Batteries and Ultra-Capacitors for the Smart Power Grid:

Market Opportunities 2009-2016

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Executive Summary

NanoMarkets, LC | PO Box 3840 | Glen Allen, VA 23058 | TEL: 804-360-2967 | FAX: 804-270-7017

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E.1 Introduction: Smart Grid Storage and Materials Opportunities

Electrical storage represents what could be considered one of the fastest areas of growth associated with the smart grid over the eight years covered by this report. Currently, there is a large market for electrical storage in uninterruptible power supply (UPS) for critical infrastructure, but the coming years will see a step function increase in the need for storage solutions to support the evolving smart grid; as intermittent generating sources such as wind and solar energy start to contribute an increasing portion of grid electricity, energy storage will become a vital component to provide stability for the smart grid.

There are many materials and integrated storage solution opportunities in the emerging smart grid. In the short term, the initial increase in demand for storage will be met with current deep cycle lead acid batteries and sodium sulfur (NaS) batteries. Lead acid is the technology with an established manufacturing base that can expand to meet demand in the near term. NaS has been commercialized in Japan, but the lack of multiple manufacturers will retard growth in the near term. In the medium term, advanced lead carbon, NaS and flow batteries will become dominate growth sectors in large scale storage applications with supercapacitors gaining significant market share in certain gird quality applications. Near the end of the reporting period, ultrabatteries and possibly liquid metal batteries may start to gain market share.

E.1.1 Overview of Smart Grid and Role of Energy Storage

The importance of the electrical grid is difficult to overstate. Inexpensive, reliable electricity is a key metric of all advanced societies. The amount of overall energy consumption in the form of electricity has increased from 10 percent in 1940, to over 40 percent today and is projected to be fastest growing energy source for the foreseeable future. The term "smart grid" is an evolving catch-all term to describe all of the improvements that will increase the grid's efficiency, reliability and security while reducing costs and carbon footprint. Components of the smart grid include: smart metering, intelligent reconfigurable plug and play components, and storage of electricity for quality and peak shaving applications.

There are several factors driving the need to upgrade the electrical grid infrastructure. For electrical generators, there is an increasingly large incentive to find ways to use the generating resources that are in place more efficiently both as a better use of capital and to avoid the regulatory impediments to increase generating capacity. Because there is currently little storage on the grid, there must be enough capacity to meet maximum demand, which results in an overall usage of generating capacity of about 60 percent.

While it has been one of the least talked about parts of the smart grid, electrical storage is now recognized as a crucial piece of the smart grid puzzle, and has been recently included as part of the national smart-grid plan. The major driver for large-scale grid storage is the planned addition of significant amounts of intermittent generating sources (wind and solar) to the grid. (Over 30 states have mandates in place that will require between 8 percent and 40 percent of electrical generating capacity to come from renewable sources by 2030.) The intermittent nature of these generating resources requires a means to store energy such that it can be released to the grid at a moments notice.

As the amount of grid electricity supplied by wind and solar increases above 10 percent–15 percent, instabilities can occur if there is no storage capacity. In fact, Ireland put a moratorium on the connection of new wind power to its national grid due to instabilities as the wind generating capacity exceeded 7 percent of overall grid capacity. It has been estimated that eliminating these instabilities will require storage capacity equal to 10 percent–20 percent of the nameplate generating capacity of the wind energy generating capacity on the grid. Grid storage for renewables with peak shifting also reduces the transmission line capacity requirements for moving energy from remote wind generation facilities to population centers. Lack of sufficient transmission capacity was cited as one of the factors that contributed to cancellation of the large wind farms planned by T. Boone Pickens in the Texas panhandle.

Large-scale energy storage is not a new concept. Pumped hydro electrical storage was first used in Europe in the late 1800's, and peaked in the U.S. at nearly 3 percent of total capacity in the mid 1990's. However, environmental concerns eliminated any further growth of pumped hydro and such facilities are limited to certain geographic regions. Another energy storage technology that is also limited to certain geographic regions is compressed air storage (CAES). While is competitive where the geographic features allow it, it is generally limited to use in area of salt domes, abandoned mines, and the like and is not a general storage solutions for all regions.

