTHORHOMBIC ALKALI METAL/MANGANESE OXIDE PHASE ACTIVE CATHODE MATERIAL
5578394	1996	1996	SAFT AMERICA INC	SEAL ASSEMBLY FOR HIGH TEMPERATURE BIPOLAR LI ALLOY METAL SULFIDE BATTERY
WO1996011486	1995	1996	MAXWELL TECHNOLOGIES INC	HIGH PERFORMANCE DOUBLE LAYER CAPACITORS INCLUDING ALUMINUM CARBON COMPOSITE ELECTRODES
5621607	1994	1997	MAXWELL TECHNOLOGIES INC	HIGH PERFORMANCE DOUBLE LAYER CAPACITORS INCLUDING ALUMINUM CARBON COMPOSITE

				ELECTRODES
5677082	1996	1997	UCAR CARBON TECH CORP	COMPACTED CARBON FOR ELECTROCHEMICAL CELLS
5698147	1996	1997	W R GRACE & CO	FABRICATION METHODS FOR LOW IMPEDANCE LITHIUM POLYMER ELECTRODES
EP0750796	1995	1997	OVONIC BATTERY CO	AN AQUEOUS LITHIUM-HYDROGEN ION RECHARGEABLE BATTERY
EP0786142	1995	1997	MAXWELL TECHNOLOGIES INC	HIGH PERFORMANCE DOUBLE LAYER CAPACITORS INCLUDING ALUMINUM CARBON COMPOSITE ELECTRODES
EP0810679	1996	1997	UCAR CARBON TECH CORP	COMPACTED CARBON, SELECTED FROM GRAPHITE AND COKE, HAVING A HIGH R-RAY DENSITY, FOR ELECTROCHEMICAL CELLS
WO1997044177	1997	1997	W R GRACE & CO	EXTRUSION OF ELECTRODE MATERIAL BY LIQUID INJECTION INTO EXTRUDER BARREL
WO1997044290	1997	1997	W R GRACE & CO	FABRICATION METHODS FOR LOW IMPEDANCE LITHIUM POLYMER ELECTRODES
WO1997044841	1997	1997	W R GRACE & CO	IMPROVED ELECTRODE COMPOSITIONS
WO1997044843	1997	1997	W R GRACE & CO	PROCESS TO PRODUCE LITHIUM-POLYMER BATTERIES
WO1997044847	1997	1997	W R GRACE & CO	CONTINUOUS PROCESS TO PRODUCE LITHIUM-POLYMER BATTERIES AND BATTERY COMPONENTS FORMED THEREBY
5725822	1996	1998	W R GRACE & CO	EXTRUSION OF ELECTRODE MATERIAL BY LIQUID INJECTION INTO EXTRUDER BARREL
5749927	1996	1998	W R GRACE & CO	CONTINUOUS PROCESS TO PRODUCE LITHIUM-POLYMER BATTERIES
5756062	1996	1998	UCAR CARBON TECH CORP	CHEMICALLY MODIFIED GRAPHITE FOR ELECTROCHEMICAL CELLS
5766796	1997	1998	EIC LABORATORIES INC	PASSIVATION-FREE SOLID STATE BATTERY
5772934	1996	1998	W R GRACE & CO	PROCESS TO PRODUCE LITHIUM-POLYMER BATTERIES
5777428	1996	1998	MAXWELL TECHNOLOGIES INC	ALUMINUM-CARBON COMPOSITE ELECTRODE
5827331	1997	1998	W R GRACE & CO	ELECTRODE COMPOSITIONS
5827602	1997	1998	COVALENT	HYDROPHOBIC IONIC LIQUIDS

			ASSOCIATES INC	
EP0825663	1997	1998	EIC LABORATORIES INC	CHEMICAL OVERCHARGE PROTECTION OF LITHIUM AND LITHIUM-ION SECONDARY BATTERIES
EP0871232	1998	1998	VARTA BATTERIE	LITHIUM ION BATTERY
EP0880190	1998	1998	NBT GMBH	MULTICELL ACCUMULATOR
WO1998015962	1997	1998	MAXWELL TECHNOLOGIES INC	MULTI-ELECTRODE DOUBLE LAYER CAPACITOR
5858573	1996	1999	EIC LABORATORIES INC	CHEMICAL OVERCHARGE PROTECTION OF LITHIUM AND LITHIUM-ION SECONDARY BATTERIES
5862035	1996	1999	MAXWELL TECHNOLOGIES INC	MULTI-ELECTRODE DOUBLE LAYER CAPACITOR HAVING SINGLE ELECTROLYTE SEAL AND ALUMINUM-IMPREGNATED CARBON CLOTH ELECTRODES
5907472	1998	1999	MAXWELL TECHNOLOGIES INC	MULTI-ELECTRODE DOUBLE LAYER CAPACITOR HAVING SINGLE ELECTROLYTE SEAL AND ALUMINUM-IMPREGNATED CARBON CLOTH ELECTRODES
5965054	1997	1999	COVALENT ASSOCIATES INC	NONAQUEOUS ELECTROLYTE FOR ELECTRICAL STORAGE DEVICES
5973913	1997	1999	COVALENT ASSOCIATES INC	NONAQUEOUS ELECTRICAL STORAGE DEVICE
6004697	1997	1999	3M CO; HYDRO-QUEBEC CORP	MODIFIED LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS PRODUCTS AND METHODS
6007944	1998	1999	VARTA BATTERIE	RECHARGEABLE LITHIUM-ION CELL
EP0946954	1997	1999	MAXWELL TECHNOLOGIES INC	MULTI-ELECTRODE DOUBLE LAYER CAPACITOR
WO1999008298	1998	1999	COVALENT ASSOCIATES INC	NONAQUEOUS ELECTRICAL STORAGE DEVICE
WO1999008299	1998	1999	COVALENT ASSOCIATES INC	NONAQUEOUS ELECTROLYTE FOR ELECTRICAL STORAGE DEVICES
WO1999030378	1998	1999	UNIV CHICAGO	MODIFIED LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS; PRODUCTS AND METHODS
WO1999031744	1998	1999	3M CO; HYDRO-QUEBEC CORP	APPARATUS AND METHOD FOR TREATING A CATHODE MATERIAL PROVIDED ON A THIN-FILM SUBSTRATE

6045952	1998	2000	US DEPT OF ENERGY	ELECTROCHEMICAL STORAGE CELL CONTAINING A SUBSTITUTED ANISOLE OR DI-ANISOLE REDOX SHUTTLE ADDITIVE FOR OVERCHARGE PROTECTION AND SUITABLE FOR USE IN LIQUID ORGANIC AND SOLID POLYMER ELECTROLYTES
6059847	1996	2000	MAXWELL TECHNOLOGIES INC	METHOD OF MAKING A HIGH PERFORMANCE ULTRACAPACITOR
6094788	1999	2000	MAXWELL TECHNOLOGIES INC	METHOD OF MAKING A MULTI-ELECTRODE DOUBLE LAYER CAPACITOR HAVING SINGLE ELECTROLYTE SEAL AND ALUMINUM-IMPREGNATED CARBON CLOTH ELECTRODES
6136476	1999	2000	3M CO; HYDRO-QUEBEC CORP	METHODS FOR MAKING LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS
6146783	1998	2000	VARTA BATTERIE	MULTI-CELL STORAGE BATTERY
EP1027712	1998	2000	COVALENT ASSOCIATES INC	NONAQUEOUS ELECTRICAL STORAGE DEVICE
EP1027713	1998	2000	COVALENT ASSOCIATES INC	NONAQUEOUS ELECTROLYTE FOR ELECTRICAL STORAGE DEVICES
EP1038328	1998	2000	3M CO; HYDRO-QUEBEC CORP	APPARATUS AND METHOD FOR TREATING A CATHODE MATERIAL PROVIDED ON A THIN-FILM SUBSTRATE
EP1042831	1998	2000	3M CO; HYDRO-QUEBEC CORP	MODIFIED LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS; PRODUCTS AND METHODS
EP1043795	2000	2000	3M CO; HYDRO-QUEBEC CORP	ELECTROCHEMICAL GENERATOR WITH COMPOSITE ELECTRODE COMPRISING TWO DIFFERENT SOLID ELECTROLYTES AND PROCESS OF MANUFACTURE
EP1047145	2000	2000	NBT GMBH	PROCESS FOR MAKING SECONDARY LITHIUM ELEMENT WITH HEAT-SENSITIVE PROTECTIVE ELEMENT
WO2000044673	2000	2000	3M CO; HYDRO-QUEBEC CORP	METHODS FOR MAKING LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS
6221531	1999	2001	UNIV CHICAGO	LITHIUM-TITANIUM-OXIDE ANODES FOR LITHIUM BATTERIES
6235425	1997	2001	3M CO; HYDRO-QUEBEC CORP	APPARATUS AND METHOD FOR TREATING A CATHODE

				MATERIAL PROVIDED ON A THIN-FILM SUBSTRATE
6297293	1999	2001	TDA RESEARCH INC	MESOPOROUS CARBONS AND POLYMERS
6322928	1999	2001	3M CO	MODIFIED LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS AND PRODUCTS
EP1109237	2000	2001	ALCATEL	MODULE CONFIGURATION
EP1149050	2000	2001	3M CO; HYDRO-QUEBEC CORP	METHODS FOR MAKING LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS
WO2001019904	2000	2001	TDA RESEARCH INC	MESOPOROUS CARBONS AND POLYMERS
WO2001022507	2000	2001	3M CO	MODIFIED LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS, PRODUCTS, AND METHODS
WO2001096446	2001	2001	ARIZONA STATE UNIVERSITY	CONDUCTIVE POLYMERIC COMPOSITIONS FOR LITHIUM BATTERIES
WO2001098396	2001	2001	ARIZONA STATE UNIVERSITY	SOLID POLYMERIC ELECTROLYTES FOR LITHIUM BATTERIES
WO2001099209	2001	2001	ARIZONA STATE UNIVERSITY	ELECTROLYTIC SALTS FOR LITHIUM BATTERIES
6399238	1999	2002	ALCATEL	MODULE CONFIGURATION
6451073	2000	2002	MAXWELL TECHNOLOGIES INC	METHOD OF MAKING A MULTI-ELECTRODE DOUBLE LAYER CAPACITOR HAVING SINGLE ELECTROLYTE SEAL AND ALUMINUM-IMPREGNATED CARBON CLOTH ELECTRODES
6455200	2000	2002	ILLINOIS INST TECHNOLOGY	FLAME-RETARDANT ADDITIVE FOR LI-ION BATTERIES
6492061	2000	2002	3M CO; HYDRO-QUEBEC CORP	COMPOSITE TREATMENT WITH LIPO3
EP1224702	2000	2002	3M CO	MODIFIED LITHIUM VANADIUM OXIDE ELECTRODE MATERIALS, PRODUCTS, AND METHODS
6511517	2000	2003	NBT GMBH	METHOD FOR PRODUCING A SECONDARY LITHIUM CELL COMPRISING A HEAT-SENSITIVE PROTECTIVE MECHANISM
6517591	2000	2003	3M CO; HYDRO-QUEBEC CORP	APPARATUS AND METHOD FOR TREATING A CATHODE MATERIAL PROVIDED ON A THIN-FILM SUBSTRATE
6528208	2000	2003	UNIV CHICAGO	ANODES FOR RECHARGEABLE LITHIUM BATTERIES
EP1289979	2001	2003	ARIZONA STATE UNIVERSITY	ELECTROLYTIC SALTS FOR LITHIUM BATTERIES
EP1292633	2001	2003	ARIZONA STATE UNIVERSITY	CONDUCTIVE POLYMERIC COMPOSITIONS FOR LITHIUM BATTERIES

WO2003083970	2003	2003	QUALLION LLC	NONAQUEOUS LIQUID ELECTROLYTE
WO2003083971	2003	2003	QUALLION LLC	SOLID POLYMER ELECTROLYTE AND METHOD OF PREPARATION
6677082	2001	2004	UNIV CHICAGO	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM CELLS AND BATTERIES
6680143	2001	2004	UNIV CHICAGO	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM CELLS AND BATTERIES
6730429	2001	2004	UNIV CHICAGO	INTERMETALLIC NEGATIVE ELECTRODES FOR NON-AQUEOUS LITHIUM CELLS AND BATTERIES
6737445	2001	2004	TDA RESEARCH INC	MESOPOROUS CARBONS AND POLYMERS
WO2004068616	2004	2004	T J TECHNOLOGIES INC	COMPOSITE MATERIAL AND ELECTRODES MADE THEREFROM
WO2004097964	2004	2004	UNIV CHICAGO	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM BATTERIES
6855460	2002	2005	UNIV CHICAGO	NEGATIVE ELECTRODES FOR LITHIUM CELLS AND BATTERIES
6858345	2002	2005	UNIV CHICAGO	WOUND BIPOLAR LITHIUM POLYMER BATTERIES
EP1595306	2004	2005	T J TECHNOLOGIES INC	COMPOSITE MATERIAL AND ELECTRODES MADE THEREFROM
WO2005043650	2004	2005	JOHNSON CONTROLS CO	BATTERY SYSTEM WITH IMPROVED HEAT DISSIPATION
7012124	2001	2006	ARIZONA STATE UNIVERSITY	SOLID POLYMERIC ELECTROLYTES FOR LITHIUM BATTERIES
7026074	2002	2006	UNIV CHICAGO	LITHIUM ION BATTERY WITH IMPROVED SAFETY
7135252	2003	2006	UCHICAGO ARGONNE LLC	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM CELLS AND BATTERIES
EP1678769	2004	2006	JOHNSON CONTROLS CO	BATTERY SYSTEM WITH IMPROVED HEAT DISSIPATION
WO2006023092	2005	2006	UNIV CHICAGO	METHOD AND APPARATUS FOR PREPARATION OF SPHERICAL METAL CARBONATES AND LITHIUM METAL OXIDES FOR LITHIUM RECHARGEABLE BATTERIES
WO2006028476	2004	2006	UNIV CHICAGO	MANGANESE OXIDE COMPOSITE ELECTRODES FOR LITHIUM BATTERIES
WO2006065605	2005	2006	UNIV CHICAGO	LONG LIFE LITHIUM BATTERIES WITH STABILIZED ELECTRODES
WO2006094069	2006	2006	UNIV CHICAGO	NOVEL REDOX SHUTTLES FOR

				OVERCHARGE PROTECTION OF LITHIUM BATTERIES
WO2006101779	2006	2006	UNIV CHICAGO	NON-AQUEOUS ELECTROLYTES FOR LITHIUM ION BATTERIES
WO2006116251	2006	2006	UNIV CHICAGO	PROCESSES FOR MAKING DENSE, SPHERICAL, ACTIVE MATERIALS FOR LITHIUM-ION CELLS
WO2006135372	2005	2006	FARASIS ENERGY INC	COMBINATORIAL METHOD AND APPARATUS FOR SCREENING ELECTROCHEMICAL MATERIALS
7205072	2003	2007	UNIV CHICAGO	LAYERED CATHODE MATERIALS FOR LITHIUM ION RECHARGEABLE BATTERIES
7303840	2005	2007	UCHICAGO ARGONNE LLC	MANGANESE OXIDE COMPOSITE ELECTRODES FOR LITHIUM BATTERIES
EP1807888	2004	2007	UNIV CHICAGO	MANGANESE OXIDE COMPOSITE ELECTRODES FOR LITHIUM BATTERIES
EP1831951	2005	2007	UCHICAGO ARGONNE LLC	LONG LIFE LITHIUM BATTERIES WITH STABILIZED ELECTRODES
WO2007001345	2005	2007	JOHNSON CONTROLS CO	LITHIUM BATTERY SYSTEM
WO2007041209	2006	2007	MIT	OXIDES HAVING HIGH ENERGY DENSITIES
WO2007050109	2006	2007	JOHNSON CONTROLS CO	LITHIUM BATTERY MANAGEMENT SYSTEM
WO2007078429	2006	2007	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS AND LITHIUM BATTERY SYSTEMS
WO2007086971	2006	2007	JOHNSON CONTROLS CO	DEVICE FOR MONITORING CELL VOLTAGE
WO2007092102	2006	2007	UCHICAGO ARGONNE LLC	LITHIUM-ION BATTERIES WITH INTRINSIC PULSE OVERCHARGE PROTECTION
WO2007142731	2007	2007	UNIV CALIFORNIA	HIGH ELASTIC MODULUS POLYMER ELECTROLYTES
7314682	2004	2008	UCHICAGO ARGONNE LLC	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM BATTERIES
7314684	2004	2008	UCHICAGO ARGONNE LLC	LAYER CATHODE METHODS OF MANUFACTURING AND MATERIALS FOR LI-ION RECHARGEABLE BATTERIES
7326494	2004	2008	T J TECHNOLOGIES INC	COMPOSITE MATERIAL AND ELECTRODES MADE THEREFROM
7358009	2003	2008	UCHICAGO ARGONNE LLC	LAYERED ELECTRODES FOR LITHIUM CELLS AND BATTERIES
7390472	2003	2008	NEI CORP	METHOD OF MAKING NANOSTRUCTURED LITHIUM IRON PHOSPHATE--BASED

				POWDERS WITH AN OLIVINE TYPE STRUCTURE
7390473	2005	2008	NEI CORP	METHOD OF MAKING FINE LITHIUM IRON PHOSPHATE/CARBON-BASED POWDERS WITH AN OLIVINE TYPE STRUCTURE
7390594	2003	2008	UCHICAGO ARGONNE LLC	ANODE MATERIAL FOR LITHIUM BATTERIES
7395163	2007	2008	UNIVERSITY OF MONTANA	METHOD OF DETECTING SYSTEM FUNCTION BY MEASURING FREQUENCY RESPONSE
7435402	2004	2008	UCHICAGO ARGONNE LLC	METHOD AND APPARATUS FOR PREPARATION OF SPHERICAL METAL CARBONATES AND LITHIUM METAL OXIDES FOR LITHIUM RECHARGEABLE BATTERIES
7465520	2004	2008	UCHICAGO ARGONNE LLC	NICKEL-TITANIUM-PHOSPHATE CATHODES
7468223	2005	2008	UCHICAGO ARGONNE LLC	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM CELLS AND BATTERIES
EP1878085	2005	2008	JOHNSON CONTROLS CO	LITHIUM BATTERY SYSTEM
EP1902490	2006	2008	JOHNSON CONTROLS CO	LITHIUM BATTERY MANAGEMENT SYSTEM
EP1977263	2006	2008	JOHNSON CONTROLS CO	DEVICE FOR MONITORING CELL VOLTAGE
WO2008016990	2007	2008	ADA TECHNOLOGIES INC	HIGH PERFORMANCE ULTRACAPACITORS WITH CARBON NANOMATERIALS AND IONIC LIQUIDS
WO2008054547	2007	2008	UCHICAGO ARGONNE LLC	SURFACE STABILIZED ELECTRODES FOR LITHIUM BATTERIES
WO2008060701	2007	2008	ELTRON RESEARCH INC	SYNTHETIC PROCESS FOR PREPARATION OF HIGH SURFACE AREA ELECTROACTIVE COMPOUNDS FOR BATTERY APPLICATIONS
WO2008138003	2008	2008	UNIV CALIFORNIA	HIGH-DISCHARGE-RATE LITHIUM ION BATTERY
WO2008157067	2008	2008	UNIV CALIFORNIA	SOLID SOLUTION LITHIUM ALLOY CERMET ANODES
7473491	2003	2009	QUALLION LLC	ELECTROLYTE FOR ELECTROCHEMICAL CELL
7498102	2002	2009	QUALLION LLC	NONAQUEOUS LIQUID ELECTROLYTE
7504473	2001	2009	ARIZONA STATE UNIVERSITY	CONDUCTIVE POLYMERIC COMPOSITIONS FOR LITHIUM BATTERIES
7507503	2005	2009	UCHICAGO ARGONNE LLC	LONG LIFE LITHIUM BATTERIES WITH STABILIZED ELECTRODES

7527899	2001	2009	ARIZONA STATE UNIVERSITY	ELECTROLYTIC ORTHOBORATE SALTS FOR LITHIUM BATTERIES
7588859	2004	2009	UNIV CHICAGO	ELECTROLYTE FOR USE IN ELECTROCHEMICAL DEVICES
7633267	2005	2009	FARASIS ENERGY INC	APPARATUS FOR COMBINATORIAL SCREENING OF ELECTROCHEMICAL MATERIALS
7635536	2005	2009	UCHICAGO ARGONNE LLC	MANGANESE OXIDE COMPOSITE ELECTRODES FOR LITHIUM BATTERIES
WO2009073258	2008	2009	TIAX LLC	NANO-SIZED SILICON
WO2009092058	2009	2009	SEEO INC	GEL POLYMER ELECTROLYTES FOR BATTERIES
WO2009120872	2009	2009	ADA TECHNOLOGIES INC	HIGH PERFORMANCE BATTERIES WITH CARBON NANOMATERIALS AND IONIC LIQUIDS
WO2009137508	2009	2009	ADA TECHNOLOGIES INC	HIGH PERFORMANCE CARBON NANOCOMPOSITES FOR ULTRACAPACITORS
7675293	2006	2010	BATTELLE ENERGY ALLIANCE LLC	METHOD AND APPARATUS FOR IN-SITU CHARACTERIZATION OF ENERGY STORAGE AND ENERGY CONVERSION DEVICES
7732096	2006	2010	UCHICAGO ARGONNE LLC	LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM BATTERIES
7790308	2009	2010	UCHICAGO ARGONNE LLC	MANGANESE OXIDE COMPOSITE ELECTRODES FOR LITHIUM BATTERIES
7851092	2006	2010	UCHICAGO ARGONNE LLC	REDOX SHUTTLES FOR OVERCHARGE PROTECTION OF LITHIUM BATTERIES
EP2240975	2009	2010	SEEO INC; UNIV CALIFORNIA	GEL POLYMER ELECTROLYTES FOR BATTERIES
WO2010005686	2009	2010	POLYPLUS BATTERY CO	AQUEOUS LITHIUM/AIR BATTERY CELLS
WO2010132279	2010	2010	3M CO	LOW ENERGY MILLING METHOD, LOW CRYSTALLINITY ALLOY, AND NEGATIVE ELECTRODE COMPOSITION
WO2010135248	2010	2010	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
WO2010138176	2010	2010	OPTODOT CORP	BATTERIES UTILIZING ELECTRODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
WO2010138177	2010	2010	OPTODOT CORP	LITHIUM BATTERIES UTILIZING NANOPOROUS SEPARATOR LAYERS
WO2010138178	2010	2010	OPTODOT CORP	BATTERIES UTILIZING

				CATHODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
WO2010138179	2010	2010	OPTODOT CORP	BATTERIES UTILIZING ANODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
WO2010144834	2010	2010	UNIVERSITY OF MONTANA	METHOD OF ESTIMATING PULSE RESPONSE USING AN IMPEDANCE SPECTRUM
WO2010144857	2010	2010	UNIVERSITY OF MONTANA	METHOD OF DETECTING SYSTEM FUNCTION BY MEASURING FREQUENCY RESPONSE
7919207	2008	2011	UCHICAGO ARGONNE LLC	ANODE MATERIAL FOR LITHIUM BATTERIES
7968231	2006	2011	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS AND LITHIUM BATTERY SYSTEMS
7968235	2004	2011	UCHICAGO ARGONNE LLC	LONG LIFE LITHIUM BATTERIES WITH STABILIZED ELECTRODES
8062792	2006	2011	UCHICAGO ARGONNE LLC	PROCESSES FOR MAKING DENSE, SPHERICAL ACTIVE MATERIALS FOR LITHIUM-ION CELLS
8080340	2009	2011	UCHICAGO ARGONNE LLC	MANGANESE OXIDE COMPOSITE ELECTRODES FOR LITHIUM BATTERIES
EP2273517	2010	2011	DELPHI TECHNOLOGIES INC	SHAPEABLE SHORT-RESISTANT CAPACITOR
EP2301105	2009	2011	POLYPLUS BATTERY CO	AQUEOUS LITHIUM/AIR BATTERY CELLS
EP2352185	2004	2011	JOHNSON CONTROLS CO	BATTERY CONTAINER WITH IMPROVED HEAT DISSIPATION
EP2360756	2004	2011	JOHNSON CONTROLS CO	BATTERY CELL WITH IMPROVED THERMAL AND ELECTRICAL CONDUCTIVITY
EP2380228	2010	2011	FLORIDA STATE UNIVERSITY	CATALYTIC ELECTRODE WITH GRADIENT POROSITY AND CATALYST DENSITY FOR FUEL CELLS
WO2011009124	2010	2011	FLORIDA STATE UNIVERSITY	CATALYTIC ELECTRODE WITH GRADIENT POROSITY AND CATALYST DENSITY FOR FUEL CELLS
WO2011028804	2010	2011	UT-BATTELLE LLC	SULFUR-CARBON NANOCOMPOSITES AND THEIR APPLICATION AS CATHODE MATERIALS IN LITHIUM-SULFUR BATTERIES
WO2011031371	2010	2011	BATTELLE MEMORIAL INSTITUTE	HIGH-ENERGY METAL AIR BATTERIES
WO2011037688	2010	2011	ALLIANCE FOR SUSTAINABLE ENERGY LLC	METHOD OF FABRICATING ELECTRODES INCLUDING HIGH-CAPACITY, BINDER-FREE

				ANODES FOR LITHIUM-ION BATTERIES
WO2011041094	2010	2011	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS, METHODS AND COMPUTER READABLE MEDIA FOR ESTIMATING CAPACITY LOSS IN RECHARGEABLE ELECTROCHEMICAL CELLS
WO2011044310	2010	2011	MILTEC CORP	ACTINIC AND ELECTRON BEAM RADIATION CURABLE ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
WO2011056847	2010	2011	ENVIA SYSTEMS INC	HIGH CAPACITY ANODE MATERIALS FOR LITHIUM ION BATTERIES
WO2011059794	2010	2011	UCHICAGO ARGONNE LLC	AUTOGENIC PRESSURE REACTIONS FOR BATTERY MATERIALS MANUFACTURE
WO2011062998	2010	2011	BATTELLE MEMORIAL INSTITUTE	ANODES FOR LITHIUM ION BATTERIES
WO2011133309	2011	2011	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS, METHODS AND COMPUTER READABLE MEDIA TO MODEL KINETIC PERFORMANCE OF RECHARGEABLE ELECTROCHEMICAL DEVICES
WO2011140131	2011	2011	BATTELLE ENERGY ALLIANCE LLC; QUALTECH SYSTEMS INC; UNIV MONTANA	CROSSTALK COMPENSATION IN ANALYSIS OF ENERGY STORAGE DEVICES
WO2011146670	2011	2011	SEEO INC	HIGH TEMPERATURE LITHIUM CELLS WITH SOLID POLYMER ELECTROLYTES
WO2011149970	2011	2011	UCHICAGO ARGONNE LLC	POLYETHER-FUNCTIONALIZED REDOX SHUTTLE ADDITIVES FOR LITHIUM ION BATTERIES
WO2011153057	2011	2011	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS, METHODS AND COMPUTER READABLE MEDIA FOR MODELING CELL PERFORMANCE FADE OF RECHARGEABLE ELECTROCHEMICAL DEVICES
WO2011153105	2011	2011	UNIV CALIFORNIA	SI COMPOSITE ELECTRODE WITH LI METAL DOPING FOR ADVANCED LITHIUM-ION BATTERY
8105719	2011	2012	UCHICAGO ARGONNE LLC	ANODE MATERIAL FOR LITHIUM BATTERIES
8110948	2009	2012	UT-BATTELLE LLC	POWER CONVERSION APPARATUS AND METHOD
8124280	2007	2012	UCHICAGO ARGONNE LLC	INTERMETALLIC ELECTRODES FOR LITHIUM BATTERIES
8148011	2007	2012	UCHICAGO	SURFACE STABILIZED

			ARGONNE LLC	ELECTRODES FOR LITHIUM BATTERIES
8150643	2008	2012	BATTELLE ENERGY ALLIANCE LLC; QUALTECH SYSTEMS INC; UNIV MONTANA	METHOD OF DETECTING SYSTEM FUNCTION BY MEASURING FREQUENCY RESPONSE
8168325	2007	2012	UCHICAGO ARGONNE LLC	LITHIUM BASED ELECTROCHEMICAL CELL SYSTEMS HAVING A DEGASSING AGENT
8173285	2006	2012	JOHNSON CONTROLS CO	LITHIUM BATTERY MANAGEMENT SYSTEM
8221853	2009	2012	UNIV CALIFORNIA	MICROWAVE PLASMA CVD OF NANO STRUCTURED TIN/CARBON COMPOSITES
8223472	2008	2012	SANDIA CORP	NORBORNYLENE-BASED POLYMER SYSTEMS FOR DIELECTRIC APPLICATIONS
8236446	2009	2012	ADA TECHNOLOGIES INC	HIGH PERFORMANCE BATTERIES WITH CARBON NANOMATERIALS AND IONIC LIQUIDS
8248030	2008	2012	JOHNSON CONTROLS CO	DEVICE FOR MONITORING CELL VOLTAGE
8268197	2008	2012	SEEO INC	SOLID ELECTROLYTE MATERIAL MANUFACTURABLE BY POLYMER PROCESSING METHODS
8268481	2008	2012	TIAX LLC	NANO-SIZED SILICON
8277683	2009	2012	UCHICAGO ARGONNE LLC	NANO-SIZED STRUCTURED LAYERED POSITIVE ELECTRODE MATERIALS TO ENABLE HIGH ENERGY DENSITY AND HIGH RATE CAPABILITY LITHIUM BATTERIES
8277691	2009	2012	ADA TECHNOLOGIES INC	HIGH PERFORMANCE CARBON NANOCOMPOSITES FOR ULTRACAPACITORS
8283074	2008	2012	UCHICAGO ARGONNE LLC	ELECTROLYTE SALTS FOR NONAQUEOUS ELECTROLYTES
8284539	2007	2012	ADA TECHNOLOGIES INC	HIGH PERFORMANCE ULTRACAPACITORS WITH CARBON NANOMATERIALS AND IONIC LIQUIDS
8287772	2009	2012	3M CO	LOW ENERGY MILLING METHOD, LOW CRYSTALLINITY ALLOY, AND NEGATIVE ELECTRODE COMPOSITION
8313721	2010	2012	UCHICAGO ARGONNE LLC	LITHIUM-OXYGEN (AIR) ELECTROCHEMICAL CELLS AND BATTERIES
8323820	2009	2012	POLYPLUS BATTERY CO	CATHOLYTES FOR AQUEOUS LITHIUM/AIR BATTERY CELLS

8338037	2008	2012	UCHICAGO ARGONNE LLC	POSITIVE ELECTRODE FOR A LITHIUM BATTERY
EP2429744	2010	2012	3M CO	LOW ENERGY MILLING METHOD, LOW CRYSTALLINITY ALLOY, AND NEGATIVE ELECTRODE COMPOSITION
EP2433323	2010	2012	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
EP2436061	2010	2012	OPTODOT CORP	BATTERIES UTILIZING ELECTRODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
EP2436063	2010	2012	OPTODOT CORP	LITHIUM BATTERIES UTILIZING NANOPOROUS SEPARATOR LAYERS
EP2436064	2010	2012	OPTODOT CORP	BATTERIES UTILIZING ANODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
EP2486615	2010	2012	MILTEC CORP	ACTINIC AND ELECTRON BEAM RADIATION CURABLE ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
EP2494634	2010	2012	UCHICAGO ARGONNE LLC	AUTOGENIC PRESSURE REACTIONS FOR BATTERY MATERIALS MANUFACTURE
EP2497144	2010	2012	ENVIA SYSTEMS INC	HIGH CAPACITY ANODE MATERIALS FOR LITHIUM ION BATTERIES
WO2012016185	2011	2012	UNIVERSITY OF TEXAS	NIOBIUM OXIDE COMPOSITIONS AND METHODS FOR USING SAME
WO2012057752	2010	2012	ALLIANCE FOR SUSTAINABLE ENERGY LLC	PASSIVE SAFETY DEVICE AND INTERNAL SHORT TESTED METHOD FOR ENERGY STORAGE CELLS AND SYSTEMS
WO2012067675	2011	2012	UCHICAGO ARGONNE LLC	ELECTRODE STRUCTURES AND SURFACES FOR LI BATTERIES
WO2012083233	2011	2012	24M TECHNOLOGIES INC	HIGH ENERGY DENSITY REDOX FLOW DEVICE
WO2012096695	2011	2012	BATTELLE MEMORIAL INSTITUTE	GRAPHENE-BASED BATTERY ELECTRODES HAVING CONTINUOUS FLOW PATHS
WO2012118786	2012	2012	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS FOR RECHARGEABLE BATTERIES
WO2012125491	2012	2012	ALLIANCE FOR SUSTAINABLE ENERGY LLC	CALORIMETERS FOR TESTING ENERGY STORAGE SYSTEMS AND POWER ELECTRONICS, METHODS OF MAKING THE SAME AND METHODS OF USE
WO2012138844	2012	2012	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTES FOR LITHIUM-AIR BATTERIES
WO2012151094	2012	2012	UCHICAGO	COMPOSITE MATERIALS FOR

			ARGONNE LLC	BATTERY APPLICATIONS
WO2012177833	2012	2012	BASF CORP	PROCESS FOR SYNTHESIS OF A LAYERED OXIDE CATHODE COMPOSITION
8346495	2010	2013	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS, METHODS AND COMPUTER READABLE MEDIA TO MODEL KINETIC PERFORMANCE OF RECHARGEABLE ELECTROCHEMICAL DEVICES
8352204	2010	2013	BATTELLE ENERGY ALLIANCE LLC	METHOD OF DETECTING SYSTEM FUNCTION BY MEASURING FREQUENCY RESPONSE
8367253	2006	2013	UCHICAGO ARGONNE LLC	LITHIUM-ION BATTERIES WITH INTRINSIC PULSE OVERCHARGE PROTECTION
8383077	2012	2013	UCHICAGO ARGONNE LLC	SURFACE STABILIZED ELECTRODES FOR LITHIUM BATTERIES
8389147	2009	2013	POLYPLUS BATTERY CO	HYDROGELS FOR AQUEOUS LITHIUM/AIR BATTERY CELLS
8407871	2009	2013	DELPHI TECHNOLOGIES INC	METHOD OF MANUFACTURING A SHAPEABLE SHORT-RESISTANT CAPACITOR
8427809	2011	2013	SANDIA CORP	THERMALLY SWITCHABLE DIELECTRICS
8449790	2010	2013	UT-BATTELLE LLC	SOLID LITHIUM ION CONDUCTING ELECTROLYTES AND METHODS OF PREPARATION
8455131	2009	2013	POLYPLUS BATTERY CO	CATHODES AND RESERVOIRS FOR AQUEOUS LITHIUM/AIR BATTERY CELLS
8467197	2010	2013	GENERAL MOTORS CO	SYSTEMS AND METHODS FOR COMPENSATING FOR ELECTRICAL CONVERTER NONLINEARITIES
8467984	2009	2013	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS, METHODS AND COMPUTER READABLE MEDIA FOR ESTIMATING CAPACITY LOSS IN RECHARGEABLE ELECTROCHEMICAL CELLS
8475688	2008	2013	UCHICAGO ARGONNE LLC	LITHIUM BATTERIES USING POLY(ETHYLENE OXIDE)-BASED NON-AQUEOUS ELECTROLYTES
8480922	2008	2013	UNIV CALIFORNIA	SOLID SOLUTION LITHIUM ALLOY CERMET ANODES
8481187	2009	2013	BATTELLE MEMORIAL INSTITUTE	HIGH-ENERGY METAL AIR BATTERIES
8491861	2007	2013	ELTRON RESEARCH INC	SYNTHETIC PROCESS FOR PREPARATION OF HIGH SURFACE AREA ELECTROACTIVE COMPOUNDS

				FOR BATTERY APPLICATIONS
8492030	2006	2013	UCHICAGO ARGONNE LLC	CATHODE MATERIAL FOR LITHIUM BATTERIES
8492033	2010	2013	UCHICAGO ARGONNE LLC	FAST CURE GEL POLYMER ELECTROLYTES
8518568	2007	2013	JOHNSON CONTROLS CO	BATTERY SYSTEM
8521497	2010	2013	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS, METHODS AND COMPUTER READABLE MEDIA FOR MODELING CELL PERFORMANCE FADE OF RECHARGEABLE ELECTROCHEMICAL DEVICES
8529800	2006	2013	MIT	OXIDES HAVING HIGH ENERGY DENSITIES
8551661	2011	2013	UCHICAGO ARGONNE LLC	LONG LIFE LITHIUM BATTERIES WITH STABILIZED ELECTRODES
8552144	2012	2013	UNIV CALIFORNIA	BLOCK COPOLYMER WITH SIMULTANEOUS ELECTRIC AND IONIC CONDUCTION FOR USE IN LITHIUM ION BATTERIES
8557438	2010	2013	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS FOR RECHARGEABLE BATTERY
8563168	2007	2013	UNIV CALIFORNIA	HIGH ELASTIC MODULUS POLYMER ELECTROLYTES
8563174	2007	2013	FARASIS ENERGY INC	SECONDARY BATTERY MATERIAL AND SYNTHESIS METHOD
8568914	2010	2013	UCHICAGO ARGONNE LLC	AUTOGENIC PRESSURE REACTIONS FOR BATTERY MATERIALS MANUFACTURE
8591774	2010	2013	UCHICAGO ARGONNE LLC	METHODS FOR PREPARING MATERIALS FOR LITHIUM ION BATTERIES
8597838	2012	2013	UT-BATTELLE LLC	LITHIUM SULFIDE COMPOSITIONS FOR BATTERY ELECTROLYTE AND BATTERY ELECTRODE COATINGS
8599577	2010	2013	GENERAL MOTORS CO	SYSTEMS AND METHODS FOR REDUCING HARMONIC DISTORTION IN ELECTRICAL CONVERTERS
8609287	2011	2013	UCHICAGO ARGONNE LLC	POLYETHER-FUNCTIONALIZED REDOX SHUTTLE ADDITIVES FOR LITHIUM ION BATTERIES
8614564	2010	2013	GENERAL MOTORS CO	SYSTEMS AND METHODS FOR PROVIDING POWER TO A LOAD BASED UPON A CONTROL STRATEGY
8616475	2013	2013	RETRIEV TECHNOLOGIES INC	RECOVERY OF LITHIUM ION BATTERIES
EP2539956	2011	2013	UCHICAGO ARGONNE LLC	POLYETHER-FUNCTIONALIZED REDOX SHUTTLE ADDITIVES

				FOR LITHIUM ION BATTERIES
EP2599146	2011	2013	UNIVERSITY OF TEXAS	NIOBIUM OXIDE COMPOSITIONS AND METHODS FOR USING SAME
EP2633585	2010	2013	ALLIANCE FOR SUSTAINABLE ENERGY LLC	PASSIVE SAFETY DEVICE AND INTERNAL SHORT TESTED METHOD FOR ENERGY STORAGE CELLS AND SYSTEMS
EP2641289	2011	2013	UCHICAGO ARGONNE LLC	ELECTRODE STRUCTURES AND SURFACES FOR LI BATTERIES
EP2652819	2011	2013	24M TECHNOLOGIES INC	HIGH ENERGY DENSITY REDOX FLOW DEVICE
EP2664023	2011	2013	BATTELLE MEMORIAL INSTITUTE	GRAPHENE-BASED BATTERY ELECTRODES HAVING CONTINUOUS FLOW PATHS
WO2013028252	2012	2013	UCHICAGO ARGONNE LLC	SILICON-CARBONACEOUS ENCAPSULATED MATERIALS
WO2013028468	2012	2013	UNIVERSITY OF TEXAS	ANODE MATERIALS FOR LITHIUM-ION BATTERIES
WO2013032593	2012	2013	UCHICAGO ARGONNE LLC	REDOX SHUTTLES FOR OVERCHARGE PROTECTION OF LITHIUM BATTERIES
WO2013052916	2012	2013	UNIV CALIFORNIA	LITHIUM METAL DOPED ELECTRODES FOR LITHIUM-ION RECHARGEABLE CHEMISTRY
WO2013056074	2012	2013	WAYNE STATE UNIV	COMPOSITE ANODE FOR LITHIUM ION BATTERIES
WO2013063278	2012	2013	PURDUE RESEARCH FOUNDATION	THERMOGRAPHY FOR BATTERY COMPONENT QUALITY ASSURANCE
WO2013103414	2012	2013	BATTELLE ENERGY ALLIANCE LLC	METHOD, SYSTEM, AND COMPUTER-READABLE MEDIUM FOR DETERMINING PERFORMANCE CHARACTERISTICS OF AN OBJECT UNDERGOING ONE OR MORE ARBITRARY AGING CONDITIONS
WO2013112454	2013	2013	BATTELLE ENERGY ALLIANCE LLC	ELECTRODES INCLUDING A POLYPHOSPHAZENE CYCLOMATRIX, METHODS OF FORMING THE ELECTRODES, AND RELATED ELECTROCHEMICAL CELLS
WO2013116711	2013	2013	UNIV CALIFORNIA	CONDUCTIVE POLYMER COATED SI NANOPARTICLES COMPOSITE AND CURRENT COLLECTORS FOR LITHIUM ION NEGATIVE ELECTRODE
WO2013119273	2012	2013	BATTELLE MEMORIAL INSTITUTE	METHODS AND ENERGY STORAGE DEVICES UTILIZING ELECTROLYTES HAVING SURFACE-SMOOTHING ADDITIVES
WO2013119322	2012	2013	BATTELLE	METHODS AND ELECTROLYTES

			MEMORIAL INSTITUTE	FOR ELECTRODEPOSITION OF SMOOTH FILMS
WO2013147930	2012	2013	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE SYSTEMS HAVING AN ELECTRODE COMPRISING LIXSY
WO2013158307	2013	2013	SOUTHWEST RESEARCH INSTITUTE	ALLOYS OF CLATHRATE ALLOTROPES FOR RECHARGEABLE BATTERIES
WO2013158816	2013	2013	COBASYS LLC	EXPECTED BATTERY LIFE DETERMINATION SYSTEM AND METHOD
WO2013165767	2013	2013	ENVIA SYSTEMS INC	BATTERY DESIGNS WITH HIGH CAPACITY ANODE MATERIALS AND CATHODE MATERIALS
WO2013169826	2013	2013	SEEO INC	COATED PARTICLES FOR LITHIUM BATTERY CATHODES
WO2013173377	2013	2013	UNIV CALIFORNIA	HIGH-RATE OVERCHARGE-PROTECTION SEPARATORS FOR RECHARGEABLE LITHIUM-ION BATTERIES AND THE METHOD OF MAKING THE SAME
WO2013191885	2013	2013	LEYDEN ENERGY INC	ELECTROLYTES INCLUDING FLUORINATED SOLVENTS FOR USE IN ELECTROCHEMICAL CELLS
8632898	2004	2014	JOHNSON CONTROLS CO	BATTERY SYSTEM INCLUDING BATTERIES THAT HAVE A PLURALITY OF POSITIVE TERMINALS AND A PLURALITY OF NEGATIVE TERMINALS
8642214	2011	2014	UCHICAGO ARGONNE LLC	SILICON-CARBONACEOUS ENCAPSULATED MATERIALS
8647773	2011	2014	UNIVERSITY OF TEXAS	NIOBIUM OXIDE COMPOSITIONS AND METHODS FOR USING SAME
8658304	2012	2014	POLYPLUS BATTERY CO	CATHOLYTES FOR AQUEOUS LITHIUM/AIR BATTERY CELLS
8673477	2009	2014	POLYPLUS BATTERY CO	HIGH ENERGY DENSITY AQUEOUS LITHIUM/AIR-BATTERY CELLS
8697291	2010	2014	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTE FOR LITHIUM-ION BATTERY
8703009	2009	2014	UNIV CALIFORNIA	HIGH-DISCHARGE-RATE LITHIUM ION BATTERY
8703310	2012	2014	UNIV CALIFORNIA	HIGH ELASTIC MODULUS POLYMER ELECTROLYTES SUITABLE FOR PREVENTING THERMAL RUNAWAY IN LITHIUM BATTERIES
8703355	2010	2014	FLORIDA STATE UNIVERSITY	CATALYTIC ELECTRODE WITH GRADIENT POROSITY AND CATALYST DENSITY FOR FUEL CELLS
8709279	2011	2014	UCHICAGO ARGONNE LLC	PRODUCTION OF BATTERY GRADE MATERIALS VIA AN OXALATE METHOD

