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Whitepaper

What's Revolutionalizing the Future of Clean Tech?

How Advances in Lithium Could Re-Energize Renewable Energy

What's Re-Energizing Renewable Energy?

Population growth, pollution, and limited natural resources have created an urgent need for innovative clean tech solutions that are smarter, cleaner, and more efficient. However, energy storage's high cost and technical limitations have kept renewable energy providers from achieving large-scale, low-cost parity with traditional energy suppliers.

The future of clean tech's checkered past of stuttered starts and stops may depend upon technological advancements in an unsung hero: the lithium battery. Standby. The singing is about to begin.

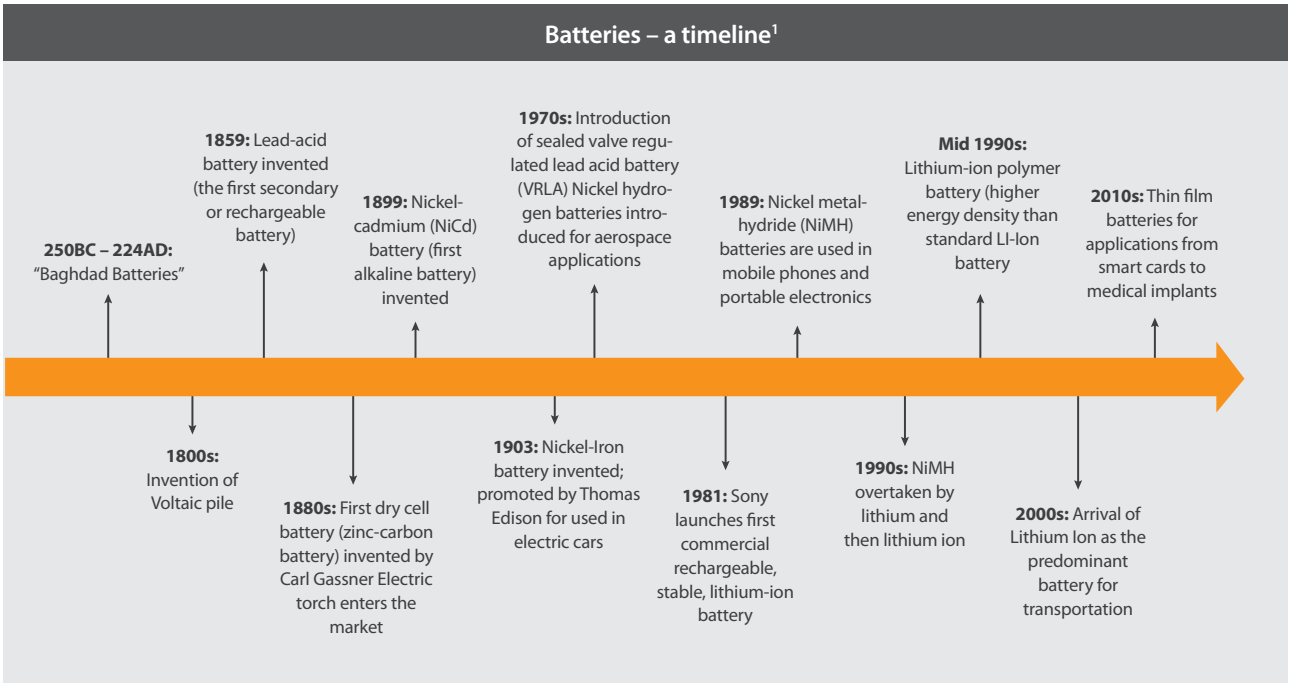
Small in size, the lithium battery — found in toys, laptops, mobile devices, and power tools — could soon become the primary energy source for cars and large-scale grids. This common battery may very well not only keep the Energizer Bunny going and going - but humans, too, as we strive to live sustainably on a green planet.

As quickly as winds change direction, developments in battery technology paradigms are having a disruptive impact on product design in the dynamic clean tech sector.

A major key to a clean tech company's success is early adoption — i.e. when does a trend or a promising new technology tip to become a standard and how does a company recognize that and adopt quickly; Because of this challenge, more innovative companies require manufacturing tools, such as such as PLM (product lifecycle management), that enables them to more efficiently embrace chance and shift product directions quickly to stay competitive.

The Common Battery: An Uncommon History

Before we peer into the future of storage, let's start by looking back at the history of batteries, especially Lithium, which has come along way from the crude Baghdad Batteries of 2500 BC.



Lithium-ion (LiB) batteries were first proposed in the 1970's and commercially developed in the 1990's. Since then, the market for lithium-ion batteries has grown to $11 billion (2010) and is expected to reach $43 billion by 2020. According to the Global Industry Analysts (GIA), the global market for all consumer batteries is forecasted to reach US $55.4 billion by the year 2017. (1)

Lithium is a "secondary battery," which means it's a rechargeable battery while "primary batteries" are non-rechargeable. Secondary batteries account for only 10% of all batteries by volume but represent more than 60% of the global battery market in terms of value. Secondary batteries also include lead-acid, nickel cadmium, nickel metal-hydride, sodium sulfur, and flow batteries.

According to the 2012 World Batteries Market Report, world demand for primary and secondary batteries is collectively forecasted to rise 8.5 % per year to $144 billion in 2016. China is predicted to remain the largest national market for batteries and will also be the fastest growing, bolstered by a large electronics manufacturing segment as well as expanding output and use of motor vehicles. Sales of batteries in India will expand only slightly slower than those in China, as the nation's manufacturing base continues to grow and personal incomes rise.