Other forms of storage such as flywheels and superconducting magnets have also been tried, but because of cost and system complexity issues these will not likely be considered for large-scale applications. This report will focus on chemical storage in batteries and short-term storage in supercapacitors. NanoMarkets' research indicates these are two areas with the highest potential for growth in the timeframe if this report.

E.1.2 Current Energy Storage Options

Currently, the most pervasive use of large-scale chemical energy storage is for power quality in the form of UPS. UPS is used to protect expensive electrical assets such as computer data centers, hospital operating suites and dialysis units, and critical infrastructure, and represents an $8 billion/year market. Such systems do not require high energy content as most power outages are less than a minute in length. Lead acid batteries are the mainstay of this industry, but it is an application where supercapacitors and integrated supercapacitor/battery back-up systems may make significant inroads as they have significantly quicker response times than batteries alone.

Power retail quality will be the first wide-scale application of electrical storage in the smart grid, followed by generation side storage for quality and peak shaving. Peak shaving amounts to storing energy generated or purchased during low demand time periods at low prices and either using or selling the stored energy at times of high demand and high prices. The model here will be similar to that of thermal storage, which has been used successfully to reduce air-cooling costs in some new commercial office construction. In addition to peak shaving, electrical grid storage will also be crucial to efficiently integrate renewable resources with acceptable grid stability and the transmission of the renewable resources from isolated areas where they are generated to population centers.

Grid storage will also be a crucial part of the evolving electrical microgrids. Microgrids will be part of the growing trend toward distributed generation world wide. We expect this growth to be strongest in areas that are just starting to rely on electricity as well as areas with poor regional grid stability. Growth of microgrids with extensive storage is also being actively investigated for military support applications. Microgrids are an area where both long-term storage in batteries and supercapacitors for frequency regulation will be necessary components.

Supercapacitors will see significant growth in two major applications. The first is frequency regulation where their fast discharge of power can maintain voltage and frequency quality during voltage sags or frequency instability of base load generating resources. Their long lifetime and near zero maintenance are additional features that make them attractive for such applications. Since this application is on the generation side where adoption of new technology can be slow, we expect the growth in this are to be shifted to near the end of the reporting period. A second area of growth for supercapacitors in grid applications is in the regenerative braking system of light rail systems. The supercapacitor-based regenerative braking demonstration has been demonstrated to reduce electrical usage by 30 percent and frequency variation placed on the overall regional grid due to frequent starts/stops of multiple trains.

The applications described above will become more and more attractive as more advanced battery and supercapacitor materials become available in volume and their costs decline. Currently, lead acid and sodium sulfur systems have the most extensive track record for grid storage. While the economics and module lifetimes of lead acid batteries in the 1980's did not warrant their adoption, improvements in lead acid technology and increased energy costs have changed the situation such that the capital cost of a modern lead-acid storage solution for UPS and peak shaving can be realized in new commercial construction in 3–5 years. In addition, recent innovations such as Firefly's and Axion's lead-carbon battery technologies have demonstrated three to four times the energy density with much improved lifetimes over conventional lead-acid batteries, pointing to the potential for further improvements for such technologies.

Another current storage technology in production is the sodium sulfur (NaS) based systems, which are extensively used in Japan with over 200 MW of total capacity in the field. In 2009, General Electric announced plans to build a large NaS battery factory in the U.S. with a projected capacity of 900 mWh/year.

Lithium-ion batteries traditionally have been considered cost prohibitive for grid storage, but there are some pilot demonstrations ongoing such as a 2-MW hybrid ancillary unit from A123Systems. Our research indicates that while extensive resources are being spent on lithium-ion research for automotive applications, unless there is a step function breakthrough in cost (lithium ion solutions are 2–3 times the cost of lead acid), lithium ion will not be cost competitive with lead acid and NaS in the near term nor the flow batteries in the long term for stationary grid storage applications where the high energy density of lithium ion is less of an advantage.