8722226	2010	2014	24M TECHNOLOGIES INC	HIGH ENERGY DENSITY REDOX FLOW DEVICE
8722247	2011	2014	SOUTHWEST RESEARCH INSTITUTE	CLATHRATE ALLOTROPES FOR RECHARGEABLE BATTERIES
8735003	2011	2014	ALLIANCE FOR SUSTAINABLE ENERGY LLC	LITHIUM-ION BATTERIES HAVING CONFORMAL SOLID ELECTROLYTE LAYERS
8758947	2011	2014	BATTELLE MEMORIAL INSTITUTE	GRAPHENE-BASED BATTERY ELECTRODES HAVING CONTINUOUS FLOW PATHS
8762109	2011	2014	BATTELLE ENERGY ALLIANCE LLC	CROSSTALK COMPENSATION IN ANALYSIS OF ENERGY STORAGE DEVICES
8765278	2013	2014	BATTELLE MEMORIAL INSTITUTE	HIGH-ENERGY METAL AIR BATTERIES
8795905	2009	2014	UCHICAGO ARGONNE LLC	ELECTROLYTES FOR LITHIUM ION BATTERIES
8808912	2010	2014	UCHICAGO ARGONNE LLC	SURFACE PROTECTED LITHIUM-METAL-OXIDE ELECTRODES
8834829	2012	2014	UT-BATTELLE LLC	FORMING GAS TREATMENT OF LITHIUM ION BATTERY ANODE GRAPHITE POWDERS
8835027	2008	2014	UCHICAGO ARGONNE LLC	POSITIVE ELECTRODES FOR LITHIUM BATTERIES
8852461	2011	2014	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
8868363	2010	2014	BATTELLE ENERGY ALLIANCE LLC; QUALTECH SYSTEMS INC; UNIV MONTANA	METHOD OF ESTIMATING PULSE RESPONSE USING AN IMPEDANCE SPECTRUM
8871374	2010	2014	UCHICAGO ARGONNE LLC	AMORPHOUS TITANIA/CARBON COMPOSITE ELECTRODE MATERIALS
8871385	2012	2014	BATTELLE ENERGY ALLIANCE LLC	ELECTRODES INCLUDING A POLYPHOSPHAZENE CYCLOMATRIX, METHODS OF FORMING THE ELECTRODES, AND RELATED ELECTROCHEMICAL CELLS
8871391	2013	2014	UT-BATTELLE LLC	LITHIUM SULFIDE COMPOSITIONS FOR BATTERY ELECTROLYTE AND BATTERY ELECTRODE COATINGS
8877390	2011	2014	UCHICAGO ARGONNE LLC	REDOX SHUTTLES FOR LITHIUM ION BATTERIES
8882007	2013	2014	RETRIEV TECHNOLOGIES INC	PROCESS FOR RECOVERING AND REGENERATING LITHIUM CATHODE MATERIAL FROM

				LITHIUM-ION BATTERIES
8889301	2009	2014	SEEO INC	GEL POLYMER ELECTROLYTES FOR BATTERIES
8906542	2012	2014	UCHICAGO ARGONNE LLC	SODIUM CHALCOGENIDE ELECTRODES FOR SODIUM BATTERIES
8906548	2010	2014	MILTEC CORP	ACTINIC AND ELECTRON BEAM RADIATION CURABLE ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
8906551	2012	2014	SOUTHWEST RESEARCH INSTITUTE	ALLOYS OF CLATHRATE ALLOTROPES FOR RECHARGEABLE BATTERIES
8906553	2011	2014	NEI CORP	HIGH VOLTAGE CATHODE MATERIAL FOR LI-ION BATTERIES
EP2684016	2012	2014	ALLIANCE FOR SUSTAINABLE ENERGY LLC	CALORIMETERS FOR TESTING ENERGY STORAGE SYSTEMS AND POWER ELECTRONICS
EP2724397	2012	2014	BASF CORP	PROCESS FOR SYNTHESIS OF A LAYERED OXIDE CATHODE COMPOSITION
EP2745342	2012	2014	UNIVERSITY OF TEXAS	ANODE MATERIALS FOR LITHIUM-ION BATTERIES
EP2769428	2012	2014	BATTELLE MEMORIAL INSTITUTE	METHODS AND ENERGY STORAGE DEVICES UTILIZING ELECTROLYTES HAVING SURFACE-SMOOTHING ADDITIVES
EP2812466	2012	2014	BATTELLE MEMORIAL INSTITUTE	METHODS AND ELECTROLYTES FOR ELECTRODEPOSITION OF SMOOTH FILMS
WO2014007868	2013	2014	UNIV CALIFORNIA	LOW TEMPERATURE SULFUR AND SODIUM METAL BATTERY FOR GRID-SCALE ENERGY STORAGE APPLICATION
WO2014011734	2013	2014	PENN STATE UNIV	DOPED CARBON-SULFUR SPECIES NANOCOMPOSITE CATHODE FOR LI-S BATTERIES
WO2014014913	2013	2014	3M CO	HIGH VOLTAGE CATHODE COMPOSITIONS FOR LITHIUM-ION BATTERIES
WO2014059440	2013	2014	PENN STATE UNIV	SYNTHESIS OF MICRO-SIZED INTERCONNECTED SI-C COMPOSITES
WO2014120970	2014	2014	BATTELLE MEMORIAL INSTITUTE	ORGANOMETALLIC-INORGANIC HYBRID ELECTRODES FOR LITHIUM-ION BATTERIES
WO2014176267	2014	2014	MAXWELL TECHNOLOGIES INC	METHODS FOR SOLID ELECTROLYTE INTERPHASE FORMATION AND ANODE PRE-LITHIATION OF LITHIUM ION CAPACITORS
WO2014186661	2014	2014	MILTEC CORP	ACTINIC AND ELECTRON BEAM

				RADIATION CURABLE WATER BASED ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
8932768	2013	2015	UCHICAGO ARGONNE LLC	CATHODE MATERIAL FOR LITHIUM BATTERIES
8932771	2012	2015	POLYPLUS BATTERY CO	CATHODE ARCHITECTURES FOR ALKALI METAL / OXYGEN BATTERIES
8936882	2011	2015	UCHICAGO ARGONNE LLC	ELECTROLYTE COMPOSITIONS FOR LITHIUM AND LITHIUM-ION BATTERIES
8956688	2012	2015	UT-BATTELLE LLC	AQUEOUS PROCESSING OF COMPOSITE LITHIUM ION ELECTRODE MATERIAL
8962132	2010	2015	GINER INC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING A POROUS SUPPORT AND A SOLID POLYMER ELECTROLYTE INCLUDING A DISPERSED REDUCED NOBLE METAL OR NOBLE METAL OXIDE
8962182	2011	2015	OPTODOT CORP	BATTERIES UTILIZING ANODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
8968940	2011	2015	UCHICAGO ARGONNE LLC	REDOX SHUTTLES FOR HIGH VOLTAGE CATHODES
8968941	2012	2015	UCHICAGO ARGONNE LLC	LI-AIR BATTERIES HAVING ETHER-BASED ELECTROLYTES
8969625	2012	2015	UCHICAGO ARGONNE LLC	METHOD FOR PRODUCING REDOX SHUTTLES
8974959	2009	2015	UCHICAGO ARGONNE LLC	MULTI-COMPONENT INTERMETALLIC ELECTRODES FOR LITHIUM BATTERIES
8980460	2012	2015	BATTELLE MEMORIAL INSTITUTE	METHODS AND ELECTROLYTES FOR ELECTRODEPOSITION OF SMOOTH FILMS
8992794	2011	2015	BASF CORP	PROCESS FOR SYNTHESIS OF A LAYERED OXIDE CATHODE COMPOSITION
8993165	2014	2015	SOUTHWEST RESEARCH INSTITUTE	CLATHRATE ALLOTROPES FOR RECHARGEABLE BATTERIES
8999561	2011	2015	UCHICAGO ARGONNE LLC	MATERIALS FOR ELECTROCHEMICAL DEVICE SAFETY
8999588	2012	2015	UCHICAGO ARGONNE LLC	POSITIVE ELECTRODE FOR A LITHIUM BATTERY
9005808	2012	2015	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS FOR RECHARGEABLE BATTERIES
9005822	2013	2015	UCHICAGO ARGONNE LLC	FUNCTIONAL ELECTROLYTE FOR LITHIUM-ION BATTERIES
9012091	2013	2015	UCHICAGO ARGONNE LLC	ELECTROACTIVE MATERIALS FOR RECHARGEABLE BATTERIES

9012094	2013	2015	A123 SYSTEMS LLC	FLUOROALKYL CONTAINING SALTS COMBINED WITH FLUORINATED SOLVENTS FOR ELECTROLYTES
9012096	2006	2015	UCHICAGO ARGONNE LLC	LONG LIFE LITHIUM BATTERIES WITH STABILIZED ELECTRODES
9023528	2010	2015	UT-BATTELLE LLC	SULFUR-CARBON NANOCOMPOSITES AND THEIR APPLICATION AS CATHODE MATERIALS IN LITHIUM-SULFUR BATTERIES
9029013	2013	2015	UCHICAGO ARGONNE LLC	ELECTROACTIVE COMPOSITIONS WITH POLY(ARYLENE OXIDE) AND STABILIZED LITHIUM METAL PARTICLES
9039788	2009	2015	BATTELLE MEMORIAL INSTITUTE	METHODS FOR MAKING ANODES FOR LITHIUM ION BATTERIES
9054373	2011	2015	UCHICAGO ARGONNE LLC	ANODE MATERIALS FOR LITHIUM ION BATTERIES
9064064	2012	2015	ROBERT BOSCH GMBH	EXPECTED BATTERY LIFE DETERMINATION SYSTEMS AND METHODS
9065093	2012	2015	MIT/UNIV CALIFORNIA/UNIV MICHIGAN	CONTROLLED POROSITY IN ELECTRODES
9065120	2011	2015	OPTODOT CORP	BATTERIES UTILIZING ELECTRODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
9077039	2012	2015	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
9077046	2013	2015	A123 SYSTEMS LLC	ELECTROLYTES INCLUDING FLUORINATED SOLVENTS FOR USE IN ELECTROCHEMICAL CELLS
9093722	2010	2015	UCHICAGO ARGONNE LLC	FUNCTIONALIZED IONIC LIQUID ELECTROLYTES FOR LITHIUM ION BATTERIES
9118047	2011	2015	OPTODOT CORP	BATTERIES UTILIZING CATHODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
9126844	2013	2015	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS FOR RECHARGEABLE BATTERY
9130226	2013	2015	UCHICAGO ARGONNE LLC	SURFACE STABILIZED ELECTRODES FOR LITHIUM BATTERIES
9130241	2013	2015	UCHICAGO ARGONNE LLC	LITHIUM BATTERIES USING POLY(ETHYLENE OXIDE)-BASED NON-AQUEOUS ELECTROLYTES

9142829	2010	2015	ALLIANCE FOR SUSTAINABLE ENERGY LLC	PASSIVE SAFETY DEVICE AND INTERNAL SHORT TESTED METHOD FOR ENERGY STORAGE CELLS AND SYSTEMS
9153353	2013	2015	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
9153380	2013	2015	DELPHI TECHNOLOGIES INC	SHAPEABLE SHORT CIRCUIT RESISTANT CAPACITOR
9153833	2014	2015	24M TECHNOLOGIES INC	HIGH ENERGY DENSITY REDOX FLOW DEVICE
9160003	2011	2015	UCHICAGO ARGONNE LLC	POLYSILOXANE BINDER FOR LITHIUM ION BATTERY ELECTRODES
9178249	2011	2015	UCHICAGO ARGONNE LLC	ELECTRODE STABILIZING MATERIALS
9184428	2006	2015	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTES FOR LITHIUM ION BATTERIES
9184436	2012	2015	BATTELLE MEMORIAL INSTITUTE	METHODS AND ENERGY STORAGE DEVICES UTILIZING ELECTROLYTES HAVING SURFACE-SMOOTHING ADDITIVES
9184467	2013	2015	A123 SYSTEMS LLC	LOW MOLECULAR WEIGHT SALTS COMBINED WITH FLUORINATED SOLVENTS FOR ELECTROLYTES
9184468	2013	2015	A123 SYSTEMS LLC	COMBINATIONS OF FLUORINATED SOLVENTS WITH IMIDE SALTS OR METHIDE SALTS FOR ELECTROLYTES
9190694	2010	2015	ENVIA SYSTEMS INC	HIGH CAPACITY ANODE MATERIALS FOR LITHIUM ION BATTERIES
9190697	2013	2015	UT-BATTELLE LLC	SOLID LITHIUM ION CONDUCTING ELECTROLYTES AND METHODS OF PREPARATION
9193595	2013	2015	DREXEL UNIVERSITY	COMPOSITIONS COMPRISING FREE-STANDING TWO-DIMENSIONAL NANOCRYSTALS
9196901	2011	2015	ALLIANCE FOR SUSTAINABLE ENERGY LLC	LITHIUM BATTERY ELECTRODES WITH ULTRA-THIN ALUMINA COATINGS
9209446	2011	2015	OPTODOT CORP	LITHIUM BATTERIES UTILIZING NANOPOROUS SEPARATOR LAYERS
9214668	2011	2015	UNIV CALIFORNIA	SI COMPOSITE ELECTRODE WITH LI METAL DOPING FOR ADVANCED LITHIUM-ION BATTERY
9218915	2014	2015	UCHICAGO	NON-AQUEOUS ELECTROLYTE

			ARGONNE LLC	FOR LITHIUM-ION BATTERY
9225011	2013	2015	PENN STATE UNIV	DOPED CARBON-SULFUR SPECIES NANOCOMPOSITE CATHODE FOR LI—S BATTERIES
EP2831938	2012	2015	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE SYSTEMS HAVING AN ELECTRODE COMPRISING LIXSY
EP2875540	2013	2015	3M CO	HIGH VOLTAGE CATHODE COMPOSITIONS FOR LITHIUM-ION BATTERIES
EP2928004	2010	2015	OPTODOT CORP	METHOD OF MAKING A LITHIUM BATTERY
WO2015003123	2014	2015	SION POWER CORP	CERAMIC/POLYMER MATRIX FOR ELECTRODE PROTECTION IN ELECTROCHEMICAL CELLS, INCLUDING RECHARGEABLE LITHIUM BATTERIES
WO2015006557	2014	2015	PENN STATE UNIV	MESOPOROUS SILICON SYNTHESIS AND APPLICATIONS IN LI-ION BATTERIES AND SOLAR HYDROGEN FUEL CELLS
WO2015057815	2014	2015	MILTEC CORP	POLYMER-BOUND CERAMIC PARTICLE BATTERY SEPARATOR COATING
WO2015077080	2014	2015	RETRIEV TECHNOLOGIES INC	PROCESS FOR RECOVERING AND REGENERATING LITHIUM CATHODE MATERIAL FROM LITHIUM-ION BATTERIES
WO2015123033	2015	2015	BATTELLE MEMORIAL INSTITUTE	THICK ELECTRODES INCLUDING NANOPARTICLES HAVING ELECTROACTIVE MATERIALS AND METHODS OF MAKING SAME
WO2015175509	2015	2015	AMPRIUS INC	STRUCTURALLY CONTROLLED DEPOSITION OF SILICON ONTO NANOWIRES
9244130	2012	2016	BATTELLE ENERGY ALLIANCE LLC; QUALTECH SYSTEMS INC; UNIV MONTANA	METHOD, SYSTEM AND COMPUTER-READABLE MEDIA FOR MEASURING IMPEDANCE OF AN ENERGY STORAGE DEVICE
9246187	2013	2016	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTE FOR LITHIUM-ION BATTERY
9257699	2013	2016	UCHICAGO ARGONNE LLC	SULFUR CATHODE HOSTED IN POROUS ORGANIC POLYMERIC MATRICES
9263769	2014	2016	UCHICAGO ARGONNE LLC	PROCESS FOR THE PRODUCTION OF LOW FLAMMABILITY ELECTROLYTE SOLVENTS
9269949	2013	2016	PENN STATE UNIV	SYNTHESIS OF MICRO-SIZED INTERCONNECTED SI-C COMPOSITES
9287560	2014	2016	AMPRIUS INC	SILICON-EMBEDDED COPPER

				NANOSTRUCTURE NETWORK FOR HIGH ENERGY STORAGE
9287573	2013	2016	POLYPLUS BATTERY CO	LITHIUM BATTERY CELL WITH PROTECTIVE MEMBRANE HAVING A GARNET LIKE STRUCTURE
9293772	2013	2016	UT-BATTELLE LLC	GRADIENT POROUS ELECTRODE ARCHITECTURES FOR RECHARGEABLE METAL-AIR BATTERIES
9293789	2014	2016	UCHICAGO ARGONNE LLC	REDOX SHUTTLES FOR LITHIUM ION BATTERIES
9306210	2014	2016	UCHICAGO ARGONNE LLC	SURFACE PROTECTED LITHIUM-METAL-OXIDE ELECTRODES
9312577	2012	2016	BATTELLE ENERGY ALLIANCE LLC	CIRCUITS AND METHODS FOR DETERMINATION AND CONTROL OF SIGNAL TRANSITION RATES IN ELECTROCHEMICAL CELLS
9341678	2012	2016	ALLIANCE FOR SUSTAINABLE ENERGY LLC	FAIL-SAFE DESIGNS FOR LARGE CAPACITY BATTERY SYSTEMS
9343736	2014	2016	BATTELLE MEMORIAL INSTITUTE	LITHIUM COMPENSATION FOR FULL CELL OPERATION
9343738	2014	2016	UCHICAGO ARGONNE LLC	PRODUCTION OF BATTERY GRADE MATERIALS VIA AN OXALATE METHOD
9362599	2012	2016	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTES FOR LITHIUM-AIR BATTERIES
9368798	2014	2016	UNIV CALIFORNIA	MODIFIED CARBON BLACK MATERIALS FOR LITHIUM-ION BATTERIES
9391345	2011	2016	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTES FOR ELECTROCHEMICAL CELLS
9406960	2012	2016	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE SYSTEMS HAVING AN ELECTRODE COMPRISING LI(SUB)XS(SUB)Y
9415570	2014	2016	DREXEL UNIVERSITY	COMPOSITIONS COMPRISING FREE-STANDING TWO-DIMENSIONAL NANOCRYSTALS
9416011	2015	2016	DREXEL UNIVERSITY	COMPOSITIONS COMPRISING FREE-STANDING TWO-DIMENSIONAL NANOCRYSTALS
9419282	2012	2016	UCHICAGO ARGONNE LLC	ORGANIC ACTIVE MATERIALS FOR BATTERIES
9431649	2010	2016	UCHICAGO ARGONNE LLC	COATED ELECTROACTIVE MATERIALS
9444090	2012	2016	UNIV CALIFORNIA	LITHIUM METAL DOPED ELECTRODES FOR LITHIUM-ION RECHARGEABLE CHEMISTRY
9444096	2014	2016	BATTELLE MEMORIAL INSTITUTE	ORGANOMETALLIC-INORGANIC HYBRID ELECTRODES FOR LITHIUM-ION

				BATTERIES
9446967	2014	2016	UCHICAGO ARGONNE LLC	METHOD FOR PRODUCING SIZE SELECTED PARTICLES
9466834	2013	2016	UT-BATTELLE LLC	LITHIUM-CONDUCTING SULFUR COMPOUND CATHODE FOR LITHIUM-SULFUR BATTERIES
9476780	2012	2016	ALLIANCE FOR SUSTAINABLE ENERGY LLC	CALORIMETERS FOR TESTING ENERGY STORAGE SYSTEMS AND POWER ELECTRONICS METHODS OF MAKING THE SAME AND METHODS OF USE
9478794	2015	2016	UCHICAGO ARGONNE LLC	ELECTROACTIVE MATERIALS FOR RECHARGEABLE BATTERIES
9478837	2015	2016	UCHICAGO ARGONNE LLC	LITHIUM AIR BATTERIES HAVING ETHER-BASED ELECTROLYTES
9484606	2014	2016	HULICO LLC	RECYCLING AND RECONDITIONING OF BATTERY ELECTRODE MATERIALS
9496590	2013	2016	UCHICAGO ARGONNE LLC	LITHIUM-AIR BATTERIES, METHOD FOR MAKING LITHIUM-AIR BATTERIES
9519031	2013	2016	BATTELLE ENERGY ALLIANCE LLC	CIRCUITS AND METHODS FOR IMPEDANCE DETERMINATION USING ACTIVE MEASUREMENT CANCELATION
9525160	2013	2016	UNIV CALIFORNIA	HIGH-RATE OVERCHARGE-PROTECTION SEPARATORS FOR RECHARGEABLE LITHIUM-ION BATTERIES AND THE METHOD OF MAKING THE SAME
EP2989649	2014	2016	MAXWELL TECHNOLOGIES INC	METHODS FOR SOLID ELECTROLYTE INTERPHASE FORMATION AND ANODE PRE-LITHIATION OF LITHIUM ION CAPACITORS
EP2997612	2014	2016	MILTEC CORP	ACTINIC AND ELECTRON BEAM RADIATION CURABLE WATER BASED ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
EP3017491	2014	2016	SION POWER CORP	CERAMIC/POLYMER MATRIX FOR ELECTRODE PROTECTION IN ELECTROCHEMICAL CELLS, INCLUDING RECHARGEABLE LITHIUM BATTERIES
EP3058607	2014	2016	MILTEC CORP	POLYMER-BOUND CERAMIC PARTICLE BATTERY SEPARATOR COATING
WO2016022858	2015	2016	ONTO TECHNOLOGY	RECYCLING POSITIVE-ELECTRODE MATERIAL OF A LITHIUM-ION BATTERY
WO2016043823	2015	2016	PENN STATE UNIV	SUPERCAPACITOR

WO2016069067	2015	2016	BATTELLE MEMORIAL INSTITUTE	ELECTROLYTE FOR BATTERIES WITH REGENERATIVE SOLID ELECTROLYTE INTERFACE
WO2016069934	2015	2016	BATTELLE MEMORIAL INSTITUTE	ELECTROLYTE FOR STABLE CYCLING OF HIGH-ENERGY LITHIUM SULFUR REDOX FLOW BATTERIES
WO2016209838	2016	2016	WILDCAT DISCOVERY TECH INC	ELECTROLYTE FORMULATIONS
9543054	2012	2017	ALLIANCE FOR SUSTAINABLE ENERGY LLC	METHOD OF FABRICATING ELECTRODES INCLUDING HIGH-CAPACITY, BINDER-FREE ANODES FOR LITHIUM-ION BATTERIES
9543565	2014	2017	MILTEC CORP	ACTINIC AND ELECTRON BEAM RADIATION CURABLE ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
9553316	2015	2017	UCHICAGO ARGONNE LLC	LITHIUM-OXYGEN BATTERIES INCORPORATING LITHIUM SUPEROXIDE
9559354	2011	2017	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS
9570748	2012	2017	UT-BATTELLE LLC	LIPON COATINGS FOR HIGH VOLTAGE AND HIGH TEMPERATURE LI-ION BATTERY CATHODES
9577250	2014	2017	BATTELLE MEMORIAL INSTITUTE	THICK ELECTRODES INCLUDING NANOPARTICLES HAVING ELECTROACTIVE MATERIALS AND METHODS OF MAKING SAME
9590248	2013	2017	UCHICAGO ARGONNE LLC	POROUS GRAPHENE NANOCAGES FOR BATTERY APPLICATIONS
9590268	2011	2017	SEEO INC	HIGH TEMPERATURE LITHIUM CELLS WITH SOLID POLYMER ELECTROLYTES
9593024	2014	2017	UCHICAGO ARGONNE LLC	ELECTRODE STRUCTURES AND SURFACES FOR LI BATTERIES
9593413	2011	2017	UCHICAGO ARGONNE LLC	COMPOSITE MATERIALS FOR BATTERY APPLICATIONS
9598545	2013	2017	UCHICAGO ARGONNE LLC	ADVANCED SEPARATORS BASED ON AROMATIC POLYMER FOR HIGH ENERGY DENSITY LITHIUM BATTERIES
9601771	2016	2017	3M CO	HIGH VOLTAGE CATHODE COMPOSITIONS FOR LITHIUM-ION BATTERIES
9601773	2014	2017	UNIVERSITY OF TEXAS	ANODE MATERIALS FOR LITHIUM-ION BATTERIES
9601806	2012	2017	UCHICAGO ARGONNE LLC	REDOX SHUTTLE ADDITIVES FOR LITHIUM-ION BATTERIES
9614231	2011	2017	24M	HIGH ENERGY DENSITY REDOX