E.2 Opportunities for Materials Producers

There are several materials advances that will likely become available in the next 3–8 years, which paint an attractive future for grid energy storage. While traditional lead-acid batteries are in volume production and have realized almost all of their expected performance improvements and cost reductions, the introduction of a carbon electrode to this traditional battery technology promises a 4x improvement in performance. The outlook for sodium sulfur batteries also looks promising with General Electric making a significant investment in NaS capacity, which should drive down costs in the next 3–5 years.

Beyond advanced lead acid and sodium sulfur technologies, flow batteries such as vanadium and ZnBr show great promise. They have been successfully demonstrated in applications such as UPS for semiconductor manufacturing, island grid capacity firming and grid peak shaving applications. While the current cost of such flow batteries is high compared to that of lead-acid batteries, as the technology enters volume production and a few large dominate players evolve, the costs should decline to a point that allows flow batteries to take a significant portion of the large-scale storage capacity in the 5–8 year timeframe. Another technology that should be fully commercialized in the 5–8 year timeframe is the ultrabattery—an advanced lead-acid battery that integrates supercapacitor elements. A hybrid electric car based on this device has already demonstrated a lifetime of over 100,000 miles.

The supercapacitor roadmap also looks exciting through the length of the reporting period. Beyond the refinement and cost reductions associated with manufacturing improvements and volume production of current activated carbon-based supercapacitors, new higher capacity supercapacitors are also converging on designs with a metal electrode and a carbon electrode similar to some of the advanced lead-carbon battery technologies.

Nanostructured metal oxide, pervoskites, nanotubes and graphenes new materials are under investigation that promise capacity 5–10 times current devices; these should be available in the 5–8 year timeframe. The development of higher performance, lower cost nanostructures of the carbon or metal oxide based electrodes will be the key materials issue for the performance of the lead carbon batteries, ultra batteries and supercapacitors.

E.3 Key Firms to Watch in the Smart Grid Energy Storage Landscape

There are several types of firms in the smart grid chemical battery storage that are worth keeping an eye on. The first type is made up of established battery technology firms. Firms to watch in this space include those with established product lines in the UPS and industrial storage area that can readily expand operations to support near-term smart grid storage applications using existing technology. Also key for these firms are partnerships with some of the emerging startup companies to push the envelope of lead-carbon battery technologies. The other established storage technology suitable for grid storage is NaS, which is dominated by one firm with a new entrant to track. This first group of firms will experience the most growth in smart grid storage in the early portion of the reporting period.

The second type consists of firms that produce advanced lead-based technologies. These firms are all either developing a lead-carbon cell or ultra batteries (lead/lead-carbon). The outlook for these firms is extremely encouraging in the later portion of the reporting period. As with most groups of similar start ups, the next several years will differentiate between technologies that will become the industry standard and those that will fall by the wayside.

The third class of firms to track is comprised of the leaders in the supercapacitor market. These can be tracked on two metrics. First is the ability to reduce costs of established technology, while the second is innovation both to the carbon electrodes and research into morphing current supercapacitor designs into advanced pseudocapacitor devices.

E.3.1 Lead Acid Based Energy Storage Companies

Exide Technologies: Exide is a key firm to watch for two reasons. First, it is currently one of the largest manufacturers of lead-acid batteries with operations in over 80 countries, which gives it the worldwide footprint necessary to supply projected growth in grid storage. It is clear that this company is sensitive to the emerging smart-grid storage market as it has recently formed a division specifically focused on renewable energy and lithium-ion applications. Exide now has a specific focus on large-scale storage for grid-connected and off-grid renewable energy storage.

Another aspect of Exide to track is the company's work with Axion on lead-carbon electrode technology. While Exide's core lead-acid technology will drive grid storage growth near term, the lead-carbon technology must progress and grow to drive growth in the 5–8 year timeframe. The combination of near-term capacity of lead-acid technologies and a roadmap to higher performance products positions Excide well to be a major supplier of advanced lead-acid batteries for smart grid applications.

C&D Technologies: While C&D is a smaller firm than the other lead-acid companies (1300 employees) discussed in this report, it is well positioned for both near-term and long-term growth in grid storage solutions. Currently, C&D is the leader in stationary lead-acid storage solutions and this technology will be a major growth for the near term. As far as long-term growth, the company's manufacturing partnership to produce Firefly-designed advanced microcell foam electrode lead-carbon batteries should be a major engine for growth in the grid storage sector in the 5–8 year timeframe. The introduction and pricing of the Firefly-designed cells into the ignition market should be watched closely as an indication of the ability to deliver large numbers of this type of advanced cell to the smart grid storage market.

Enersys: Enersys is the largest industrial battery manufacturer in the world with operations in over 100 countries. The company offers an improvement to the lead-acid battery with its proprietary thin plate pure lead (TPPL) technology. While not as disruptive a design advancement as the lead-carbon technologies, it is an incremental improvement that should be watched as it will be available in volume earlier than the lead-carbon technologies, and will be an alternative to them if the lead-carbon fails to live up to current expectations.

Furukawa Battery Company/East Penn Manufacturing: Furukawa of Japan and East Penn of the U.S. are both manufacturers of competitive lead-acid ignition and industrial storage batteries. The key for these companies is their involvement with Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia as manufacturers of the CSIRO designed lead/lead-carbon Ultrabattery. Furukawa is the developer of the original CSIRO design. East Penn has signed an agreement in late 2008 to manufacture the battery in the U.S. Like the other lead-carbon technologies, the early penetration and pricing of these cells for ignition purposes will offer insight into the ability of these devices to grow into the large grid storage market in the 5–8 year timeframe.

E.3.2 Lead Carbon Based Energy Storage Companies

Axion Power International: While Axion is a start up company with no large-scale commercial products in the field, we believe that this company has bright prospects in the future. The company's decision to pursue lead-carbon technology is sound, and its agreement with Exide to provide batteries based on Axion's lead-carbon technology should allow the company to expand to volume manufacturing faster than possible if working alone. Axion plans to keep manufacturing the carbon electrode used in all batteries regardless of whether the final battery is manufactured by Axion or Exide. The current target markets for this new technology are in hybrid, plug in electric and heavy duty transport applications, but major new applications are envisioned for power quality, load leveling, peak sharing, and storage for network grid applications. Our prediction is that in the longer term, Axion represents a company with a key enabling technology for large-scale grid storage.

Firefly Energy: Firefly is another key firm to watch in the lead-carbon battery space. This company's version of a lead-carbon battery uses a traditional positive electrode with a negative electrode based on composite graphite foam. Firefly has paired with C&D Technology to build its cells. Pairing with an established battery company and fitting the carbon foam electrode in a form factor that will fit in a traditional battery manufacturing flow is another factor that should increase the chances for success of this technology. The performance is superior to traditional lead-acid batteries and similar to the other evolving lead-carbon technologies. Like the other lead-carbon technologies, the introduction and pricing of initial ignition batteries will be a signal of their ability to effectively meet the demands of the storage market.

E.3.3 Sodium Sulfur Based Energy Storage Companies

NGK Insulators Ltd: NGK is currently the only large-scale supplier of NaS technology. The company has firmly established the technology as viable for grid storage applications and has deployed the technology in 200 locations (160 in Japan) with over 300 MW/2000 mWh of capacity in the field.

In NanoMarkets opinion, NGK's NaS technology is one of the most likely paths for near-term grid storage with the company's 20-year track record of development and deployment, and enough capitalization to warrant further production expansions and manufacturing improvements, which are needed to reduce costs. NGK's capacity in 2005 was 48 MW/year, 2008 capacity was 90 MW/year and planned capacity in 2010 is 150 MW/year.