			TECHNOLOGIES INC	FLOW DEVICE
9620773	2015	2017	UCHICAGO ARGONNE LLC	ANODE MATERIALS FOR LITHIUM ION BATTERIES
9625532	2012	2017	BATTELLE ENERGY ALLIANCE LLC	METHOD, SYSTEM, AND COMPUTER-READABLE MEDIUM FOR ESTIMATING A PREDICTED ARBITRARY AGING CONDITION OF AN OBJECT
9627712	2014	2017	UCHICAGO ARGONNE LLC	HETEROAROMATIC-BASED ELECTROLYTES FOR LITHIUM AND LITHIUM-ION BATTERIES
9647266	2014	2017	UCHICAGO ARGONNE LLC	AMORPHOUS TITANIA/CARBON COMPOSITE ELECTRODE MATERIALS
9653734	2014	2017	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
9656243	2014	2017	PENN STATE UNIV	MESOPOROUS SILICON SYNTHESIS AND APPLICATIONS IN LI-ION BATTERIES AND SOLAR HYDROGEN FUEL CELLS
9660297	2015	2017	OPTODOT CORP	METHODS OF PRODUCING BATTERIES UTILIZING ANODE COATINGS DIRECTLY ON NANOPOROUS SEPARATORS
9680143	2014	2017	MILTEC CORP	POLYMER-BOUND CERAMIC PARTICLE BATTERY SEPARATOR COATING
9685652	2015	2017	UT-BATTELLE LLC	AQUEOUS PROCESSING OF COMPOSITE LITHIUM ION ELECTRODE MATERIAL
9689820	2012	2017	PURDUE RESEARCH FOUNDATION	THERMOGRAPHY FOR BATTERY COMPONENT QUALITY ASSURANCE
9692086	2014	2017	UNIV CALIFORNIA	CO-SOLVENTS WITH HIGH COULOMBIC EFFICIENCY IN PROPYLENE CARBONATE BASED ELECTROLYTES
9705127	2013	2017	UNIV CALIFORNIA	CONDUCTIVE POLYMER AND SI NANOPARTICLES COMPOSITE SECONDARY PARTICLES AND STRUCTURED CURRENT COLLECTORS FOR HIGH LOADING LITHIUM ION NEGATIVE ELECTRODE APPLICATION
9711297	2014	2017	MAXWELL TECHNOLOGIES INC	METHODS FOR SOLID ELECTROLYTE INTERPHASE FORMATION AND ANODE PRE-LITHIATION OF LITHIUM ION CAPACITORS
9711797	2013	2017	SEEO INC	COATED PARTICLES FOR LITHIUM BATTERY CATHODES
9722245	2015	2017	UT-BATTELLE	SULFUR-CARBON

			LLC	NANOCOMPOSITES AND THEIR APPLICATION AS CATHODE MATERIALS IN LITHIUM-SULFUR BATTERIES
9722252	2015	2017	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
9722277	2014	2017	BATTELLE MEMORIAL INSTITUTE	ELECTROLYTE FOR BATTERIES WITH REGENERATIVE SOLID ELECTROLYTE INTERFACE
9770991	2013	2017	GENERAL MOTORS CO	SYSTEMS AND METHODS FOR INITIALIZING A CHARGING SYSTEM
9780358	2013	2017	ZENLABS ENERGY INC	BATTERY DESIGNS WITH HIGH CAPACITY ANODE MATERIALS AND CATHODE MATERIALS
9786954	2014	2017	UNIV CHICAGO	ELECTROLYTE INCLUDING SILANE FOR USE IN ELECTROCHEMICAL DEVICES
9825341	2015	2017	ONTO TECHNOLOGY	RECYCLING POSITIVE-ELECTRODE MATERIAL OF A LITHIUM-ION BATTERY
9837182	2016	2017	DREXEL UNIVERSITY	COMPOSITIONS COMPRISING FREE-STANDING TWO-DIMENSIONAL NANOCRYSTALS
9837665	2017	2017	UT-BATTELLE LLC	LIPON COATINGS FOR HIGH VOLTAGE AND HIGH TEMPERATURE LI-ION BATTERY CATHODES
9851414	2015	2017	BATTELLE ENERGY ALLIANCE LLC	ENERGY STORAGE CELL IMPEDANCE MEASURING APPARATUS, METHODS AND RELATED SYSTEMS
EP3143657	2015	2017	AMPRIUS INC	STRUCTURALLY CONTROLLED DEPOSITION OF SILICON ONTO NANOWIRES
EP3166168	2011	2017	24M TECHNOLOGIES INC	HIGH ENERGY DENSITY REDOX FLOW DEVICE
EP3178127	2015	2017	ONTO TECHNOLOGY	RECYCLING POSITIVE-ELECTRODE MATERIAL OF A LITHIUM-ION BATTERY
WO2017040299	2016	2017	ENERG2 TECH INC	NOVEL MATERIALS WITH EXTREMELY DURABLE INTERCALATION OF LITHIUM AND MANUFACTURING METHODS THEREOF
WO2017160851	2017	2017	APPLE INC	CATHODE ACTIVE MATERIALS FOR LITHIUM-ION BATTERIES
WO2017160852	2017	2017	APPLE INC	CATHODE ACTIVE MATERIALS FOR LITHIUM-ION BATTERIES
WO2017160856	2017	2017	APPLE INC	CATHODE ACTIVE MATERIALS FOR LITHIUM-ION BATTERIES
9876224	2016	2018	AMPRIUS INC	SILICON-EMBEDDED COPPER NANOSTRUCTURE NETWORK

				FOR HIGH ENERGY STORAGE
9911541	2015	2018	PENN STATE UNIV	SUPERCAPACITOR
9911974	2012	2018	WAYNE STATE UNIV	COMPOSITE ANODE FOR LITHIUM ION BATTERIES
9923201	2015	2018	AMPRIUS INC	STRUCTURALLY CONTROLLED DEPOSITION OF SILICON ONTO NANOWIRES
9929432	2013	2018	UNIV CALIFORNIA	LOW TEMPERATURE SULFUR AND SODIUM METAL BATTERY FOR GRID-SCALE ENERGY STORAGE APPLICATION
9929453	2014	2018	UCHICAGO ARGONNE LLC	BI-METALLIC NANOPARTICLES AS CATHODE ELECTROCATALYSTS
9954229	2014	2018	BATTELLE MEMORIAL INSTITUTE	ELECTROLYTE FOR STABLE CYCLING OF HIGH-ENERGY LITHIUM SULFUR REDOX FLOW BATTERIES
9966598	2015	2018	STANFORD UNIV	HIGH CAPACITY PRELITHIATION REAGENTS AND LITHIUM-RICH ANODE MATERIALS
9985293	2017	2018	STANFORD UNIV	STRUCTURE THAT ENCAPSULATES LITHIUM METAL FOR HIGH ENERGY DENSITY BATTERY ANODE
9985318	2016	2018	WILDCAT DISCOVERY TECH INC	ELECTROLYTE FORMULATIONS
9991559	2015	2018	UCHICAGO ARGONNE LLC	FUNCTIONALIZED IONIC LIQUID ELECTROLYTES FOR LITHIUM ION BATTERIES
9994959	2014	2018	SION POWER CORP	CERAMIC/POLYMER MATRIX FOR ELECTRODE PROTECTION IN ELECTROCHEMICAL CELLS, INCLUDING RECHARGEABLE LITHIUM BATTERIES
9994960	2014	2018	SION POWER CORP	CERAMIC/POLYMER MATRIX FOR ELECTRODE PROTECTION IN ELECTROCHEMICAL CELLS, INCLUDING RECHARGEABLE LITHIUM BATTERIES
10003068	2015	2018	ZENLABS ENERGY INC	HIGH CAPACITY ANODE MATERIALS FOR LITHIUM ION BATTERIES
10008743	2014	2018	UCHICAGO ARGONNE LLC	HIGH VOLTAGE REDOX SHUTTLES, METHOD FOR MAKING HIGH VOLTAGE REDOX SHUTTLES
10020491	2013	2018	ZENLABS ENERGY INC	SILICON-BASED ACTIVE MATERIALS FOR LITHIUM ION BATTERIES AND SYNTHESIS WITH SOLUTION PROCESSING
10024922	2014	2018	UCHICAGO ARGONNE LLC	METHOD AND STRATEGY FOR MULTIPLEXING BATTERY

				CYCLER HARDWARE
10069143	2015	2018	UCHICAGO ARGONNE LLC	COBALT-STABILIZED LITHIUM METAL OXIDE ELECTRODES FOR LITHIUM BATTERIES
10079387	2015	2018	UNIV CALIFORNIA	ELECTRICAL CONDUCTIVE POLYMER BINDER FOR SI ALLOY MATERIALS
10084181	2015	2018	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS FOR RECHARGEABLE BATTERIES
10084187	2017	2018	APPLE INC	CATHODE ACTIVE MATERIALS HAVING IMPROVED PARTICLE MORPHOLOGIES
10099994	2016	2018	UCHICAGO ARGONNE LLC	PROCESS FOR THE PRODUCTION OF HIGH VOLTAGE ELECTROLYTE SOLVENTS FOR LI-ION BATTERIES
10102979	2014	2018	MILTEC CORP	ACTINIC AND ELECTRON BEAM RADIATION CURABLE WATER BASED ELECTRODE BINDERS AND ELECTRODES INCORPORATING SAME
10107696	2015	2018	ALLIANCE FOR SUSTAINABLE ENERGY LLC	METHODS AND DEVICES FOR ELECTROCHEMICAL SYSTEM ANALYSIS
10122046	2014	2018	UCHICAGO ARGONNE LLC	ELECTROLYTE COMPOSITIONS FOR HIGH VOLTAGE LITHIUM-ION BATTERIES
10128537	2016	2018	WILDCAT DISCOVERY TECH INC	ELECTROLYTE FORMULATIONS FOR ELECTROCHEMICAL CELLS CONTAINING A SILICON ELECTRODE
10141572	2017	2018	APPLE INC	CATHODE ACTIVE MATERIALS FOR LITHIUM-ION BATTERIES
10147950	2016	2018	GROUP 14 TECHNOLOGIES INC	MATERIALS WITH EXTREMELY DURABLE INTERCALATION OF LITHIUM AND MANUFACTURING METHODS THEREOF
10164242	2015	2018	MIT/UNIV CALIFORNIA/UNIV MICHIGAN	CONTROLLED POROSITY IN ELECTRODES
10164256	2017	2018	APPLE INC	CATHODE ACTIVE MATERIALS FOR LITHIUM-ION BATTERIES
EP3341990	2016	2018	ENERG2 TECH INC	NOVEL MATERIALS WITH EXTREMELY DURABLE INTERCALATION OF LITHIUM AND MANUFACTURING METHODS THEREOF
WO2018044879	2017	2018	WILDCAT DISCOVERY TECH INC	ELECTROLYTE FORMULATIONS FOR ELECTROCHEMICAL CELLS CONTAINING A SILICON ELECTRODE
WO2018057584	2017	2018	APPLE INC	CATHODE ACTIVE MATERIALS HAVING IMPROVED PARTICLE MORPHOLOGIES

10170750	2016	2019	UT-BATTELLE LLC	LITHIUM-CONDUCTING SULFUR COMPOUND CATHODE FOR LITHIUM-SULFUR BATTERIES
10170765	2015	2019	UNIV CALIFORNIA	ELECTRONICALLY CONDUCTIVE POLYMER BINDER FOR LITHIUM-ION BATTERY ELECTRODE
10214428	2015	2019	UCHICAGO ARGONNE LLC	ELECTRODE MATERIALS FOR RECHARGEABLE BATTERY
10224125	2017	2019	DREXEL UNIVERSITY	COMPOSITIONS COMPRISING FREE-STANDING TWO-DIMENSIONAL NANOCRYSTALS
10236518	2015	2019	24M TECHNOLOGIES INC; MIT	HIGH ENERGY DENSITY REDOX FLOW DEVICE
10276859	2017	2019	UNIV CALIFORNIA	CONDUCTIVE POLYMER AND SI NANOPARTICLES COMPOSITE SECONDARY PARTICLES AND STRUCTURED CURRENT COLLECTORS FOR HIGH LOADING LITHIUM ION NEGATIVE ELECTRODE APPLICATION
10297823	2017	2019	APPLE INC	CATHODE ACTIVE MATERIALS HAVING IMPROVED PARTICLE MORPHOLOGIES
10403874	2017	2019	OPTODOT CORP	METHODS OF PRODUCING BATTERIES UTILIZING ANODE METAL DEPOSITIONS DIRECTLY ON NANOPOROUS SEPARATORS
10424792	2017	2019	UT-BATTELLE LLC	LIPON COATINGS FOR HIGH VOLTAGE AND HIGH TEMPERATURE LI-ION BATTERY CATHODES
10581118	2017	2020	UNIV CALIFORNIA	CO-SOLVENTS WITH HIGH COULOMBIC EFFICIENCY IN PROPYLENE CARBONATE BASED ELECTROLYTES

Appendix B. Other DOE-Funded Advanced Batteries Patents used in the Analysis

Patent #	Application Year	Issue / Publication Year	Original Assignees	TITLE
4130500	1977	1978	US DEPT OF ENERGY	LITHIUM-ALUMINUM-MAGNESIUM ELECTRODE COMPOSITION
4158720	1977	1979	US DEPT OF ENERGY	LITHIUM-ALUMINUM-IRON ELECTRODE COMPOSITION
4189827	1978	1980	US DEPT OF ENERGY	TREATMENT OF ELECTROCHEMICAL CELL COMPONENTS WITH LITHIUM TETRACHLOROALUMINATE (LIALCL4) TO PROMOTE ELECTROLYTE WETTING
4251600	1979	1981	US DEPT OF ENERGY	METHOD OF PREPARING A SINTERED LITHIUM ALUMINATE STRUCTURE FOR CONTAINING ELECTROLYTE
4315059	1980	1982	US DEPT OF ENERGY	MOLTEN SALT LITHIUM CELLS
4340652	1980	1982	US DEPT OF ENERGY	TERNARY COMPOUND ELECTRODE FOR LITHIUM CELLS
4405416	1981	1983	STANFORD UNIV	MOLTEN SALT LITHIUM CELLS
4489143	1984	1984	US DEPT OF ENERGY	LITHIUM ALUMINUM/IRON SULFIDE BATTERY HAVING LITHIUM ALUMINUM AND SILICON AS NEGATIVE ELECTRODE
4540642	1984	1985	US DEPT OF ENERGY	CELL DESIGN FOR LITHIUM ALLOY/METAL SULFIDE BATTERY
4764437	1986	1988	US DEPT OF ENERGY	LITHIUM DISULFIDE BATTERY
4832463	1987	1989	TRUSTEES OF TUFTS COLLEGE	THIN FILM ION CONDUCTING COATING
4851306	1988	1989	ARCH DEVELOPMENT CORP	MOLTEN SALT ELECTROLYTE BATTERY CELL WITH OVERCHARGE TOLERANCE
4882243	1988	1989	POLYTECHNIC UNIVERSITY	PREPARATION OF METALLIC CATION CONDUCTING POLYMERS BASED ON STERICALLY HINDERED PHENOLS CONTAINING POLYMERIC SYSTEMS
4935316	1989	1990	US DEPT OF ENERGY	OVERDISCHARGE PROTECTION IN HIGH-TEMPERATURE CELLS AND BATTERIES
EP0376466	1989	1990	ASS UNIVERSITIES INC; UNIV POLYTECHNIC	SOLVENT-FREE SOLID POLYMER ELECTROLYTE AND PROCESS FOR ITS PREPARATION.
EP0386350	1989	1990	TRUSTEES OF TUFTS COLLEGE	THIN FILM ION CONDUCTING COATING.
5002843	1989	1991	AT&T CORP	SEPARATOR MATERIAL FOR

				ELECTROCHEMICAL CELLS
5015530	1988	1991	US DEPT OF ENERGY	HIGH EXPANSION, LITHIUM CORROSION RESISTANT SEALING GLASSES
5154784	1991	1992	WESTINGHOUSE ELECTRIC CORP	PROCESS FOR MANUFACTURING A LITHIUM ALLOY ELECTROCHEMICAL CELL
EP0497633	1992	1992	WESTINGHOUSE ELECTRIC CORP	PROCESS FOR MANUFACTURING A LITHIUM ALLOY ELECTROCHEMICAL CELL.
5202203	1991	1993	US DEPT OF ENERGY	CHLOROMETHYL CHLOROSULFATE AS A VOLTAGE DELAY INHIBITOR IN LITHIUM CELLS
5208003	1992	1993	MARTIN MARIETTA ENERGY SYSTEMS INC	MICROCELLULAR CARBON FOAM AND METHOD
5219673	1991	1993	US DEPT OF ENERGY	CELL STRUCTURE FOR ELECTROCHEMICAL DEVICES AND METHOD OF MAKING SAME
5219679	1991	1993	EIC LABORATORIES INC	SOLID ELECTROLYTES
5252413	1992	1993	EIC LABORATORIES INC	SOLID POLYMER ELECTROLYTE LITHIUM BATTERIES
5260855	1992	1993	UNIVERSITY OF CALIFORNIA	SUPERCAPACITORS BASED ON CARBON FOAMS
5268395	1993	1993	MARTIN MARIETTA ENERGY SYSTEMS INC	MICROCELLULAR CARBON FOAM AND METHOD
EP0576225	1993	1993	ARIZONA STATE UNIVERSITY	LITHIUM ION CONDUCTING ELECTROLYTES.
WO1993014511	1993	1993	UNIVERSITY OF CALIFORNIA	SUPERCAPACITORS BASED ON CARBON FOAMS
5300272	1993	1994	MARTIN MARIETTA ENERGY SYSTEMS INC	MICROCELLULAR CARBON FOAM AND METHOD
5314765	1993	1994	MARTIN MARIETTA ENERGY SYSTEMS INC	PROTECTIVE LITHIUM ION CONDUCTING CERAMIC COATING FOR LITHIUM METAL ANODES AND ASSOCIATE METHOD
5336274	1993	1994	UNIVERSITY OF CALIFORNIA	METHOD FOR FORMING A CELL SEPARATOR FOR USE IN BIPOLAR-STACK ENERGY STORAGE DEVICES
5338625	1992	1994	MARTIN MARIETTA ENERGY SYSTEMS INC	THIN FILM BATTERY AND METHOD FOR MAKING SAME
5358802	1993	1994	UNIVERSITY OF	DOPING OF CARBON FOAMS FOR USE IN ENERGY STORAGE DEVICES

			CALIFORNIA	
EP0602984	1993	1994	ASSOCIATED UNIVERSITIES INC	ELECTROCHEMICAL CELL.
WO1994022943	1994	1994	UNIVERSITY OF CALIFORNIA	METHOD OF LOW PRESSURE AND/OR EVAPORATIVE DRYING OF AEROGEL
WO1994023462	1994	1994	UNIVERSITY OF CALIFORNIA	DOPING OF CARBON FOAMS FOR USE IN ENERGY STORAGE DEVICES
5378550	1993	1995	US DEPT OF ENERGY	ELECTROLYTES FOR POWER SOURCES
5393619	1994	1995	UNIVERSITY OF CALIFORNIA	CELL SEPARATOR FOR USE IN BIPOLAR-STACK ENERGY STORAGE DEVICES
5402306	1993	1995	UNIVERSITY OF CALIFORNIA	AQUAGEL ELECTRODE SEPARATOR FOR USE IN BATTERIES AND SUPERCAPACITORS
5420168	1993	1995	UNIVERSITY OF CALIFORNIA	METHOD OF LOW PRESSURE AND/OR EVAPORATIVE DRYING OF AEROGEL
5426006	1993	1995	SANDIA CORP	STRUCTURAL MICRO-POROUS CARBON ANODE FOR RECHARGEABLE LITHIUM-ION BATTERIES
5441831	1993	1995	ASSOCIATED UNIVERSITIES INC	CELLS HAVING CATHODES CONTAINING POLYCARBON DISULFIDE MATERIALS
5443601	1993	1995	UNIVERSITY OF CALIFORNIA	METHOD FOR INTERCALATING ALKALI METAL IONS INTO CARBON ELECTRODES
5445906	1994	1995	MARTIN MARIETTA ENERGY SYSTEMS INC	METHOD AND SYSTEM FOR CONSTRUCTING A RECHARGEABLE BATTERY AND BATTERY STRUCTURES FORMED WITH THE METHOD
5455126	1994	1995	MARTIN MARIETTA ENERGY SYSTEMS INC	ELECTRA-OPTICAL DEVICE INCLUDING A NITROGEN CONTAINING ELECTROLYTE
5470674	1994	1995	SANDIA CORP	ELECTROLYTE SALTS FOR POWER SOURCES
5474860	1994	1995	EIC LABORATORIE S INC	SOLID POLYMER ELECTROLYTES
5476878	1994	1995	UNIVERSITY OF CALIFORNIA	ORGANIC AEROGELS FROM THE SOL-GEL POLYMERIZATION OF PHENOLIC-FURFURAL MIXTURES
WO1995006002	1994	1995	UNIVERSITY OF CALIFORNIA	METHOD FOR MAKING THIN CARBON FOAM ELECTRODES
5484670	1994	1996	ARIZONA STATE UNIVERSITY	LITHIUM ION CONDUCTING IONIC ELECTROLYTES
5506073	1992	1996	ARIZONA STATE	LITHIUM ION CONDUCTING ELECTROLYTES

			UNIVERSITY	
5508341	1993	1996	UNIVERSITY OF CALIFORNIA	ORGANIC AEROGEL MICROSPHERES AND FABRICATION METHOD THEREFOR
5512147	1994	1996	MARTIN MARIETTA ENERGY SYSTEMS INC	METHOD OF MAKING AN ELECTROLYTE FOR AN ELECTROCHEMICAL CELL
5527640	1994	1996	UNIVERSITY OF CALIFORNIA	ELECTROCHEMICAL SUPERCAPACITORS
5529971	1993	1996	UNIVERSITY OF CALIFORNIA	CARBON FOAMS FOR ENERGY STORAGE DEVICES
5536600	1994	1996	US DEPT OF ENERGY	LI-ALLOY ELECTRODE FOR LI-ALLOY/METAL SULFIDE CELLS
5556892	1995	1996	UNIVERSITY OF CALIFORNIA	ORGANIC AEROGELS FROM THE SOL-GEL POLYMERIZATION OF PHENOLIC-FURFURAL MIXTURES
5561004	1994	1996	MARTIN MARIETTA ENERGY SYSTEMS INC	PACKAGING MATERIAL FOR THIN FILM LITHIUM BATTERIES
5567210	1994	1996	MARTIN MARIETTA ENERGY SYSTEMS INC	METHOD FOR MAKING AN ELECTROCHEMICAL CELL
5569520	1995	1996	MARTIN MARIETTA ENERGY SYSTEMS INC	RECHARGEABLE LITHIUM BATTERY FOR USE IN APPLICATIONS REQUIRING A LOW TO HIGH POWER OUTPUT
5589295	1995	1996	SANDIA CORP	THIN FILM POLYMERIC GEL ELECTROLYTES
WO1996039725	1996	1996	ARIZONA STATE UNIVERSITY	ALKALI-METAL-ION CONDUCTING ELECTROLYTES
5597660	1994	1997	MARTIN MARIETTA ENERGY SYSTEMS INC	ELECTROLYTE FOR AN ELECTROCHEMICAL CELL
5612152	1996	1997	MARTIN MARIETTA ENERGY SYSTEMS INC	RECHARGEABLE LITHIUM BATTERY FOR USE IN APPLICATIONS REQUIRING A LOW TO HIGH POWER OUTPUT
5626977	1995	1997	UNIVERSITY OF CALIFORNIA	COMPOSITE CARBON FOAM ELECTRODE
5630994	1995	1997	AT&T CORP	NON-AQUEOUS SOLUTION PREPARATION OF DOPED AND UNDOPED LIXMNYOZ
5636437	1995	1997	UNIVERSITY OF CALIFORNIA	FABRICATING SOLID CARBON POROUS ELECTRODES FROM POWDERS
5691080	1996	1997	SANDIA CORP	METHOD OF PREPARING THIN FILM POLYMERIC GEL ELECTROLYTES
EP0797788	1996	1997	MIDWEST	SOLID LITHIUM-ION ELECTROLYTE