GeoBattery Corp.: GeoBattery is a recent start up dedicated to grid storage using NaS batteries. The company's unique value proposition is to attempt to wrap a turn-key storage solution of power electronics and software around NaS cells and target this solution to intermittent renewable energy generators (wind and solar). This concept is sound, and its success is worth watching as it will be a indicator of a market for full service turn-key storage solutions.

General Electric (GE): General Electric's entry into the NaS battery market is a key development to watch in the NaS area and smart-grid storage in general. The company announced plans to enter the market in early 2009 with plans to have a plant on line in 2011 and predictions of growth to a billion dollar business within 10 years. Tracking this growth is important as it will most likely mirror the growth of the storage sector overall. GE has a high probability of success in developing the cells as the company has an active research program in NaS battery systems for stationary applications in the late 1970s. Our prediction is that the increased competition in the field should be a major driver of cost reduction for this technology.

E.3.4 Flow Battery Based Energy Storage Companies

ZBB Energy: ZBB is the dominant player in the zinc bromide battery storage market at this time. The company's proprietary zinc bromide flow battery is based on technology originally developed by Exxon in the 1970s. ZBB has applied for stimulus money to expand production, which will be key to ZBB's ability to grow with respect to its competitors and to supply its customers in a timely manor with a competitively priced solution. Keys to success include a successful ramp to 100's of mWh from the current 30 in 2008. If ZBB meets its projections of 48 mWh in 2009 and 72 mWh in 2010, and successful launch of a 300-mWh facility, the company could be a major factor in the flow-battery space in the 5–8 year timeframe for large-scale peak shifting applications.

Prudent Energy (Formerly VRB Power, Formerly, Pinnacle VRB): Pinnacle VRB was the original holder of the vanadium redox battery patents and sold them to VRB Power Systems in July 2004. VRB went into receivership in November 2008, and was then acquired by Prudent Energy. Prudent is based in Bejing, China and is attempting to build a profitable enterprise. While the trail of failures is a red flag, Prudent has purchased the assets of the most experienced firm in the vanadium redox battery field. It is a firm to watch in the near term as effective management may be able to revitalize the company as the underlying technology is sound. While the original vanadium redox patents have run out, the Pinnacle VRB assets do include the equipment and knowledge that could help Prudent achieve an effective turn around. For Prudent to be a player in the flow battery market, the company will need to quickly demonstrate the ability to generate revenue for as well as supply customers.

VFuel Pty Ltd: VFuel is a key company to watch in the flow battery area as it holds the rights to the second generation of vanadium redox battery (VRB) technology. The company claims that the GEN2 vanadium bromide flow battery has almost twice the energy density as the original GEN1 vanadium flow batteries. It remains to be seen if the increased energy density will make an impact on large-scale commercialization. The company was founded in 2003 by two of the original inventors of the VRB technology, Maria Skyllas-Kazacos and Michael Kazacos, both at the University of New South Wales. If the technology can be commercialized in volume, then it may be a major competitor in the large-scale peakshifting energy storage market.

Cellennium Company, Ltd: Based in Thailand, Cellennium was one of the original licensee's of the initial vanadium redox flow battery patents. While the company is more of a regional player in the flow battery manufacturing industry, our opinion is that Cellennium will be competitive in the Asian market as the company has been allocating resources to process improvements and cost reductions of its modules. Cellennium is focusing on the right areas (cost/manufacturability) and should be successful if the flow battery market grows as anticipated.

Sumitomo Electric Industries: Sumitomo Electric Industries, Ltd. (SEI) has been involved in the development of redox flow battery cells since and was granted a license by Pinnacle VRB to manufacture vanadium based flow batteries in 1999. Sumitomo has the resources to build on the demonstration scale unites they have already built for grid load leveling applications. Our opinion is that their size will allow them to expand with market demands faster than their competitors and be a major force in flow battery technology.

E.3.5 Supercapacitor Based Energy Storage Companies

Maxwell Technologies: Maxwell is one of the best-known manufacturers in the supercapacitor field, and has been at the forefront of cost-reduction measures in the industry. These aggressive reductions in manufacturing costs have helped open new markets and will continue to in the future. Maxwell has a full portfolio of cells from 5 F to 3000 F in hydroxide-based electrolytes. The company's near-term smart grid growth in the 3–5 year timeframe is in the regenerative braking markets for light rail. The company has also successfully demonstrated smart-grid applications for frequency regulation of critical infrastructure (California water plant), which should be an engine of growth in the 5–8 year timeframe.

Siemens: Siemens is a key firm to watch because of the company's leadership position in integrating supercapacitors with the regenerative braking systems for trains and automobiles, mostly in Europe. Siemens will likely expand from this base in Europe to worldwide applications of this system, and will likely move into the supercapacitor market for grid quality as this market expands. The company's growth in this sector will be a bellwether of adoption and growth of this technology by others worldwide.

ESMA: ESMA is a key company to watch, partly because it was the first to produce supercapacitors with specific energy exceeding 10 Wh/kg in modules with 30 MJ of storage capacity, which were used as motive power units for city busses and trucks in 1997. A key to the company's technology is an asymmetric capacitor geometry (Ni/Carbon in NaoH), which puts the company in the pseudocapacitor category unlike most of its competition. The asymmetric electrode setup is a step function improvement in energy storage density compared to symmetric supercapacitors, though it does reduce cycling lifetime to around 5000. There are demonstration systems in place in the U.S. with American Electric Power for grid storage peak shifting. If it can be put into volume production at a cost point similar to lead acid technologies, it will be an extremely attractive option for grid storage. An additional important aspect to track is the company's agreement, which was signed early this year to commercialize ESMA's technology, with SAFT.

Nesscap: Nesscap of Korea is a more recent entry into the supercapacitor market as it was formed from work out of the Daewoo group in 1998. The company has a competitive portfolio of offerings from 3 to 5000 Farads with an organic electrolyte, which allows higher voltages (2.7 V) than most of the competition. Nesscap is aggressively pursuing the 42 V hybrid automobile markets in the near term, but its offerings are competitive for smart-grid applications as that market grows. Also, an eye should be kept on the company's work with asymmetric electrodes, as this will be key along with cost reductions to its symmetric electrode offerings to long-term growth in the smart grid storage area.

E.4 Summary of Forecasts

The large-scale grid storage market is in its infancy, and therefore there is little precedent to predictions of its growth; that being said, NanoMarkets sees growth in this sector coming from three major areas. The first area will be large-scale retail customers on the grid where the current UPS strategies that have been exploited to protect critical assets will be extended to peak sharing for electrical cost reductions. This trend will accelerate as electrical costs go up and storage system costs go down. These systems will be dominated by VRLA lead acid batteries in the first five years of the forecast with accelerating penetration of lead-carbon batteries in the final three years of the reporting period with the largest growth of the lead-carbon systems in the Asian markets

The second major growth area will be the generation/distribution side of the grid with extensive growth in storage for grid stability and peak shaving to support the increased capacity provided by wind and solar intermittent generating sources. These users will make extensive use of the available NaS capacity and lead acid capacity in the near term, and will be early adopters of the lead-carbon technologies as these technologies become commercially available. This second growth area will take advantage of the flow battery technologies as their costs come down to the point that they are economically viable.

The third major area of growth for battery-based grid storage applications will be in the microgrid area. Because this market is in its infancy, its growth will be weighted toward the end of the reporting period. This market will favor the lead-carbon technologies, and will experience the majority of its growth in India and China—regions where there is explosive economic growth, which is currently limited by access to reliable electric grids.