			RESEARCH INSTITUTE	
WO1997013178	1996	1997	MIDWEST RESEARCH INSTITUTE	SOLID LITHIUM-ION ELECTROLYTE
WO1997020768	1996	1997	SANDIA CORP	METHODS OF PREPARATION OF CARBON MATERIALS FOR USE AS ELECTRODES IN RECHARGEABLE BATTERIES
WO1997044842	1997	1997	SRI INTERNATION AL	NONFLAMMABLE/SELF-EXTINGUISHING ELECTROLYTES FOR BATTERIES
5705293	1997	1998	LOCKHEED MARTIN ENERGY RESEARCH CORP	SOLID STATE THIN FILM BATTERY HAVING A HIGH TEMPERATURE LITHIUM ALLOY ANODE
5710699	1996	1998	GENERAL ELECTRIC CO	POWER ELECTRONIC INTERFACE CIRCUITS FOR BATTERIES AND ULTRACAPACITORS IN ELECTRIC VEHICLES AND BATTERY STORAGE SYSTEMS
5716736	1995	1998	MIDWEST RESEARCH INSTITUTE	SOLID LITHIUM-ION ELECTROLYTE
5723956	1996	1998	GENERAL ELECTRIC CO	LOW COST ELECTRONIC ULTRACAPACITOR INTERFACE TECHNIQUE TO PROVIDE LOAD LEVELING OF A BATTERY FOR PULSED LOAD OR MOTOR TRACTION DRIVE APPLICATIONS
5731360	1996	1998	UNIVERSITY OF CALIFORNIA	COMPRESSION MOLDING OF AEROGEL MICROSPHERES
5744510	1996	1998	UNIVERSITY OF CALIFORNIA	ORGANIC CARBON AEROGELS FROM THE SOL-GEL POLYMERIZATION OF PHENOLIC-FURFURAL MIXTURES
5776384	1995	1998	SANDIA CORP	METHOD FOR MAKING CARBON SUPER CAPACITOR ELECTRODE MATERIALS
5786110	1995	1998	ARIZONA STATE UNIVERSITY	ALKALI-METAL-ION CONDUCTING ELECTROLYTES
5789338	1996	1998	UNIVERSITY OF CALIFORNIA	PROCESS FOR PRODUCING CARBON FOAMS FOR ENERGY STORAGE DEVICES
5830600	1996	1998	SRI INTERNATION AL	NONFLAMMABLE/SELF-EXTINGUISHING ELECTROLYTES FOR BATTERIES
5834137	1997	1998	MIDWEST RESEARCH INSTITUTE	THIN FILM METHOD OF CONDUCTING LITHIUM-IONS
5841627	1997	1998	UNIVERSITY OF CHICAGO	PSEUDO-CAPACITOR DEVICE FOR AQUEOUS ELECTROLYTES
WO1998016960	1997	1998	MASSACHUSET	POLYMER ELECTROLYTE,

			TS INSTITUTE OF TECHNOLOGY	INTERCALATION COMPOUNDS AND ELECTRODES FOR BATTERIES
WO1998047196	1998	1998	LOCKHEED MARTIN ENERGY RESEARCH CORP	SILICON-TIN OXYNITRIDE GLASSY COMPOSITION AND USE AS ANODE FOR LITHIUM-ION BATTERY
WO1998052869	1998	1998	PRINCETON UNIVERSITY	LYOTROPIC LIQUID CRYSTALLINE L3 PHASE SILICATED NANOPOROUS MONOLITHIC COMPOSITES AND THEIR PRODUCTION
5882621	1997	1999	SANDIA CORP	METHOD OF PREPARATION OF CARBON MATERIALS FOR USE AS ELECTRODES IN RECHARGEABLE BATTERIES
5898564	1996	1999	UNIVERSITY OF CALIFORNIA	CAPACITOR WITH A COMPOSITE CARBON FOAM ELECTRODE
5908896	1996	1999	UNIVERSITY OF CALIFORNIA	ORGANIC AEROGEL MICROSPHERES
5925408	1998	1999	SANDIA CORP	METHOD FOR MAKING CARBON FILMS
5932185	1993	1999	UNIVERSITY OF CALIFORNIA	METHOD FOR MAKING THIN CARBON FOAM ELECTRODES
5945677	1999	1999	UNIVERSITY OF CALIFORNIA	FOCUSED ION BEAM SYSTEM
5949219	1998	1999	US DEPT OF ENERGY	OPTICAL STATE-OF-CHARGE MONITOR FOR BATTERIES
5962169	1998	1999	ARIZONA STATE UNIVERSITY	LITHIUM ION CONDUCTING ELECTROLYTES
5963417	1996	1999	WISCONSIN ALUMNI RES FOUND/LOCKHEED MARTIN	ELECTROCHEMICAL CAPACITOR
5989748	1998	1999	US DEPT OF ENERGY	CYANOETHYLATED COMPOUNDS AS ADDITIVES IN LITHIUM/LITHIUM BATTERIES
5993969	1997	1999	SANDIA CORP	CARBON FILM ELECTRODES FOR SUPER CAPACITOR APPLICATIONS
EP0906641	1997	1999	SRI INTERNATIONAL	NONFLAMMABLE/SELF-EXTINGUISHING ELECTROLYTES FOR BATTERIES
EP0951742	1997	1999	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	POLYMER ELECTROLYTE, INTERCALATION COMPOUNDS AND ELECTRODES FOR BATTERIES
6040561	1999	2000	GENERAL MOTORS CORP	HIGH VOLTAGE BUS AND AUXILIARY HEATER CONTROL SYSTEM FOR AN ELECTRIC OR HYBRID VEHICLE
6084766	1998	2000	GENERAL	METHOD OF MAKING AN

			ELECTRIC CO	ULTRACAPACITOR ELECTRODE
6084767	1998	2000	GENERAL ELECTRIC CO	ULTRACAPACITOR SEPARATOR
6096454	1998	2000	UNIVERSITY OF CALIFORNIA	SURFACE MODIFICATIONS FOR CARBON LITHIUM INTERCALATION ANODES
6110321	1997	2000	GENERAL ELECTRIC CO	METHOD FOR SEALING AN ULTRACAPACITOR, AND RELATED ARTICLES
6110621	1998	2000	UNIVERSITY OF CHICAGO	CARBONS FOR LITHIUM BATTERIES PREPARED USING SEPIOLITE AS AN INORGANIC TEMPLATE
6132905	1998	2000	UNIVERSITY OF DAYTON	SOLID COMPOSITE ELECTROLYTES FOR LITHIUM BATTERIES
6152970	1998	2000	GENERAL ELECTRIC CO	DRYING AN ULTRACAPACITOR
EP0993061	1999	2000	VARTA AKTIENGESLLSCHAFT	SECONDARY LITHIUM ION CELL
WO2000019462	1999	2000	GENERAL ELECTRIC CO	METHOD OF MAKING AN ULTRACAPACITOR ELECTRODE
WO2000019463	1999	2000	GENERAL ELECTRIC CO	ULTRACAPACITOR ELECTROLYTE
WO2000019464	1999	2000	GENERAL ELECTRIC CO	ULTRACAPACITOR SEPARATOR
WO2000019465	1999	2000	GENERAL ELECTRIC CO	ULTRACAPACITOR CURRENT COLLECTOR
WO2000019466	1999	2000	GENERAL ELECTRIC CO	SEALING AN ULTRACAPACITOR
WO2000022635	1999	2000	GENERAL ELECTRIC CO	ULTRACAPACITOR SEPARATOR
6168694	1999	2001	CHEMAT TECHNOLOGY INC	METHODS FOR AND PRODUCTS OF PROCESSING NANOSTRUCTURE NITRIDE, CARBONITRIDE AND OXYCARBONITRIDE ELECTRODE POWER MATERIALS BY UTILIZING SOL GEL TECHNOLOGY FOR SUPERCAPACITOR APPLICATIONS
6190806	2000	2001	UNIVERSITY OF DAYTON	SOLID COMPOSITE ELECTROLYTES FOR LITHIUM BATTERIES
6198620	1998	2001	GENERAL ELECTRIC CO	ULTRACAPACITOR SEPARATOR
6201685	1998	2001	GENERAL ELECTRIC CO	ULTRACAPACITOR CURRENT COLLECTOR
6207124	1999	2001	SANDIA CORP	LITHIUM INTERCALATION CARBON AND METHOD FOR PRODUCING SAME
6212061	1998	2001	GENERAL ELECTRIC CO	SEALING AN ULTRACAPACITOR
6218049	1994	2001	UT-BATTELLE LLC	CATHODE FOR AN ELECTROCHEMICAL CELL
6242132	1998	2001	UT-BATTELLE LLC	SILICON-TIN OXYNITRIDE GLASSY COMPOSITION AND USE AS ANODE FOR LITHIUM-ION BATTERY
6256190	1998	2001	GENERAL ELECTRIC CO	ULTRACAPACITOR ELECTROYTE

6299850	1999	2001	US DEPT OF ENERGY	CARBON ACTIVATION PROCESS FOR INCREASED SURFACE ACCESSIBILITY IN ELECTROCHEMICAL CAPACITORS
6304426	1998	2001	GENERAL ELECTRIC CO	METHOD OF MAKING AN ULTRACAPACITOR ELECTRODE
6332990	1999	2001	UNIVERSITY OF CALIFORNIA	METHOD FOR FABRICATING COMPOSITE CARBON FOAM
WO2001020696	2000	2001	UT-BATTELLE LLC	FABRICATION OF HIGHLY TEXTURED LITHIUM COBALT OXIDE FILMS BY RAPID THERMAL ANNEALING
WO2001071827	2001	2001	MIDWEST RESEARCH INSTITUTE	METHOD FOR IMPROVING THE DURABILITY OF ION INSERTION MATERIALS
6335115	1999	2002	VARTA AKTIENGESLLSCHAFT	SECONDARY LITHIUM-ION CELL WITH AN AUXILIARY ELECTRODE
6344366	1999	2002	LOCKHEED MARTIN ENERGY RESEARCH CORP	FABRICATION OF HIGHLY TEXTURED LITHIUM COBALT OXIDE FILMS BY RAPID THERMAL ANNEALING
6356433	2000	2002	UNIVERSITY OF CALIFORNIA	CONDUCTING POLYMER ULTRACAPACITOR
6364915	2000	2002	GENERAL ELECTRIC CO	METHOD OF SEALING AN ULTRACAPACITOR SUBSTANTIALLY FREE OF WATER
6383640	2000	2002	UNIVERSITY OF CALIFORNIA	CONDUCTING POLYMER FOR HIGH POWER ULTRACAPACITOR
6407330	2000	2002	NORTH CAROLINA STATE UNIVERSITY/JOHNS HOPKINS UNIVERSITY	SOLAR CELLS INCORPORATING LIGHT HARVESTING ARRAYS
6420071	2000	2002	MIDWEST RESEARCH INSTITUTE	METHOD FOR IMPROVING THE DURABILITY OF ION INSERTION MATERIALS
6466428	2000	2002	GENERAL ELECTRIC CO	ULTRACAPACITOR HAVING RESIDUAL WATER REMOVED UNDER VACUUM
WO2002009197	2001	2002	NORTH CAROLINA STATE UNIVERSITY/JOHNS HOPKINS UNIVERSITY	SOLAR CELLS INCORPORATING LIGHT HARVESTING ARRAYS
WO2002011228	2001	2002	BECHTEL BWXT IDAHO LLC	SELF-DOPED MOLECULAR COMPOSITE BATTERY ELECTROLYTES
6508959	2001	2003	UNIVERSITY OF	PREPARATION OF ENERGY STORAGE MATERIALS

			CALIFORNIA	
6544690	2000	2003	BECHTEL BWXT IDAHO LLC	SELF-DOPED MOLECULAR COMPOSITE BATTERY ELECTROLYTES
6544691	2000	2003	SANDIA CORP	BATTERIES USING MOLTEN SALT ELECTROLYTE
6555270	2001	2003	LOCKHEED MARTIN ENERGY RESEARCH CORP	FABRICATION OF HIGHLY TEXTURED LITHIUM COBALT OXIDE FILMS BY RAPID THERMAL ANNEALING
6558437	2001	2003	GENERAL ELECTRIC CO	METHOD OF MAKING AN ULTRACAPACITOR ELECTRODE
6562518	2001	2003	LOCKHEED MARTIN ENERGY RESEARCH CORP	FABRICATION OF HIGHLY TEXTURED LITHIUM COBALT OXIDE FILMS BY RAPID THERMAL ANNEALING
6565701	2000	2003	GENERAL ELECTRIC CO	ULTRACAPACITOR CURRENT COLLECTOR
6583599	2000	2003	FORD GLOBAL TECHNOLOGIES INC	METHOD AND APPARATUS FOR CONTROLLING BATTERY CHARGING IN A HYBRID ELECTRIC VEHICLE
6596935	2002	2003	NORTH CAROLINA STATE UNIVERSITY	SOLAR CELLS INCORPORATING LIGHT HARVESTING ARRAYS
6603070	2001	2003	NORTH CAROLINA STATE UNIVERSITY	CONVERGENT SYNTHESIS OF MULTIPORPHYRIN LIGHT-HARVESTING RODS
6638885	2000	2003	PRINCETON UNIVERSITY	LYOTROPIC LIQUID CRYSTALLINE L3 PHASE SILICATED NANOPOROUS MONOLITHIC COMPOSITES AND THEIR PRODUCTION
6656390	2003	2003	UNIVERSITY OF CALIFORNIA	PREPARATION OF ENERGY STORAGE MATERIALS
6656641	2001	2003	UNIVERSITY OF DAYTON	METHODS OF ENHANCING CONDUCTIVITY OF A POLYMER-CERAMIC COMPOSITE ELECTROLYTE
EP1273056	2001	2003	MIDWEST RESEARCH INSTITUTE	METHOD FOR IMPROVING THE DURABILITY OF ION INSERTION MATERIALS
EP1303884	2001	2003	NORTH CAROLINA STATE UNIVERSITY/JOHNS HOPKINS UNIVERSITY	SOLAR CELLS INCORPORATING LIGHT HARVESTING ARRAYS
WO2003012908	2002	2003	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS

WO2003019621	2002	2003	NORTH CAROLINA STATE UNIVERSITY	CONVERGENT SYNTHESIS OF MULTIPORPHYRIN LIGHT-HARVESTING RODS
WO2003049219	2002	2003	BOSTON COLLEGE	COATED CARBON NANOTUBE ARRAY ELECTRODES
WO2003056646	2002	2003	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
WO2004000800	2003	2003	UNIVERSITY OF CALIFORNIA	ELECTROCHROMIC SALTS, SOLUTIONS, AND DEVICES
6703200	2000	2004	PARADIGM GENETICS INC	METHODS AND MATERIALS FOR THE RAPID AND HIGH VOLUME PRODUCTION OF A GENE KNOCK-OUT LIBRARY IN AN ORGANISM
6746794	2001	2004	TECH DRIVE INC	THERMAL RUNAWAY INHIBITORS
6787232	2000	2004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	INTERCALATION COMPOUNDS AND ELECTRODES FOR BATTERIES
6805999	2003	2004	MIDWEST RESEARCH INSTITUTE	BURIED ANODE LITHIUM THIN FILM BATTERY AND PROCESS FOR FORMING THE SAME
EP1433217	2002	2004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY; A123 SYSTEMS INC	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
EP1456895	2002	2004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
6838072	2002	2005	US DEPT OF ENERGY	PLASMA SYNTHESIS OF LITHIUM BASED INTERCALATION POWDERS FOR SOLID POLYMER ELECTROLYTE BATTERIES
6956083	2002	2005	UNIVERSITY OF CALIFORNIA	SINGLE ION CONDUCTOR CROSS-LINKED POLYMERIC NETWORKS
WO2005117199	2005	2005	BATTELLE ENERGY ALLIANCE LLC	SAFE BATTERY SOLVENTS
6982132	2000	2006	TRUSTEES OF TUFTS COLLEGE	RECHARGEABLE THIN FILM BATTERY AND METHOD FOR MAKING THE SAME
7026071	2001	2006	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	NON-CROSSLINKED, AMORPHOUS, BLOCK COPOLYMER ELECTROLYTE FOR BATTERIES
7041414	2003	2006	UNIVERSITY OF CHICAGO	SILVER MANGANESE OXIDE ELECTRODES FOR LITHIUM BATTERIES

7049031	2003	2006	UNIVERSITY OF CHICAGO	PROTECTIVE COATING ON POSITIVE LITHIUM-METAL-OXIDE ELECTRODES FOR LITHIUM BATTERIES
7064212	2002	2006	UNIVERSITY OF CALIFORNIA	ELECTROCHROMIC SALTS, SOLUTIONS, AND DEVICES
7077983	2002	2006	UNIVERSITY OF CHICAGO	POLYMER NANOCOMPOSITES FOR LITHIUM BATTERY APPLICATIONS
7101643	2002	2006	UNIVERSITY OF CALIFORNIA	POLYMERIC ELECTROLYTES BASED ON HYDROSILYATION REACTIONS
7147966	2002	2006	BOSTON COLLEGE	COATED CARBON NANOTUBE ARRAY ELECTRODES
WO2006036957	2005	2006	GINER ELECTROCHEM ICAL SYSTEMS LLC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING PLASMA ETCHED POROUS SUPPORT
WO2006073427	2005	2006	CALIFORNIA INST TECHNOLOGY; CNRS	HIGH-CAPACITY NANOSTRUCTURED GERMANIUM-CONTAINING MATERIALS AND LITHIUM ALLOYS THEREOF
WO2006078866	2006	2006	ARIZONA STATE UNIVERSITY	ELECTRIC CURRENT-PRODUCING DEVICE HAVING SULFONE-BASED ELECTROLYTE
7226702	2003	2007	QUALLION LLC	SOLID POLYMER ELECTROLYTE AND METHOD OF PREPARATION
7285362	2004	2007	BATTELLE ENERGY ALLIANCE LLC	SAFE BATTERY SOLVENTS
EP1743392	2005	2007	CALIFORNIA INST TECHNOLOGY; CNRS	HIGH-CAPACITY NANOSTRUCTURED GERMANIUM-CONTAINING MATERIALS AND LITHIUM ALLOYS THEREOF
EP1756904	2005	2007	BATTELLE ENERGY ALLIANCE LLC	SAFE BATTERY SOLVENTS
EP1842250	2006	2007	ARIZONA STATE UNIVERSITY	ELECTRIC CURRENT-PRODUCING DEVICE HAVING A SULFONE-BASED ELECTROLYTE
WO2007117263	2006	2007	CALIFORNIA INST TECHNOLOGY; CNRS	ELECTROCHEMICAL THERMODYNAMIC MEASUREMENT SYSTEM
7338734	2002	2008	MASSACHUSET TS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
7435509	2003	2008	UCHICAGO ARGONNE LLC	ELECTRODE FOR A LITHIUM CELL
7436570	2004	2008	LOS ALAMOS NATIONAL SECURITY LLC	ELECTROCHROMIC SALTS, SOLUTIONS, AND DEVICES
7442284	2006	2008	BOSTON COLLEGE	COATED CARBON NANOTUBE ARRAY ELECTRODES
7450293	2004	2008	LOS ALAMOS	ELECTROCHROMIC SALTS,

			NATIONAL SECURITY LLC	SOLUTIONS, AND DEVICES
EP1918728	2007	2008	HONEYWELL INTERNATION AL INC	LITHIUM-ION BATTERY DIAGNOSTIC AND PROGNOSTIC TECHNIQUES
EP1924849	2006	2008	CALIFORNIA INST TECHNOLOGY; CNRS	ELECTROCHEMICAL THERMODYNAMIC MEASUREMENT SYSTEM
WO2008039806	2007	2008	UNIVERSITY OF TEXAS	SURFACE AND BULK MODIFIED HIGH CAPACITY LAYERED OXIDE CATHODES WITH LOW IRREVERSIBLE CAPACITY LOSS
WO2008039808	2007	2008	UNIVERSITY OF TEXAS	CATION-SUBSTITUTED SPINEL OXIDE AND OXYFLUORIDE CATHODES FOR LITHIUM ION BATTERIES
WO2008058231	2007	2008	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
WO2008153564	2007	2008	MIDWEST RESEARCH INSTITUTE	MULTILAYER SOLID ELECTROLYTE FOR LITHIUM THIN FILM BATTERIES
7579112	2002	2009	A123 SYSTEMS INC/MIT	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
7595611	2006	2009	CALIFORNIA INST TECHNOLOGY; CNRS	ELECTROCHEMICAL THERMODYNAMIC MEASUREMENT SYSTEM
7612540	2006	2009	HONEYWELL INTERNATION AL INC	LITHIUM-ION BATTERY DIAGNOSTIC AND PROGNOSTIC TECHNIQUES
7623340	2006	2009	NANOTEK INSTRUMENTS INC	NANO-SCALED GRAPHENE PLATE NANOCOMPOSITES FOR SUPERCAPACITOR ELECTRODES
7632602	2004	2009	ALLIANCE FOR SUSTAINABLE ENERGY LLC	THIN FILM BURIED ANODE BATTERY
EP2058918	2008	2009	HONEYWELL INTERNATION AL INC	HYBRID POWER SOURCE
EP2067197	2007	2009	UNIVERSITY OF TEXAS	SURFACE AND BULK MODIFIED HIGH CAPACITY LAYERED OXIDE CATHODES WITH LOW IRREVERSIBLE CAPACITY LOSS
EP2067198	2007	2009	UNIVERSITY OF TEXAS	CATION-SUBSTITUTED SPINEL OXIDE AND OXYFLUORIDE CATHODES FOR LITHIUM ION BATTERIES
EP2109868	2007	2009	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
WO2009029111	2007	2009	MIDWEST RESEARCH INSTITUTE	THIN-FILM LITHIUM-BASED BATTERIES AND ELECTROCHROMIC DEVICES FABRICATED WITH NANOCOMPOSITE ELECTRODE MATERIALS

WO2009108184	2008	2009	MIDWEST RESEARCH INSTITUTE	HOMOGENEOUS, DUAL LAYER, SOLID STATE, THIN FILM DEPOSITION FOR STRUCTURAL AND/OR ELECTROCHEMICAL CHARACTERISTICS
WO2009123784	2009	2009	DREXEL UNIVERSITY	SUPERCAPACITOR COMPOSITIONS, DEVICES, AND RELATED METHODS
7678503	2007	2010	UNIVERSITY OF TEXAS	SURFACE AND BULK MODIFIED HIGH CAPACITY LAYERED OXIDE CATHODES WITH LOW IRREVERSIBLE CAPACITY LOSS
7718319	2007	2010	UNIVERSITY OF TEXAS	CATION-SUBSTITUTED SPINEL OXIDE AND OXYFLUORIDE CATHODES FOR LITHIUM ION BATTERIES
7718321	2004	2010	QUALLION LLC	BATTERY HAVING ELECTROLYTE INCLUDING ORGANOBORATE SALT
7781102	2004	2010	CALIFORNIA INST TECHNOLOGY; CNRS	HIGH-CAPACITY NANOSTRUCTURED GERMANIUM-CONTAINING MATERIALS AND LITHIUM ALLOYS THEREOF
7807063	2004	2010	GINER ELECTROCHEMICAL SYSTEMS LLC	SOLID POLYMER ELECTROLYTE COMPOSITE MEMBRANE COMPRISING PLASMA ETCHED POROUS SUPPORT
7833666	2007	2010	ARIZONA STATE UNIVERSITY	ELECTRIC CURRENT-PRODUCING DEVICE HAVING SULFONE-BASED ELECTROLYTE
7846585	2008	2010	UCHICAGO ARGONNE LLC	SILVER MANGANESE VANADIUM OXIDE ELECTRODES FOR LITHIUM BATTERIES
EP2248218	2008	2010	ALLIANCE FOR SUSTAINABLE ENERGY LLC	HOMOGENEOUS, DUAL LAYER, SOLID STATE, THIN FILM DEPOSITION FOR STRUCTURAL AND/OR ELECTROCHEMICAL CHARACTERISTICS
WO2010014215	2009	2010	BATTELLE MEMORIAL INSTITUTE/PRINCETON UNIV	NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
WO2010030361	2009	2010	BATTELLE MEMORIAL INSTITUTE/PRINCETON UNIV	MESOPOROUS METAL OXIDE GRAPHENE NANOCOMPOSITE MATERIALS
WO2010105062	2010	2010	CALIFORNIA INST TECHNOLOGY; CNRS	A BATTERY STATE OF HEALTH ASSESSMENT SYSTEM
WO2010107496	2010	2010	LOS ALAMOS NATIONAL SECURITY LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
WO2010144153	2010	2010	UNIVERSITY OF CALIFORNIA	MESOPOROUS NANOCRYSTALLINE FILM ARCHITECTURE FOR CAPACITIVE STORAGE DEVICES
7875219	2007	2011	NANOTEK INSTRUMENTS	PROCESS FOR PRODUCING NANO-SCALED GRAPHENE PLATELET

			INC	NANOCOMPOSITE ELECTRODES FOR SUPERCAPACITORS
7902299	2005	2011	UNIVERSITY OF CALIFORNIA	SINGLE ION CONDUCTOR CROSS-LINKED POLYMERIC NETWORKS
7936076	2008	2011	UT-BATTELLE LLC	UTILIZATION OF ROTOR KINETIC ENERGY STORAGE FOR HYBRID VEHICLES
7947397	2007	2011	SANDIA CORP	BATTERY COMPONENTS EMPLOYING A SILICATE BINDER
7981319	2009	2011	LOS ALAMOS NATIONAL SECURITY LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
7988746	2010	2011	A123 SYSTEMS INC/MIT	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
8057900	2008	2011	TOYOTA MOTOR CO/UNIV NEW MEXICO	MATERIAL WITH CORE-SHELL STRUCTURE
8057949	2007	2011	FORD GLOBAL TECHNOLOGIES INC	FUEL CELL STACK FLOW DIVERSION
8076031	2005	2011	QUALLION LLC	ELECTROCHEMICAL DEVICE HAVING ELECTROLYTE INCLUDING DISILOXANE
8076032	2005	2011	QUALLION LLC	ELECTROLYTE INCLUDING SILANE FOR USE IN ELECTROCHEMICAL DEVICES
EP2278643	2002	2011	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
EP2318311	2009	2011	BATTELLE MEMORIAL INSTITUTE	NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
EP2331460	2009	2011	BATTELLE MEMORIAL INSTITUTE	MESOPOROUS METAL OXIDE GRAPHENE NANOCOMPOSITE MATERIALS
WO2011019764	2010	2011	BATTELLE MEMORIAL INSTITUTE	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
WO2011019765	2010	2011	BATTELLE MEMORIAL INSTITUTE	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
WO2011038233	2010	2011	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH-PERFORMANCE RECHARGEABLE BATTERIES WITH FAST SOLID-STATE ION CONDUCTORS
WO2011057074	2010	2011	NORTHWESTERN UNIVERSITY	ELECTRODE MATERIAL COMPRISING GRAPHENE-COMPOSITE MATERIALS IN A GRAPHITE NETWORK
WO2011156419	2011	2011	UNIVERSITY OF CALIFORNIA	LITHIUM ION BATTERIES BASED ON NANOPOROUS SILICON

WO2011156776	2011	2011	UNIVERSITY OF CALIFORNIA	SMART ELECTRIC VEHICLE (EV) CHARGING AND GRID INTEGRATION APPARATUS AND METHODS
WO2011162806	2011	2011	STANFORD UNIV	HIGH ENERGY STORAGE CAPACITOR BY EMBEDDING TUNNELING NANO-STRUCTURES
8114547	2011	2012	FORD GLOBAL TECHNOLOGIES INC	FUEL CELL STACK FLOW DIVERSION
8119273	2007	2012	US DEPT OF ENERGY	UNIQUE BATTERY WITH AN ACTIVE MEMBRANE SEPARATOR HAVING UNIFORM PHYSICO-CHEMICALLY FUNCTIONALIZED ION CHANNELS AND A METHOD MAKING THE SAME
8129052	2006	2012	POLYPLUS BATTERY CO	POLYMER ADHESIVE SEALS FOR PROTECTED ANODE ARCHITECTURES
8148013	2007	2012	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
8168326	2009	2012	A123 SYSTEMS INC/MIT	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
8187746	2009	2012	UCHICAGO ARGONNE LLC	SURFACE MODIFICATION AGENTS FOR LITHIUM BATTERIES
8193761	2007	2012	HONEYWELL INTERNATIONAL INC	HYBRID POWER SOURCE
8206468	2010	2012	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
8206469	2011	2012	A123 SYSTEMS INC/MIT	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
8227105	2007	2012	US DEPT OF ENERGY	UNIQUE BATTERY WITH A MULTI-FUNCTIONAL, PHYSICOCHEMICALLY ACTIVE MEMBRANE SEPARATOR/ELECTROLYTE-ELECTRODE MONOLITH AND A METHOD MAKING THE SAME
8236207	2010	2012	LOS ALAMOS NATIONAL SECURITY LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS REFERENCE TO RELATED APPLICATION
8241789	2010	2012	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES AND RELATED METHODS
8257867	2009	2012	BATTELLE MEMORIAL INSTITUTE	NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
8292974	2012	2012	UCHICAGO ARGONNE LLC	SURFACE MODIFICATION AGENTS FOR LITHIUM BATTERIES

8315039	2009	2012	NANOTEK INSTRUMENTS INC	SPACER-MODIFIED NANO GRAPHENE ELECTRODES FOR SUPERCAPACITORS
EP2408873	2010	2012	LOS ALAMOS NATIONAL SECURITY LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
EP2465157	2010	2012	BATTELLE MEMORIAL INSTITUTE	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
EP2465158	2010	2012	BATTELLE MEMORIAL INSTITUTE	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
WO2012009010	2011	2012	STANFORD UNIV	ENERGY STORAGE DEVICE WITH LARGE CHARGE SEPARATION
WO2012012713	2011	2012	UNIVERSITY OF DELAWARE	LITHIUM BATTERIES HAVING ANODES BASED ON POLYTHIOCYANOGEN
WO2012047329	2011	2012	BATTELLE MEMORIAL INSTITUTE	GRAPHENE-SULFUR NANOCOMPOSITES FOR RECHARGEABLE LITHIUM-SULFUR BATTERY ELECTRODES
WO2012047372	2011	2012	BATTELLE MEMORIAL INSTITUTE	TITANIA-GRAPHENE ANODE ELECTRODE PAPER
WO2012048194	2011	2012	BATTELLE MEMORIAL INSTITUTE	LITHIUM ION BATTERIES WITH TITANIA/GRAPHENE ANODES
WO2012050682	2011	2012	APPLIED MATERIALS INC	ELECTROSPINNING FOR INTEGRATED SEPARATOR FOR LITHIUM-ION BATTERIES
WO2012051619	2011	2012	UNIVERSITY OF WASHINGTON	V2O5 ELECTRODES WITH HIGH POWER AND ENERGY DENSITIES
WO2012064702	2011	2012	CORNELL UNIVERSITY	SULFUR CONTAINING NANOPOROUS MATERIALS, NANOPARTICLES, METHODS AND APPLICATIONS
WO2012112481	2012	2012	DREXEL UNIVERSITY	ELECTROCHEMICAL FLOW CAPACITORS
WO2012148596	2012	2012	ELECTRIC TRANSPORTATION ENGINEERING CORP	SYSTEM FOR MEASURING ELECTRICITY AND METHOD OF PROVIDING AND USING THE SAME
WO2012158608	2012	2012	ENVIA SYSTEMS INC	SILICON OXIDE BASED HIGH CAPACITY ANODE MATERIALS FOR LITHIUM ION BATTERIES
WO2012159001	2012	2012	BATTELLE MEMORIAL INSTITUTE	NANOMATERIALS FOR SODIUM-ION BATTERIES
WO2012167010	2012	2012	CORNELL UNIVERSITY	MANGANESE OXIDE NANOPARTICLES, METHODS AND APPLICATIONS
WO2012170749	2012	2012	FASTCAP SYSTEMS CORP	ENERGY STORAGE MEDIA FOR ULTRACAPACITORS
WO2012174235	2012	2012	BROOKHAVEN SCIENCE	INTERMETALLIC M-SN5 (M=FE, CU, CO, NI) COMPOUND AND A METHOD

			ASSOCIATES LLC	OF SYNTHESIS THEREOF
WO2012174433	2012	2012	UNIVERSITY OF SOUTHERN CALIFORNIA	HIGH EFFICIENCY IRON ELECTRODE AND ADDITIVES FOR USE IN RECHARGEABLE IRON-BASED BATTERIES
WO2012177932	2012	2012	STANFORD UNIV	HIGH RATE, LONG CYCLE LIFE BATTERY ELECTRODE MATERIALS WITH AN OPEN FRAMEWORK STRUCTURE
8389157	2009	2013	ALLIANCE FOR SUSTAINABLE ENERGY LLC	ORIENTED NANOTUBE ELECTRODES FOR LITHIUM ION BATTERIES AND SUPERCAPACITORS
8394298	2011	2013	LOS ALAMOS NATIONAL SECURITY LLC	NON-AQUEOUS LIQUID COMPOSITIONS COMPRISING ION EXCHANGE POLYMERS
8404613	2010	2013	BROOKHAVEN SCIENCE ASSOCIATES LLC	PLATINUM-BASED ELECTROCATALYSTS SYNTHESIZED BY DEPOSITING CONTIGUOUS ADLAYERS ON CARBON NANOSTRUCTURES
8445136	2011	2013	POLYPLUS BATTERY CO	LITHIUM/SULFUR BATTERY WITH HERMETICALLY SEALED ANODE
8446127	2009	2013	CALIFORNIA INST TECHNOLOGY; CNRS	METHODS FOR THERMODYNAMIC EVALUATION OF BATTERY STATE OF HEALTH
8450014	2010	2013	BATTELLE MEMORIAL INSTITUTE	LITHIUM ION BATTERIES WITH TITANIA/GRAPHENE ANODES
8460823	2010	2013	SANDIA CORP	ELECTROCHEMICAL COMPONENTS EMPLOYING POLYSILOXANE-DERIVED BINDERS
8498097	2009	2013	DREXEL UNIVERSITY	SUPERCAPACITOR COMPOSITIONS, DEVICES AND RELATED METHODS
8551650	2011	2013	NORTHWESTERN UNIVERSITY	GRAPHENE MATERIALS HAVING RANDOMLY DISTRIBUTED TWO-DIMENSIONAL STRUCTURAL DEFECTS
8557441	2010	2013	BATTELLE MEMORIAL INSTITUTE	TITANIA-GRAPHENE ANODE ELECTRODE PAPER
8557442	2012	2013	BATTELLE MEMORIAL INSTITUTE/PRINCETON UNIV	NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
8563169	2012	2013	BATTELLE MEMORIAL INSTITUTE	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
8580430	2012	2013	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES, AND RELATED METHODS
8580438	2010	2013	LAWRENCE LIVERMORE NATIONAL	MONOLITHIC THREE-DIMENSIONAL ELECTROCHEMICAL ENERGY STORAGE SYSTEM ON AEROGEL OR

			SECURITY LLC	NANOTUBE SCAFFOLD
8586238	2012	2013	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	BATTERY STRUCTURES, SELF-ORGANIZING STRUCTURES, AND RELATED METHODS
8592075	2012	2013	US DEPT OF ENERGY	UNIQUE BATTERY WITH A MULTI-FUNCTIONAL, PHYSICOCHEMICALLY ACTIVE MEMBRANE SEPARATOR/ELECTROLYTE-ELECTRODE MONOLITH AND A METHOD MAKING THE SAME
8595122	2012	2013	ELECTRIC TRANSPORTATION ENGINEERING CORP	SYSTEM FOR MEASURING ELECTRICITY AND METHOD OF PROVIDING AND USING THE SAME
8615812	2010	2013	ADVANCED FUEL RESEARCH INC	HIGH-STRENGTH POROUS CARBON AND ITS MULTIFUNCTIONAL APPLICATIONS
EP2586047	2011	2013	STANFORD UNIV	HIGH ENERGY STORAGE CAPACITOR BY EMBEDDING TUNNELING NANO-STRUCTURES
EP2625735	2011	2013	BATTELLE MEMORIAL INSTITUTE	GRAPHENE-SULFUR NANOCOMPOSITES FOR RECHARGEABLE LITHIUM-SULFUR BATTERY ELECTRODES AND METHOD FOR THEIR PREPARATION.
EP2638581	2011	2013	UNIVERSITY OF WASHINGTON	V2O5 ELECTRODES WITH HIGH POWER AND ENERGY DENSITIES
EP2638584	2011	2013	CORNELL UNIVERSITY	SULFUR CONTAINING NANOPOROUS MATERIALS, NANOPARTICLES, METHODS AND APPLICATIONS
WO2013009457	2012	2013	APPLIED MATERIALS INC	METHODS TO FABRICATE VARIATIONS IN POROSITY OF LITHIUM ION BATTERY ELECTRODE FILMS
WO2013028574	2012	2013	POLYPLUS BATTERY CO	AQUEOUS LITHIUM AIR BATTERIES
WO2013040067	2012	2013	STANFORD UNIV	ENCAPSULATED SULFUR CATHODES FOR RECHARGEABLE LITHIUM BATTERIES
WO2013048597	2012	2013	UCHICAGO ARGONNE LLC	HIGH CAPACITY ELECTRODE MATERIALS FOR BATTERIES AND PROCESS FOR THEIR MANUFACTURE
WO2013049663	2012	2013	UNIVERSITY OF CALIFORNIA	GRAPHENE OXIDE AS A SULFUR IMMOBILIZER IN HIGH PERFORMANCE LITHIUM/SULFUR CELLS
WO2013052294	2012	2013	BATTELLE ENERGY ALLIANCE LLC	IONIC LIQUIDS, ELECTROLYTE SOLUTIONS INCLUDING THE IONIC LIQUIDS, AND ENERGY STORAGE DEVICES INCLUDING THE IONIC LIQUIDS

WO2013055573	2012	2013	SION POWER CORP	ELECTRODE STRUCTURE AND METHOD FOR MAKING THE SAME
WO2013066448	2012	2013	BATTELLE MEMORIAL INSTITUTE	POLYMER-SULFUR COMPOSITE MATERIALS FOR ELECTRODES IN LI-S ENERGY STORAGE DEVICES
WO2013074772	2012	2013	POLYPLUS BATTERY CO	AQUEOUS ELECTROLYTE LITHIUM SULFUR BATTERIES
WO2013119295	2012	2013	WILLIAM MARSH RICE UNIVERSITY	GRAPHENE-CARBON NANOTUBE HYBRID MATERIALS AND USE AS ELECTRODES
WO2013122868	2013	2013	UT-BATTELLE LLC	MESOPOROUS METAL OXIDE MICROSPHERE ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
WO2013123339	2013	2013	PRINCETON UNIVERSITY/VORBECK MATERIALS CORP	GRAPHENE-IONIC LIQUID COMPOSITES
WO2013147958	2012	2013	ENVIA SYSTEMS INC	POROUS SILICON BASED ANODE MATERIAL FORMED USING METAL REDUCTION
WO2013155507	2013	2013	SEEO INC	SMALL DOMAIN-SIZE MULTIBLOCK COPOLYMER ELECTROLYTES
WO2013177132	2013	2013	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	BATTERY MANAGEMENT SYSTEM WITH DISTRIBUTED WIRELESS SENSORS
WO2013188265	2013	2013	24M TECHNOLOGIES INC	ELECTROCHEMICAL SLURRY COMPOSITIONS AND METHODS FOR PREPARING THE SAME
8629076	2011	2014	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH SURFACE AREA SILICON CARBIDE-COATED CARBON AEROGEL
8643930	2007	2014	ALLIANCE FOR SUSTAINABLE ENERGY LLC	THIN FILM LITHIUM-BASED BATTERIES AND ELECTROCHROMIC DEVICES FABRICATED WITH NANOCOMPOSITE ELECTRODE MATERIALS
8664143	2011	2014	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH SURFACE AREA, ELECTRICALLY CONDUCTIVE NANOCARBON-SUPPORTED METAL OXIDE
8675346	2011	2014	UNIVERSITY OF CALIFORNIA	MESOPOROUS NANOCRYSTALLINE FILM ARCHITECTURE FOR CAPACITIVE STORAGE DEVICES
8691177	2011	2014	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
8691444	2013	2014	POLYPLUS BATTERY CO	LITHIUM BATTERY WITH HERMETICALLY SEALED ANODE
8691447	2008	2014	ALLIANCE FOR SUSTAINABLE ENERGY LLC	HOMOGENEOUS, DUAL LAYER, SOLID STATE, THIN FILM DEPOSITION FOR STRUCTURAL AND/OR ELECTROCHEMICAL CHARACTERISTICS

8699207	2009	2014	BROOKHAVEN SCIENCE ASSOCIATES LLC	ELECTRODES SYNTHESIZED FROM CARBON NANOSTRUCTURES COATED WITH A SMOOTH AND CONFORMAL METAL ADLAYER
8722246	2010	2014	UNIVERSITY OF TEXAS	CATION-SUBSTITUTED SPINEL OXIDE AND OXYFLUORIDE CATHODES FOR LITHIUM ION BATTERIES
8722256	2010	2014	UT-BATTELLE LLC	MULTI-LAYERED, CHEMICALLY BONDED LITHIUM-ION AND LITHIUM/AIR BATTERIES
8734674	2012	2014	NORTHWESTERN UNIVERSITY	METHOD OF ENHANCED LITHIATION OF DOPED SILICON CARBIDE VIA HIGH TEMPERATURE ANNEALING IN AN INERT ATMOSPHERE
8734988	2011	2014	UNIVERSITY OF DELAWARE	LITHIUM BATTERIES HAVING ANODES BASED ON POLYTHIOCYANOGEN
8753772	2011	2014	BATTELLE MEMORIAL INSTITUTE	GRAPHENE-SULFUR NANOCOMPOSITES FOR RECHARGEABLE LITHIUM-SULFUR BATTERY ELECTRODES
8765295	2011	2014	UNIVERSITY OF CHICAGO	ELECTROLYTE INCLUDING SILANE FOR USE IN ELECTROCHEMICAL DEVICES
8765303	2012	2014	NANOTEK INSTRUMENTS INC	LITHIUM-ION CELL HAVING A HIGH ENERGY DENSITY AND HIGH POWER DENSITY
8778538	2010	2014	NORTHWESTERN UNIVERSITY	ELECTRODE MATERIAL COMPRISING GRAPHENE-COMPOSITE MATERIALS IN A GRAPHITE NETWORK
8778540	2013	2014	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	MONOLITHIC THREE-DIMENSIONAL ELECTROCHEMICAL ENERGY STORAGE SYSTEM ON AEROGEL OR NANOTUBE SCAFFOLD
8778546	2010	2014	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	AIR BREATHING LITHIUM POWER CELLS
8828533	2012	2014	UT-BATTELLE LLC	MESOPOROUS CARBON MATERIALS
8828574	2012	2014	POLYPLUS BATTERY CO	ELECTROLYTE COMPOSITIONS FOR AQUEOUS ELECTROLYTE LITHIUM SULFUR BATTERIES
8828575	2012	2014	POLYPLUS BATTERY CO	AQUEOUS ELECTROLYTE LITHIUM SULFUR BATTERIES
8835046	2010	2014	BATTELLE MEMORIAL INSTITUTE	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
8852807	2012	2014	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CONDUCTIVE LITHIUM STORAGE ELECTRODE
8877367	2010	2014	STANFORD	HIGH ENERGY STORAGE