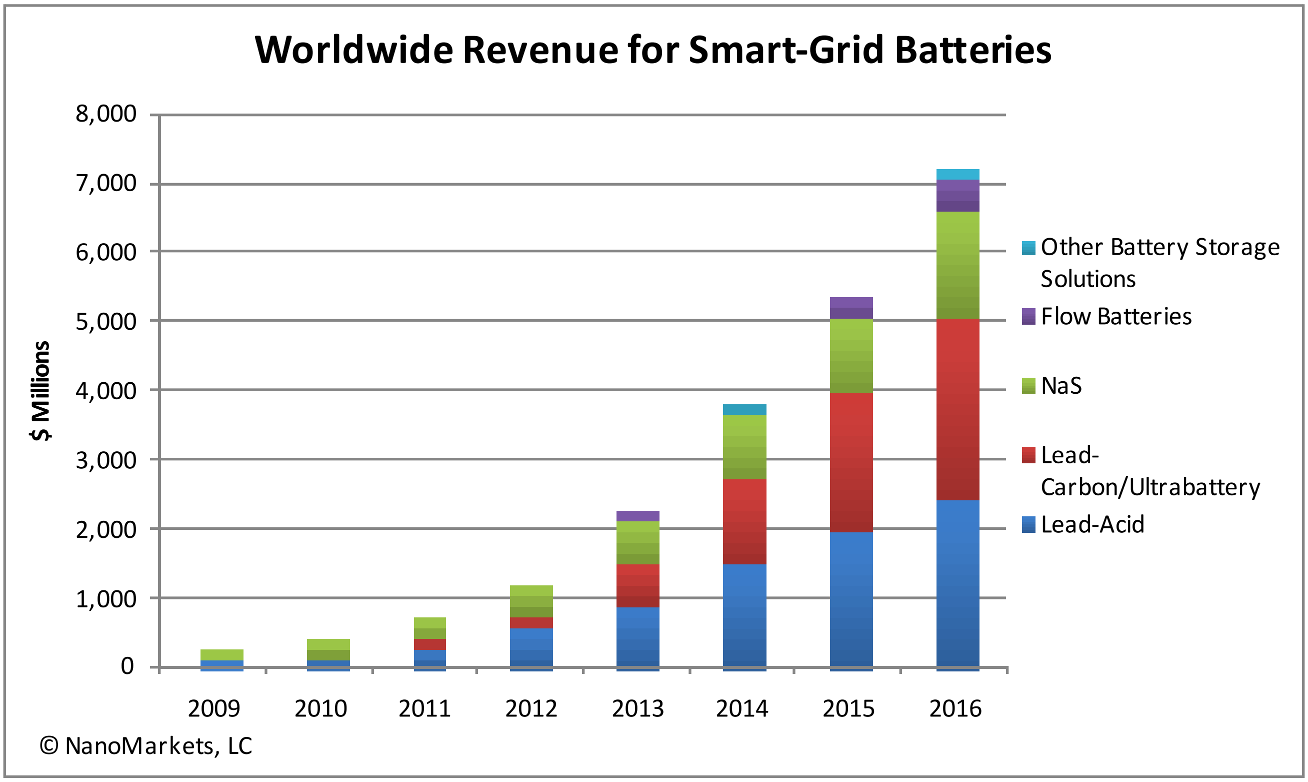
The growth in supercapacitors will also be explosive during the next eight years, but will be more focused in its smart-grid applications. Because of their fast discharge rate and low maintenance, supercapacitors will experience the most growth in frequency regulation applications. It is now just becoming economical to use supercapacitors for such applications. The conservative nature of the generation industry will retard this growth somewhat in the near term, but by the end of the reporting period, it should be gaining general industry acceptance.