			UNIV	CAPACITOR BY EMBEDDING TUNNELING NANO-STRUCTURES
8877388	2012	2014	SANDIA CORP	SOLID-STATE LITHIUM BATTERY
8901892	2013	2014	CALIFORNIA INST TECHNOLOGY; CNRS	METHODS AND SYSTEMS FOR THERMODYNAMIC EVALUATION OF BATTERY STATE OF HEALTH
8911904	2012	2014	UT-BATTELLE LLC	MESOPOROUS METAL OXIDE MICROSPHERE ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
8920970	2009	2014	UNIVERSITY OF LOUISVILLE	ANODE MATERIALS FOR LITHIUM-ION BATTERIES
8921611	2012	2014	UCHICAGO ARGONNE LLC	PROCESS FOR PRODUCING REDOX SHUTTLES
EP2718945	2012	2014	FASTCAP SYSTEMS CORP	ENERGY STORAGE MEDIA FOR ULTRACAPACITORS
EP2721688	2012	2014	UNIVERSITY OF SOUTHERN CALIFORNIA	HIGH EFFICIENCY IRON ELECTRODE AND ADDITIVES FOR USE IN RECHARGEABLE IRON-BASED BATTERIES
EP2724398	2012	2014	STANFORD UNIV	HIGH RATE, LONG CYCLE LIFE BATTERY ELECTRODE MATERIALS WITH AN OPEN FRAMEWORK STRUCTURE
EP2748882	2012	2014	STANFORD UNIV	ENCAPSULATED SULFUR CATHODES FOR RECHARGEABLE LITHIUM BATTERIES
EP2761688	2012	2014	UNIVERSITY OF CALIFORNIA	GRAPHENE OXIDE AS A SULFUR IMMOBILIZER IN HIGH PERFORMANCE LITHIUM/SULFUR CELLS
EP2764003	2012	2014	BATTELLE ENERGY ALLIANCE LLC	IONIC LIQUIDS, ELECTROLYTE SOLUTIONS AND ENERGY STORAGE DEVICES INCLUDING THE SAME
EP2766949	2012	2014	SION POWER CORP	ELECTRODE STRUCTURE AND METHOD FOR MAKING THE SAME
EP2780124	2012	2014	WILLIAM MARSH RICE UNIVERSITY	GRAPHENE-CARBON NANOTUBE HYBRID MATERIALS AND USE AS ELECTRODES
EP2780971	2012	2014	POLYPLUS BATTERY CO	AQUEOUS ELECTROLYTE LITHIUM SULFUR BATTERIES
WO2014018546	2013	2014	BATTELLE MEMORIAL INSTITUTE	HYBRID ENERGY STORAGE DEVICES HAVING SODIUM
WO2014025876	2013	2014	SAGE ELECTROCHROMICS INC/ALLIANCE FOR SUSTAINABLE ENERGY LLC	TERNARY NICKEL OXIDE MATERIALS FOR ELECTROCHROMIC DEVICES
WO2014062898	2013	2014	THE UNIVERSITY OF NORTH CAROLINA AT	ION CONDUCTING POLYMERS AND POLYMER BLENDS FOR ALKALI METAL ION BATTERIES

			CHAPEL HILL	
WO2014074504	2013	2014	CORNELL UNIVERSITY	CARBON DIOXIDE ASSISTED METAL-OXYGEN BATTERY AND RELATED METHOD
WO2014081793	2013	2014	UT-BATTELLE LLC; US DEPT ENERGY	NITROGEN-SULFUR-CARBON NANOCOMPOSITES AND THEIR APPLICATION AS CATHODE MATERIALS IN LITHIUM-SULFUR BATTERIES
WO2014116335	2013	2014	STANFORD UNIV	SEAL-HEALING COMPOSITES AND APPLICATIONS THEREOF
WO2014124366	2014	2014	WILDCAT DISCOVERY TECHNOLOGIES INC	HIGH ENERGY CATHODE MATERIAL
WO2014150210	2014	2014	24M TECHNOLOGIES INC	ASYMMETRIC BATTERY HAVING A SEMI-SOLID CATHODE AND HIGH ENERGY DENSITY ANODE
WO2014150763	2014	2014	LOS ALAMOS NATIONAL SECURITY LLC	ANTI-PEROVSKITE SOLID ELECTROLYTE COMPOSITIONS
WO2014153503	2014	2014	CORNELL UNIVERSITY/HUAZHONG UNIV SCI TECH	CARBON MATERIAL SUPPORTED HOLLOW METAL OXIDE NANOPARTICLES, METHODS AND APPLICATIONS
WO2014176584	2014	2014	CORNELL UNIVERSITY	CARBON MATERIAL SUPPORTED HOLLOW METAL OXIDE NANOPARTICLES, METHODS AND APPLICATIONS
WO2014190180	2014	2014	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	LI-ION BATTERY THERMAL RUNAWAY SUPPRESSION SYSTEM USING MICROCHANNEL COOLERS AND REFRIGERANT INJECTIONS
WO2014190183	2014	2014	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	ENERGY STORAGE MANAGEMENT SYSTEM WITH DISTRIBUTED WIRELESS SENSORS
8926932	2007	2015	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
8927068	2012	2015	APPLIED MATERIALS INC	METHODS TO FABRICATE VARIATIONS IN POROSITY OF LITHIUM ION BATTERY ELECTRODE FILMS
8936870	2012	2015	SION POWER CORP	ELECTRODE STRUCTURE AND METHOD FOR MAKING THE SAME
8940444	2012	2015	ALLIANCE FOR SUSTAINABLE ENERGY LLC	HYBRID RADICAL ENERGY STORAGE DEVICE AND METHOD OF MAKING
8947854	2012	2015	NANOTEK INSTRUMENTS INC	SPACER-MODIFIED GRAPHENE ELECTRODE FOR SUPERCAPACITOR
8951671	2012	2015	US DEPT OF ENERGY	TERNARY ALKALI-METAL AND TRANSITION METAL OR METALLOID ACETYLIDES AS ALKALI-METAL INTERCALATION ELECTRODES FOR BATTERIES

8951673	2012	2015	STANFORD UNIV	HIGH RATE, LONG CYCLE LIFE BATTERY ELECTRODE MATERIALS WITH AN OPEN FRAMEWORK STRUCTURE
8958198	2012	2015	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	SUPER CAPACITOR WITH FIBERS
8962188	2010	2015	NANOTEK INSTRUMENTS INC	ANODE COMPOSITIONS FOR LITHIUM SECONDARY BATTERIES
8993113	2011	2015	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	GRAPHENE AEROGELS
8995041	2013	2015	SAGE ELECTROCHROMICS INC/ALLIANCE FOR SUSTAINABLE ENERGY LLC	TERNARY NICKEL OXIDE MATERIALS FOR ELECTROCHROMIC DEVICES
8999574	2014	2015	BATTELLE MEMORIAL INSTITUTE	METHOD OF PREPARING GRAPHENE-SULFUR NANOCOMPOSITES FOR RECHARGEABLE LITHIUM-SULFUR BATTERY ELECTRODES
9001495	2012	2015	FASTCAP SYSTEMS CORP	HIGH POWER AND HIGH ENERGY ELECTRODES USING CARBON NANOTUBES
9005816	2013	2015	UCHICAGO ARGONNE LLC	COATING OF POROUS CARBON FOR USE IN LITHIUM AIR BATTERIES
9017756	2010	2015	NANOTEK INSTRUMENTS INC	CONTINUOUS PROCESS FOR PRODUCING SPACER-MODIFIED NANO GRAPHENE ELECTRODES FOR SUPERCAPACITORS
9017867	2009	2015	BATTELLE MEMORIAL INSTITUTE/PRINCETON UNIV	SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
9023529	2012	2015	BATTELLE MEMORIAL INSTITUTE	NANOMATERIALS FOR SODIUM-ION BATTERIES
9026347	2012	2015	UNIVERSITY OF CALIFORNIA	SMART ELECTRIC VEHICLE (EV) CHARGING AND GRID INTEGRATION APPARATUS AND METHODS
9040197	2013	2015	SION POWER CORP	ELECTRODE STRUCTURE AND METHOD FOR MAKING THE SAME
9040200	2013	2015	BATTELLE MEMORIAL INSTITUTE	TITANIA-GRAPHENE ANODE ELECTRODE PAPER
9054361	2012	2015	GENERAL MOTORS CORP	UTILIZING VACUUM TO PRE-COMPRESS FOAM TO ENABLE CELL INSERTION DURING HV BATTERY MODULE ASSEMBLY
9065115	2012	2015	UCHICAGO	SURFACE MODIFICATION AGENTS

			ARGONNE LLC	FOR LITHIUM BATTERIES
9065122	2011	2015	APPLIED MATERIALS INC	ELECTROSPINNING FOR INTEGRATED SEPARATOR FOR LITHIUM-ION BATTERIES
9070942	2013	2015	BATTELLE MEMORIAL INSTITUTE/PRINCETON UNIV	NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS
9079249	2011	2015	UCHICAGO ARGONNE LLC	INTERMETALLIC NANOPARTICLES
9082524	2014	2015	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH SURFACE AREA, ELECTRICALLY CONDUCTIVE NANOCARBON-SUPPORTED METAL OXIDE
9093707	2007	2015	ALLIANCE FOR SUSTAINABLE ENERGY LLC	MULTILAYER SOLID ELECTROLYTE FOR LITHIUM THIN FILM BATTERIES
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
9112243	2013	2015	BATTELLE MEMORIAL INSTITUTE	ENERGY STORAGE DEVICES HAVING ANODES CONTAINING MG AND ELECTROLYTES UTILIZED THEREIN
9123959	2014	2015	WILDCAT DISCOVERY TECHNOLOGIES INC	HIGH ENERGY CATHODE MATERIAL
9139441	2012	2015	ENVIA SYSTEMS INC	POROUS SILICON BASED ANODE MATERIAL FORMED USING METAL REDUCTION
9142833	2011	2015	UNIVERSITY OF CALIFORNIA	LITHIUM ION BATTERIES BASED ON NANOPOROUS SILICON
9150968	2013	2015	BROOKHAVEN SCIENCE ASSOCIATES LLC	PLATINUM-BASED ELECTROCATALYSTS SYNTHESIZED BY DEPOSITING CONTIGUOUS ADLAYERS ON CARBON NANOSTRUCTURES
9171679	2012	2015	DREXEL UNIVERSITY	ELECTROCHEMICAL FLOW CAPACITORS
9187806	2015	2015	UCHICAGO ARGONNE LLC	INTERMETALLIC NANOPARTICLES
9190667	2008	2015	NANOTEK INSTRUMENTS INC	GRAPHENE NANOCOMPOSITES FOR ELECTROCHEMICAL CELL ELECTRODES
9203112	2012	2015	UCHICAGO ARGONNE LLC	REDOX SHUTTLES HAVING AN AROMATIC RING FUSED TO A 1,1,4,4-TETRASUBSTITUTED CYCLOHEXANE RING
9206210	2011	2015	BATTELLE ENERGY ALLIANCE LLC	IONIC LIQUIDS, ELECTROLYTE SOLUTIONS INCLUDING THE IONIC LIQUIDS, AND ENERGY STORAGE

				DEVICES INCLUDING THE IONIC LIQUIDS
9209494	2014	2015	PALO ALTO RESEARCH CENTER INC	MONITORING/MANAGING ELECTROCHEMICAL ENERGY DEVICE USING DETECTED INTERCALATION STAGE CHANGES
9209501	2013	2015	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	ENERGY STORAGE MANAGEMENT SYSTEM WITH DISTRIBUTED WIRELESS SENSORS
9214695	2014	2015	BATTELLE MEMORIAL INSTITUTE	HYBRID ANODES FOR REDOX FLOW BATTERIES
9217198	2012	2015	ITN ENERGY SYSTEMS INC	INSERTION OF LITHIUM INTO ELECTROCHROMIC DEVICES AFTER COMPLETION
9218917	2012	2015	FASTCAP SYSTEMS CORP	ENERGY STORAGE MEDIA FOR ULTRACAPACITORS
EP2862226	2013	2015	24M TECHNOLOGIE S INC	ELECTROCHEMICAL SLURRY COMPOSITIONS AND METHODS FOR PREPARING THE SAME
EP2883107	2013	2015	SAGE ELECTROCHRO MICS INC/ALLIANCE FOR SUSTAINABLE ENERGY LLC	LITHIUM METAL OXIDE MATERIALS FOR ELECTROCHROMIC DEVICES
EP2909886	2013	2015	THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL	ION CONDUCTING POLYMERS AND POLYMER BLENDS FOR ALKALI METAL ION BATTERIES
EP2928006	2015	2015	PALO ALTO RESEARCH CENTER INC	METHOD FOR MONITORING/MANAGING ELECTROCHEMICAL ENERGY DEVICE BY DETECTING INTERCALATION STAGE CHANGES
EP2937928	2015	2015	PALO ALTO RESEARCH CENTER INC	BATTERY MANAGEMENT BASED ON INTERNAL OPTICAL SENSING
WO2015006279	2014	2015	STANFORD UNIV	STABLE CYCLING OF LITHIUM SULFIDE CATHODES THROUGH STRONG AFFINITY WITH MULTIFUNCTIONAL BINDERS
WO2015031841	2014	2015	UNIVERSITY OF TEXAS	DOPED GRAPHITE OXIDE AND DOPED GRAPHENE, METHODS FOR PRODUCING THE SAME, ELECTRODES AND ULTRACAPACITORS COMPRISING THE SAME
WO2015085290	2014	2015	UNIVERSITY OF CALIFORNIA	POLYMER NETWORK SINGLE ION CONDUCTORS
WO2015118857	2015	2015	SHARP LABORATORIE	CYANOMETALLATE CATHODE BATTERY AND METHOD FOR

			S OF AMERICA INC	FABRICATION
WO2015143088	2015	2015	MOTIVO ENGINEERING LLC	MOBILE POWER CONVERSION AND DISTRIBUTION SYSTEM
WO2015160334	2014	2015	UCHICAGO ARGONNE LLC	LITHIUM-SULFUR BATTERIES
WO2015179831	2015	2015	BATTELLE ENERGY ALLIANCE LLC	ELECTROLYTE SOLUTIONS INCLUDING A PHOSPHORANIMINE COMPOUND, AND ENERGY STORAGE DEVICES INCLUDING SAME
WO2015181210	2015	2015	BASF SE; SION POWER CORP	POLYMER FOR USE AS PROTECTIVE LAYERS AND OTHER COMPONENTS IN ELECTROCHEMICAL CELLS
WO2015196052	2015	2015	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LUBRICANT-IMPREGNATED SURFACES FOR ELECTROCHEMICAL APPLICATIONS, AND DEVICES AND SYSTEMS USING SAME
9246188	2013	2016	LOS ALAMOS NATIONAL SECURITY LLC	ANTI-PEROVSKITE SOLID ELECTROLYTE COMPOSITIONS
9252461	2013	2016	BATTELLE MEMORIAL INSTITUTE	HYBRID ENERGY STORAGE DEVICES HAVING SODIUM
9267993	2013	2016	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	BATTERY MANAGEMENT SYSTEM WITH DISTRIBUTED WIRELESS SENSORS
9300009	2012	2016	UT-BATTELLE LLC	ELECTROLYTE COMPOSITIONS FOR LITHIUM ION BATTERIES
9300010	2013	2016	UNIVERSITY OF CALIFORNIA	SOLID LITHIUM ELECTROLYTE VIA ADDITION OF LITHIUM SALTS TO METAL-ORGANIC FRAMEWORKS
9312398	2011	2016	STANFORD UNIV	ENERGY STORAGE DEVICE WITH LARGE CHARGE SEPARATION
9324992	2014	2016	ALLIANCE FOR SUSTAINABLE ENERGY LLC	HYBRID RADICAL ENERGY STORAGE DEVICE AND METHOD OF MAKING
9325030	2012	2016	SAVANNAH RIVER NUCLEAR SOLUTIONS LLC	HIGH ENERGY DENSITY BATTERY BASED ON COMPLEX HYDRIDES
9346680	2009	2016	BATTELLE MEMORIAL INSTITUTE	MESOPOROUS METAL OXIDE GRAPHENE NANOCOMPOSITE MATERIALS
9352968	2013	2016	NORTHWESTERN UNIVERSITY	GRAPHENE MATERIALS HAVING RANDOMLY DISTRIBUTED TWO-DIMENSIONAL STRUCTURAL DEFECTS
9359695	2012	2016	UT-BATTELLE LLC	LIGNIN-BASED ACTIVE ANODE MATERIALS SYNTHESIZED FROM LOW-COST RENEWABLE RESOURCES
9368775	2014	2016	POLYPLUS	PROTECTED LITHIUM ELECTRODES

			BATTERY CO	HAVING POROUS CERAMIC SEPARATORS, INCLUDING AN INTEGRATED STRUCTURE OF POROUS AND DENSE LI ION CONDUCTING GARNET SOLID ELECTROLYTE LAYERS
9368789	2014	2016	UNIVERSITY OF TEXAS	NANOCOMPOSITE ANODE MATERIALS FOR SODIUM-ION BATTERIES
9368832	2012	2016	UCHICAGO ARGONNE LLC	NON-AQUEOUS ELECTROLYTES FOR ELECTROCHEMICAL CELLS
9391319	2013	2016	UCHICAGO ARGONNE LLC	HOLLOW NANOPARTICLE CATHODE MATERIALS FOR SODIUM ELECTROCHEMICAL CELLS AND BATTERIES
9397345	2013	2016	UNIVERSITY OF MISSOURI	CATHODES FOR LITHIUM-AIR BATTERY CELLS WITH ACID ELECTROLYTES
9406919	2014	2016	SHARP LABORATORIE S OF AMERICA INC	METAL CYANOMETALLATE ELECTRODE WITH SHIELD STRUCTURE
9412484	2013	2016	UNIVERSITY OF TEXAS	ULTRACAPACITOR WITH A NOVEL CARBON
9419278	2014	2016	SHARP LABORATORIE S OF AMERICA INC	RECHARGEABLE METAL-ION BATTERY WITH NON-AQUEOUS HYBRID ION ELECTROLYTE
9425001	2015	2016	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	METHOD OF MAKING SUPER CAPACITOR WITH FIBERS
9431655	2015	2016	SHARP LABORATORIE S OF AMERICA INC	ANTIOMONY AND LAYERED CARBON NETWORK BATTERY ANODE
9437864	2014	2016	24M TECHNOLOGIE S INC	ASYMMETRIC BATTERY HAVING A SEMI-SOLID CATHODE AND HIGH ENERGY DENSITY ANODE
9437899	2014	2016	BATTELLE MEMORIAL INSTITUTE	SOLID-STATE RECHARGEABLE MAGNESIUM BATTERY
9443664	2014	2016	SHARP LABORATORIE S OF AMERICA INC	SUPERCAPACITOR WITH METAL CYANOMETALLATE ANODE AND CARBONACEOUS CATHODE
9450224	2013	2016	SHARP LABORATORIE S OF AMERICA INC	SODIUM IRON(II)-HEXACYANOFERRATE(II) BATTERY ELECTRODE AND SYNTHESIS METHOD
9450272	2013	2016	SEEO INC	SMALL DOMAIN-SIZE MULTIBLOCK COPOLYMER ELECTROLYTES
9455094	2012	2016	WILLIAM MARSH RICE UNIVERSITY	GRAPHENE-CARBON NANOTUBE HYBRID MATERIALS AND USE AS ELECTRODES
9455431	2014	2016	SHARP	CYANOMETALLATE CATHODE

			LABORATORIES OF AMERICA INC	BATTERY AND METHOD FOR FABRICATION
9455439	2012	2016	UT-BATTELLE LLC	NITROGEN—SULFUR—CARBON NANOCOMPOSITES AND THEIR APPLICATION AS CATHODE MATERIALS IN LITHIUM—SULFUR BATTERIES
9455446	2015	2016	SHARP LABORATORIES OF AMERICA INC	SODIUM AND POTASSIUM ION BATTERIES WITH HALOGEN SALTS
9466853	2011	2016	UT-BATTELLE LLC/UNIV TEXAS	HIGH ENERGY DENSITY ALUMINUM BATTERY
9478782	2012	2016	UCHICAGO ARGONNE LLC	LITHIUM AIR BATTERY HAVING A CROSS-LINKED POLYSILOXANE SEPARATOR
9478798	2015	2016	SHARP LABORATORIES OF AMERICA INC	PRUSSIAN BLUE ANALOGUE ELECTRODES WITHOUT ZEOLITIC WATER CONTENT
9484158	2013	2016	PRINCETON UNIVERSITY/VORBECK MATERIALS CORP	GRAPHENE-IONIC LIQUID COMPOSITES
9484569	2013	2016	24M TECHNOLOGIES INC	ELECTROCHEMICAL SLURRY COMPOSITIONS AND METHODS FOR PREPARING THE SAME
9490045	2013	2016	STANFORD UNIV	SELF-HEALING COMPOSITES AND APPLICATIONS THEREOF
9490507	2013	2016	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	LI-ION BATTERY THERMAL RUNAWAY SUPPRESSION SYSTEM USING MICROCHANNEL COOLERS AND REFRIGERANT INJECTIONS
9515310	2013	2016	UNIVERSITY OF WASHINGTON	V(SUB)2O(SUB)5 ELECTRODES WITH HIGH POWER AND ENERGY DENSITIES
9515318	2013	2016	UT-BATTELLE LLC	MESOPOROUS METAL OXIDE MICROSPHERE ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
9517445	2013	2016	UNIVERSITY OF MISSOURI	HIGH SURFACE AREA CARBON AND PROCESS FOR ITS PRODUCTION
9525190	2016	2016	UNIVERSITY OF CALIFORNIA	SOLID LITHIUM ELECTROLYTE VIA ADDITION OF LITHIUM SALTS TO METAL-ORGANIC FRAMEWORKS
9531002	2015	2016	SHARP LABORATORIES OF AMERICA INC	TRANSITION METAL CYANOMETALLATE CATHODE BATTERY WITH METAL PLATING ANODE
9531003	2016	2016	SHARP LABORATORIES OF AMERICA INC	SODIUM IRON(II)-HEXACYANOFERRATE(II) BATTERY ELECTRODE

EP2973798	2014	2016	24M TECHNOLOGIES INC	ASYMMETRIC BATTERY HAVING A SEMI-SOLID CATHODE AND HIGH ENERGY DENSITY ANODE
WO2016018561	2015	2016	APPLE INC	HIGH-DENSITY PRECURSOR FOR MANUFACTURE OF COMPOSITE METAL OXIDE CATHODES FOR LI-ION BATTERIES
WO2016025734	2015	2016	UNIVERSITY OF HOUSTON	RECHARGEABLE ALKALINE BATTERY USING ORGANIC MATERIALS AS NEGATIVE ELECTRODES
WO2016033479	2015	2016	UNIVERSITY OF MICHIGAN	BULK FORCE IN A BATTERY PACK AND ITS APPLICATION TO STATE OF CHARGE ESTIMATION
WO2016089897	2015	2016	POLYPLUS BATTERY CO	STANDALONE SULFIDE BASED LITHIUM ION-CONDUCTING GLASS SOLID ELECTROLYTE AND ASSOCIATED STRUCTURES, CELLS AND METHODS
WO2016089899	2015	2016	POLYPLUS BATTERY CO	VITREOUS SOLID ELECTROLYTE SHEETS OF LI ION CONDUCTING SULFUR-BASED GLASS AND ASSOCIATED STRUCTURES, CELLS AND METHODS
WO2016118458	2016	2016	CORNING INC	REACTIVE SINTERING OF CERAMIC LITHIUM ION ELECTROLYTE MEMBRANES
WO2016141013	2016	2016	UT-BATTELLE LLC	ELECTROLYTES FOR SUPERCAPACITORS
9533352	2015	2017	UCHICAGO ARGONNE LLC	INTERMETALLIC NANOPARTICLES
9537131	2014	2017	SHARP LABORATORIES OF AMERICA INC	BATTERY ANODE WITH PRELOADED METALS
9543569	2013	2017	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	GRAPHENE-SUPPORTED METAL OXIDE MONOLITH
9546097	2014	2017	SHARP LABORATORIES OF AMERICA INC	METHOD FOR THE SYNTHESIS OF IRON HEXACYANOFERRATE
9548512	2013	2017	UT-BATTELLE LLC	HIGH CONDUCTING OXIDE-SULFIDE COMPOSITE LITHIUM SUPERIONIC CONDUCTOR
9553465	2014	2017	PALO ALTO RESEARCH CENTER INC	BATTERY MANAGEMENT BASED ON INTERNAL OPTICAL SENSING
9577298	2012	2017	UNIVERSITY OF SOUTHERN CALIFORNIA	HIGH EFFICIENCY IRON ELECTRODE AND ADDITIVES FOR USE IN RECHARGEABLE IRON-BASED BATTERIES
9583751	2014	2017	SHARP LABORATORIES OF AMERICA	BATTERY WITH AN ANODE PRELOAD WITH CONSUMABLE METALS

			INC	
9583796	2014	2017	PALO ALTO RESEARCH CENTER INC	METHOD FOR MONITORING/MANAGING ELECTROCHEMICAL ENERGY DEVICE BY DETECTING INTERCALATION STAGE CHANGES
9601226	2013	2017	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH-DENSITY 3D GRAPHENE-BASED MONOLITH AND RELATED MATERIALS, METHODS, AND DEVICES
9601228	2011	2017	ENVIA SYSTEMS INC	SILICON OXIDE BASED HIGH CAPACITY ANODE MATERIALS FOR LITHIUM ION BATTERIES
9601801	2014	2017	UCHICAGO ARGONNE LLC	ELECTROLYTES COMPRISING METAL AMIDE AND METAL CHLORIDES FOR MULTIVALENT BATTERY
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
9620783	2014	2017	UT-BATTELLE LLC	MESOPOROUS METAL OXIDE MICROSPHERE ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
9620815	2014	2017	SHARP LABORATORIES OF AMERICA INC	ELECTROLYTE ADDITIVES FOR TRANSITION METAL CYANOMETALLATE ELECTRODE STABILIZATION
9627671	2014	2017	SHARP LABORATORIES OF AMERICA INC	FABRICATION METHOD FOR METAL BATTERY ELECTRODE WITH PYROLYZED COATING
9627691	2014	2017	ADA TECHNOLOGIES INC	METALIZED, THREE-DIMENSIONAL STRUCTURED OXYGEN CATHODE MATERIALS FOR LITHIUM/AIR BATTERIES AND METHOD FOR MAKING AND USING THE SAME
9634317	2014	2017	SHARP LABORATORIES OF AMERICA INC	REACTIVE SEPARATOR FOR A METAL-ION BATTERY
9640334	2010	2017	NANOTEK INSTRUMENTS INC	FLEXIBLE ASYMMETRIC ELECTROCHEMICAL CELLS USING NANO GRAPHENE PLATELET AS AN ELECTRODE MATERIAL
9653219	2014	2017	UNIVERSITY OF CALIFORNIA	MESOPOROUS NANOCRYSTALLINE FILM ARCHITECTURE FOR CAPACITIVE STORAGE DEVICES
9660241	2014	2017	SHARP LABORATORIES OF AMERICA INC	NASICON-POLYMER ELECTROLYTE STRUCTURE

9660265	2015	2017	POLYPLUS BATTERY CO	LITHIUM SULFUR BATTERIES AND ELECTROLYTES AND SULFUR CATHODES THEREOF
9660268	2015	2017	SHARP LABORATORIES OF AMERICA INC	ALKALI-ION BATTERY WITH ENHANCED TRANSITION METAL CYANOMETALLATE ELECTRODE STRUCTURE
9660299	2013	2017	SOUTHWEST RESEARCH INSTITUTE	STRAIN MEASUREMENT BASED BATTERY TESTING
9660311	2012	2017	POLYPLUS BATTERY CO	AQUEOUS LITHIUM AIR BATTERIES
9666850	2016	2017	POLYPLUS BATTERY CO	SAFETY ENHANCED LI-ION AND LITHIUM METAL BATTERY CELLS HAVING PROTECTED LITHIUM ELECTRODES WITH ENHANCED SEPARATOR SAFETY AGAINST DENDRITE SHORTING
9666907	2014	2017	UT-BATTELLE LLC	THERMAL MANAGEMENT FOR HIGH-CAPACITY LARGE FORMAT LI-ION BATTERIES
9673447	2012	2017	NANOTEK INSTRUMENTS INC	METHOD OF OPERATING A LITHIUM-ION CELL HAVING A HIGH-CAPACITY CATHODE
9673452	2012	2017	UNIVERSITY OF CALIFORNIA	GRAPHENE OXIDE AS A SULFUR IMMOBILIZER IN HIGH PERFORMANCE LITHIUM/SULFUR CELLS
9673483	2015	2017	CORNING INC	REACTIVE SINTERING OF CERAMIC LITHIUM ION ELECTROLYTE MEMBRANES
9692078	2016	2017	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH-PERFORMANCE RECHARGEABLE BATTERIES WITH FAST SOLID-STATE ION CONDUCTORS
9705130	2015	2017	SHARP LABORATORIES OF AMERICA INC	ANTIMONY-BASED ANODE ON ALUMINUM CURRENT COLLECTOR
9714173	2014	2017	CORNELL UNIVERSITY	GYROIDAL MESOPOROUS CARBON MATERIALS AND METHODS THEREOF
9716265	2014	2017	APPLE INC	HIGH-DENSITY PRECURSOR FOR MANUFACTURE OF COMPOSITE METAL OXIDE CATHODES FOR LI-ION BATTERIES
9722247	2015	2017	TOYOTA MOTOR CO/SUNY	VANADYL PHOSPHATES AS HIGH ENERGY DENSITY CATHODE MATERIALS FOR RECHARGEABLE SODIUM BATTERY
9728344	2015	2017	OREGON STATE UNIVERSITY/UNIV CALIFORNIA/UNIV OREGON	ENERGY STORAGE DEVICE INCLUDING A REDOX-ENHANCED ELECTROLYTE

9728773	2014	2017	NORTHWESTERN UNIVERSITY	ELECTRODE MATERIAL COMPRISING GRAPHENE-COMPOSITE MATERIALS IN A GRAPHITE NETWORK
9735411	2015	2017	BASF SE; SION POWER CORP	POLYMER FOR USE AS PROTECTIVE LAYERS AND OTHER COMPONENTS IN ELECTROCHEMICAL CELLS
9735444	2015	2017	OREGON STATE UNIVERSITY, SHARP LABORATORIES OF AMERICA	HARD CARBON COMPOSITE FOR ALKALI METAL-ION BATTERIES
9742027	2015	2017	SHARP LABORATORIES OF AMERICA INC	ANODE FOR SODIUM-ION AND POTASSIUM-ION BATTERIES
9748568	2012	2017	CORNELL UNIVERSITY	MANGANESE OXIDE NANOPARTICLES, METHODS AND APPLICATIONS
9748572	2013	2017	UCHICAGO ARGONNE LLC	ULTRASOUND ASSISTED IN-SITU FORMATION OF CARBON/SULFUR CATHODES
9748604	2013	2017	THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL	ION CONDUCTING POLYMERS AND POLYMER BLENDS FOR ALKALI METAL ION BATTERIES
9755229	2012	2017	BROOKHAVEN SCIENCE ASSOCIATES LLC	INTERMETALLIC M-SN(SUB)5 (M=FE, CU, CO, NI) COMPOUND AND A METHOD OF SYNTHESIS THEREOF
9761866	2017	2017	SHARP LABORATORIES OF AMERICA INC	BATTERY ELECTRODE WITH METAL PARTICLES AND PYROLYZED COATING
9761910	2015	2017	BATTELLE ENERGY ALLIANCE LLC	ELECTROLYTE SOLUTIONS INCLUDING A PHOSPHORANIMINE COMPOUND, AND ENERGY STORAGE DEVICES INCLUDING SAME
9776156	2015	2017	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	NITROGEN-DOPED CARBON AEROGELS FOR ELECTRICAL ENERGY STORAGE
9786915	2015	2017	UT-BATTELLE LLC	ALL-SOLID STATE LITHIUM CARBON MONOFLUORIDE BATTERIES
9806338	2013	2017	UT-BATTELLE LLC	NANOPOROUS TITANIUM NIOBIUM OXIDE AND TITANIUM TANTALUM OXIDE COMPOSITIONS AND THEIR USE IN ANODES OF LITHIUM ION BATTERIES
9825287	2015	2017	UCHICAGO ARGONNE LLC	SURFACE MODIFICATION AGENTS FOR LITHIUM BATTERIES
9831522	2016	2017	24M	ASYMMETRIC BATTERY HAVING A

			TECHNOLOGIES INC	SEMI-SOLID CATHODE AND HIGH ENERGY DENSITY ANODE
9847531	2015	2017	UT-BATTELLE LLC	CURRENT COLLECTORS FOR IMPROVED SAFETY
9853284	2017	2017	UNIVERSITY OF CALIFORNIA	GRAPHENE OXIDE AS A SULFUR IMMOBILIZER IN HIGH PERFORMANCE LITHIUM/SULFUR CELLS
EP3132483	2014	2017	UCHICAGO ARGONNE LLC	LITHIUM-SULFUR BATTERIES
EP3149798	2015	2017	BASF SE; SION POWER CORP	POLYMER FOR USE AS PROTECTIVE LAYERS AND OTHER COMPONENTS IN ELECTROCHEMICAL CELLS
EP3186652	2015	2017	UNIVERSITY OF MICHIGAN	BULK FORCE IN A BATTERY PACK AND ITS APPLICATION TO STATE OF CHARGE ESTIMATION
EP3191410	2015	2017	APPLE INC	HIGH-DENSITY PRECURSOR FOR MANUFACTURE OF COMPOSITE METAL OXIDE CATHODES FOR LI-ION BATTERIES
EP3227952	2015	2017	POLYPLUS BATTERY CO	VITREOUS SOLID ELECTROLYTE SHEETS OF LI ION CONDUCTING SULFUR-BASED GLASS AND ASSOCIATED STRUCTURES, CELLS AND METHODS
EP3231028	2015	2017	BASF CORP	METAL HYDRIDE COMPOSITIONS AND LITHIUM ION BATTERIES
WO2017095622	2016	2017	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS AND RELATED METHODS FOR DETERMINING SELF-DISCHARGE CURRENTS AND INTERNAL SHORTS IN ENERGY STORAGE CELLS
9865900	2015	2018	BATTELLE MEMORIAL INSTITUTE	SOLID ELECTROLYTE INTERPHASE FILM-SUPPRESSION ADDITIVES
9869726	2015	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	WIRELESS BATTERY MANAGEMENT CONTROL AND MONITORING SYSTEM
9870871	2016	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	GRAPHENE MACRO-ASSEMBLY-FULLERENE COMPOSITE FOR ELECTRICAL ENERGY STORAGE
9871240	2015	2018	APPLIED MATERIALS INC	ELECTROSPINNING FOR INTEGRATED SEPARATOR FOR LITHIUM-ION BATTERIES
9882199	2011	2018	CORNELL UNIVERSITY	SULFUR CONTAINING NANOPOROUS MATERIALS, NANOPARTICLES, METHODS AND APPLICATIONS
9882245	2013	2018	UT-BATTELLE LLC	ALKOXIDE-BASED MAGNESIUM ELECTROLYTE COMPOSITIONS FOR MAGNESIUM BATTERIES
9908817	2012	2018	UCHICAGO ARGONNE LLC	MULTILAYER CAPACITORS, METHOD FOR MAKING MULTILAYER CAPACITORS
9917295	2015	2018	UCHICAGO	METHODS FOR USING ATOMIC

			ARGONNE LLC	LAYER DEPOSITION TO PRODUCE A FILM FOR SOLID STATE ELECTROLYTES AND PROTECTIVE ELECTRODE COATINGS FOR LITHIUM BATTERIES
9929400	2013	2018	UT-BATTELLE LLC	HIGH CAPACITY MONOLITHIC COMPOSITE SI/CARBON FIBER ELECTRODE ARCHITECTURES SYNTHESIZED FROM LOW COST MATERIALS AND PROCESS TECHNOLOGIES
9929429	2012	2018	BATTELLE MEMORIAL INSTITUTE	POLYMER-SULFUR COMPOSITE MATERIALS FOR ELECTRODES IN LI-S ENERGY STORAGE DEVICES
9935208	2016	2018	STANFORD UNIV	ENERGY STORAGE DEVICE WITH LARGE CHARGE SEPARATION
9935314	2014	2018	UCHICAGO ARGONNE LLC	HIGH CAPACITY ELECTRODE MATERIALS FOR BATTERIES AND PROCESS FOR THEIR MANUFACTURE
9941058	2015	2018	UT-BATTELLE LLC/DREXEL UNIV	FLEXIBLE AND CONDUCTIVE WASTE TIRE-DERIVED CARBON/POLYMER COMPOSITE PAPER AS PSEUDOCAPACITIVE ELECTRODE
9947481	2015	2018	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LUBRICANT-IMPREGNATED SURFACES FOR ELECTROCHEMICAL APPLICATIONS, AND DEVICES AND SYSTEMS USING SAME
9954222	2015	2018	BASF CORP	METAL HYDRIDE COMPOSITIONS AND LITHIUM ION BATTERIES
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
9960447	2014	2018	UNIVERSITY OF CALIFORNIA	POLYMER NETWORK SINGLE ION CONDUCTORS
9979060	2017	2018	NANOTEK INSTRUMENTS INC	FLEXIBLE ASYMMETRIC ELECTROCHEMICAL CELLS USING NANO GRAPHENE PLATELET AS AN ELECTRODE MATERIAL
9991512	2015	2018	UCHICAGO ARGONNE LLC	THERMALLY CONDUCTIVE LITHIUM ION ELECTRODES AND BATTERIES
9997802	2016	2018	UT-BATTELLE LLC	HIGH ENERGY DENSITY ALUMINUM BATTERY
10003059	2015	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	ION CONDUCTIVE INKS AND SOLUTIONS FOR ADDITIVE MANUFACTURING OF LITHIUM MICROBATTERIES
10008338	2016	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH TEMPERATURE OXYGEN TREATED CARBON AEROGELS

10008738	2015	2018	UT-BATTELLE LLC	NANOCONFINED ELECTROLYTES AND THEIR USE IN BATTERIES
10014090	2016	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	HIGH-DENSITY CARBON NANOTUBE-BASED MONOLITH AND RELATED MATERIALS, METHODS, AND DEVICES
10018583	2014	2018	CORNELL UNIVERSITY/HUAZHONG UNIV SCI TECH	CARBON MATERIAL SUPPORTED HOLLOW METAL OXIDE NANOPARTICLES, METHODS AND APPLICATIONS
10020493	2012	2018	UT-BATTELLE LLC	COATING COMPOSITIONS FOR ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
10020538	2015	2018	UCHICAGO ARGONNE LLC	SALTS FOR MULTIVALENT ION BATTERIES
10026958	2013	2018	CORNELL UNIVERSITY	CARBON DIOXIDE ASSISTED METAL-OXYGEN BATTERY AND RELATED METHOD
10033039	2015	2018	UNIVERSITY OF HOUSTON	RECHARGEABLE ALKALINE BATTERY USING ORGANIC MATERIALS AS NEGATIVE ELECTRODES
10033040	2014	2018	STANFORD UNIV	STABLE CYCLING OF LITHIUM SULFIDE CATHODES THROUGH STRONG AFFINITY WITH MULTIFUNCTIONAL BINDERS
10036779	2015	2018	BATTELLE ENERGY ALLIANCE LLC	SYSTEMS AND RELATED METHODS FOR DETERMINING SELF-DISCHARGE CURRENTS AND INTERNAL SHORTS IN ENERGY STORAGE CELLS
10037855	2016	2018	UNIVERSITY OF TEXAS	ULTRACAPACITOR WITH A NOVEL DOPED CARBON
10044031	2017	2018	UNIVERSITY OF CALIFORNIA	GRAPHENE OXIDE AS A SULFUR IMMOBILIZER IN HIGH PERFORMANCE LITHIUM/SULFUR CELLS
10044038	2014	2018	UT-BATTELLE LLC	NITRIDE- AND OXIDE-MODIFIED ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
10044039	2016	2018	UT-BATTELLE LLC	NITROGEN-SULFUR-CARBON NANOCOMPOSITES AND THEIR APPLICATION AS CATHODE MATERIALS IN LITHIUM-SULFUR BATTERIES
10044061	2015	2018	LOS ALAMOS NATIONAL SECURITY LLC	METHODS FOR GROWTH OF LITHIUM-RICH ANTIPEROVSKITE ELECTROLYTE FILMS AND USE THEREOF
10046641	2015	2018	MOTIVO ENGINEERING LLC	MOBILE POWER CONVERSION AND DISTRIBUTION SYSTEM
10056199	2017	2018	UNIVERSITY OF CALIFORNIA	MESOPOROUS NANOCRYSTALLINE FILM ARCHITECTURE FOR CAPACITIVE STORAGE DEVICES
10056618	2017	2018	STANFORD	ENCAPSULATED SULFUR

			UNIV	CATHODES FOR RECHARGEABLE LITHIUM BATTERIES
10062904	2016	2018	UNIVERSITY OF ILLINOIS	SCAFFOLD-FREE 3D POROUS ELECTRODE AND METHOD OF MAKING A SCAFFOLD-FREE 3D POROUS ELECTRODE
10068716	2016	2018	PRINCETON UNIVERSITY/VORBECK MATERIALS CORP	GRAPHENE-IONIC LIQUID COMPOSITES
10074996	2015	2018	UNIVERSITY OF MICHIGAN	BULK FORCE IN A BATTERY PACK AND ITS APPLICATION TO STATE OF CHARGE ESTIMATION
10079413	2014	2018	FARASIS ENERGY INC	LI-ION POUCH CELL AND A CELL MODULE
10084310	2017	2018	NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA LLC	LOW-INDUCTANCE DIRECT CURRENT POWER BUS
10102982	2016	2018	UT-BATTELLE LLC	ELECTROLYTES FOR SUPERCAPACITORS
10106418	2015	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	GRAPHENE AEROGELS
10109845	2016	2018	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	METHODS FOR MAKING GRAPHENE-SUPPORTED METAL OXIDE MONOLITH
10109886	2014	2018	UCHICAGO ARGONNE LLC	LITHIUM-SULFUR BATTERIES
10115942	2014	2018	UNIVERSITY OF CALIFORNIA	RATE-SENSITIVE AND SELF-RELEASING BATTERY CELLS AND BATTERY-CELL STRUCTURES AS STRUCTURAL AND/OR ENERGY-ABSORBING VEHICLE COMPONENTS
10120035	2015	2018	SOUTHWEST RESEARCH INSTITUTE	MONITORING AND CONTROL OF ELECTROCHEMICAL CELL DEGRADATION VIA STRAIN BASED BATTERY TESTING
10128489	2016	2018	UT-BATTELLE LLC	SURFACE MODIFICATIONS FOR ELECTRODE COMPOSITIONS AND THEIR METHODS OF MAKING
10128494	2017	2018	APPLE INC	HIGH-DENSITY PRECURSOR FOR MANUFACTURE OF COMPOSITE METAL OXIDE CATHODES FOR LI-ION BATTERIES
10128496	2015	2018	GINER ELECTROCHEMICAL SYSTEMS LLC	THREE-DIMENSIONAL, POROUS ANODE FOR USE IN LITHIUM-ION BATTERIES AND METHOD OF FABRICATION THEREOF
10147936	2016	2018	UNIVERSITY OF	NANOPOROUS TIN POWDER FOR ENERGY APPLICATIONS

			CALIFORNIA	
10147968	2015	2018	POLYPLUS BATTERY CO	STANDALONE SULFIDE BASED LITHIUM ION-CONDUCTING GLASS SOLID ELECTROLYTE AND ASSOCIATED STRUCTURES, CELLS AND METHODS
10164289	2015	2018	POLYPLUS BATTERY CO	VITREOUS SOLID ELECTROLYTE SHEETS OF LI ION CONDUCTING SULFUR-BASED GLASS AND ASSOCIATED STRUCTURES, CELLS AND METHODS
EP3355394	2012	2018	UNIVERSITY OF SOUTHERN CALIFORNIA	HIGH EFFICIENCY IRON ELECTRODE AND ADDITIVES FOR USE IN RECHARGEABLE IRON-BASED BATTERIES
10199642	2017	2019	NORTHWESTERN UNIVERSITY	ELECTRODE MATERIAL COMPRISING GRAPHENE-COMPOSITE MATERIALS IN A GRAPHITE NETWORK
10236500	2017	2019	NANOTEK INSTRUMENTS INC	LITHIUM-ION CELL HAVING A HIGH-CAPACITY CATHODE
10347909	2018	2019	APPLE INC	HIGH-DENSITY PRECURSOR FOR MANUFACTURE OF COMPOSITE METAL OXIDE CATHODES FOR LI-ION BATTERIES
10374234	2017	2019	UT-BATTELLE LLC	CURRENT COLLECTORS FOR IMPROVED SAFETY
10374261	2016	2019	UNIVERSITY OF SOUTHERN CALIFORNIA	HIGH EFFICIENCY IRON ELECTRODE AND ADDITIVES FOR USE IN RECHARGEABLE IRON-BASED BATTERIES
10399054	2017	2019	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	NITROGEN-DOPED CARBON AEROGELS FOR ELECTRICAL ENERGY STORAGE
10460881	2018	2019	UT-BATTELLE LLC/DREXEL UNIV	FLEXIBLE AND CONDUCTIVE WASTE TIRE-DERIVED CARBON/POLYMER COMPOSITE PAPER AS PSEUDOCAPACITIVE ELECTRODE
10522870	2017	2019	24M TECHNOLOGIES INC	ASYMMETRIC BATTERY HAVING A SEMI-SOLID CATHODE AND HIGH ENERGY DENSITY ANODE
EP3543781	2013	2019	SAGE ELECTROCHROMICS INC/ALLIANCE FOR SUSTAINABLE ENERGY LLC	LITHIUM METAL OXIDE MATERIALS FOR ELECTROCHROMIC DEVICES
10529971	2017	2020	POLYPLUS BATTERY CO	SAFETY ENHANCED LI-ION AND LITHIUM METAL BATTERY CELLS HAVING PROTECTED LITHIUM ELECTRODES WITH ENHANCED SEPARATOR SAFETY AGAINST

				DENDRITE SHORTING
10566595	2018	2020	LAWRENCE LIVERMORE NATIONAL SECURITY LLC	ION CONDUCTIVE INKS AND SOLUTIONS FOR ADDITIVE MANUFACTURING OF LITHIUM MICROBATTERIES
10566630	2018	2020	STANFORD UNIV	ENCAPSULATED SULFUR CATHODES FOR RECHARGEABLE LITHIUM BATTERIES

An Analysis of the Influence of VTO-funded Advanced Batteries Patents

Report prepared by 1790 Analytics LLC

DOE/EE Publication Number: 2370