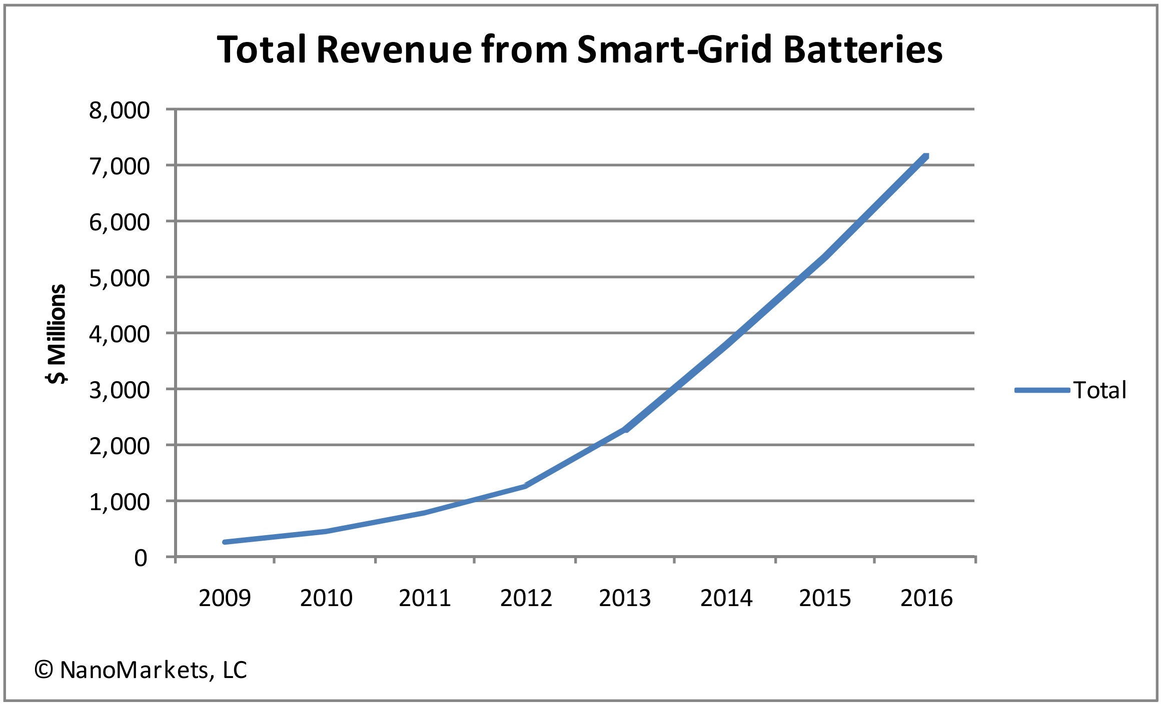
The other area where we expect significant growth for supercapacitors is in regenerative braking for grid connected light rail systems. The supercapacitor-based regenerative systems have demonstrated 30-percent electrical cost reductions and offer frequency smoothing of the regional grid supplying the light rail system.

While predictions of growth in such a new area as grid storage can be difficult, natural gas storage may provide a model of the evolution of grid storage. Storage has played a pivotal role in the development of the unregulated natural gas market, and has allowed 50 percent of transmission system upgrades costs to be avoided in the natural gas business. Part of the natural gas efficiency came from penalizing fluctuating demand and making the cost benefit of salt dome storage transparent. Storage in natural gas is divided into two types. Storage near the well head has helped uncouple supply from demand and allowed lower cost production from fewer, more portable wells, while storage near the end user has allowed efficient arbitrage. Similarly in the electrical storage field, we envision large-scale storage near the generating capacity, which will increase profitability of those facilities and storage at the end user for arbitrage purposes.

One issue that is difficult to predict is the resolution of regulatory issues that may be an impediment to growth in this new area. For example, as recently as this year, while NGK has over 200 MWH of capacity currently in the field in Japan and three 10 MW demonstration units in the U.S., it has had several additional projects delayed 6–12 months by regulatory issues in the U.S. Ironing out these issues is crucial to meeting the aggressive 2030 smart grid deployment goals. Current regulations impede owners of NaS storage from accruing the benefits of both market service and grid services. Market services are energy trading and ancillary services. Grid services include reliability/quality improvement and capacity/transmission upgrade deferral. The barrier creates uncertainty in investment recovery for all grid storage. Current FERC rules have a rigid separation between generation and transmission and retail, so answering the question of where grid storage lies in the regulatory framework needs to be resolved for investment to flow into this area. Currently, storage in most cases is regulated as a generation asset. In the future, storage will need to be regulated as its own category to allow profitability and growth.

Exhibit E-1 summarizes NanoMarkets' forecasts for batteries used for smart-grid storage.





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