1

U.S. and European Players Enter Automotive Battery Market

Companies based out of U.S. and Europe are emerging as strong players in the automotive LIB battery segment. These companies have an increased interest in working with key component sourcing companies from their home country to break reliance on imports from Asia.

Above is the first of four battery trends that will have the potential to impact product designs in the near term.

The report forecasts that sales to consumer markets will post the fastest gains through 2016. Rising incomes in developing nations will drive greater use of basic battery powered devices, while expanding use of portable electronics will fuel demand from the consumer market worldwide. The report went on to note that demand for secondary battery types is expected to rise at a faster rate than sales of primary batteries. (2)

The popularity of portable electronics has grown rapidly, expanding the share of the market held by secondary – especially lithium – battery suppliers. According to a recent Marketresearch.com report, the cost of Li-ion batteries will dip 45% by 2022. Li-ion batteries may lose market share to cheaper molten-salt batteries for large projects but will remain the system of choice for space-constrained projects because of the battery's high energy density.

NAVITAS SYSTEMS

The LiB market is expected to continue to grow at an annual rate of about 10% by capacity volume. The strong demand for electronic devices would also support the demand for Nickel-Metal Hydride (NiMH) batteries to a certain extent (readily available in retail stores in the common sizes AAA and AA, used as small rechargeable batteries). (3)

An Increasing Demand for Renewable Batteries

Automotive battery market suppliers will benefit from increased output of hybrid and electric vehicles, as well as from rising production and use of standard automobiles. The market for electric-vehicle energy storage devices is expected to grow from $7.7 billion in 2010 to $14.5 billion in 2015, according to a report from Lux Research.

Electric Transport Rechargeable battery Types:

- **Lead-acid:** Traditionally, most electric vehicles have used lead-acid batteries due to their mature technology, high availability, and low cost.
- **Nickel-based aqueous:** Nickel-cadmium and nickel-metal hydride are the two main nickel-based aqueous (liquid electrolyte) battery types. Cost and toxicity of cadmium are the main concerns for nickel-cadmium batteries (EU has imposed bans in most cases).
- **Lithium-ion:** The most popular and commonly used battery type for portable consumer electronics, displaying favorable characteristics like durability, high specific energy, correspondingly light weight and reasonably fast-charge/discharge capability.
- **Lithium metal and Metal-air:** Currently under development with a promise of up to a tenfold increase in energy. Full-fledged deployment in the transportation sector has not been made as it is in the R&D stage, though these technologies have demonstrated basic performance and energy density potential in niche applications.

2

China's Growth

Chinese domestic market is setting the tone for growth in the midsize and large LiB market and growth in smart phones.

Lithium-ion Trends and Business Drivers (continued)

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An interesting finding in a recent Lux Research "Alternative Power and Energy Storage Service" report predicted that e-bikes and scooters – not automobiles - will drive the biggest growth for these batteries in the next five years. The e-bike and scooter market is forecasted to grow from a $6.4 billion market in 2010 to $10.9 billion in 2015. Policy makers, auto manufacturers and the media have locked their attention on battery technologies for plug-in and electric vehicles. (4)

Batteries Not on the Grid…Yet

Sales of batteries for use in industrial applications and grid storage will be driven by increasing levels of gross fixed investment, global manufacturing output, and efforts toward industrialization in developing nations.
A recent MarketResearch.com report claims that the default option for grid batteries today is lead-acid, accounting for more than 55% of revenues from grid batteries currently. By 2018, the share will decline to around 30% as new grid battery technologies become commercialized. The lead-acid battery will itself get an upgrade; carbon electrodes, promising a 4x performance improvement. In addition, the ultrabattery, with combination lead/carbon electrodes, will compete for grid-storage markets. In 2018, lead-carbon batteries/ultrabatteries will generate around $300 million in revenues.

The Battery's Bright Future

Lithium-ion will dominate the consumer and automotive markets for a long time due to: their high efficiency and energy density, long cycle and calendar life, and manageable safety. Further increase in energy density is possible with lithium metal systems. But intrinsic problems with reversibility, cyclability and safety of lithium metal must be overcome to make the systems more viable.

Continuous research and development is taking place to improve the efficiency and reduce the size of lithium-ion batteries. In August 2012, researchers at the Korea Advanced Institute of Science and Technology (KAIST) developed a solid state, think-film lithium-ion battery, claiming it had the highest energy density ever achieved for a flexible battery.

Another trend revolutionizing the battery industry is the development of an ultra-thin, flexible, lithium polymer battery that could usher in future e-readers and tablets that could be paper thin and partially foldable.

3

Japan Ships LiB Overseas

In small LiBs, Japanese companies like Panasonic and Sony are increasingly shifting production of cylindrical cells in mobile phones overseas to cut costs.

A thriving clean tech ecosystem for battery development requires collaboration among advanced battery technology entrepreneurs, research institutions and governments that provide policies and incentives to foster exploration of new storage technologies. While some batteries, such as the lithium-ion, may be small in size, they will play a big role in unlocking the future of renewable energy's potential.

Emerging Technologies Beyond Lithium-ion

Battery System	Probability of Success	Advantages	Disadvantages
Li-metal / Sulfur	< 50%	Low cost	Low cycle life, safety issues
Li-metal / Air	< 30%	Low cost	Low cycle life, low efficiency, safety issues
Li-Ion / Flow Battery (Cambridge Crude)	NA	Separation of Energy storage from energy conversion	Pumping of liquids containing dispersednano particles
Li / Metal polymer (60 C)	< 50%	No liquids	Healing required, low power output, safety issues
Li-metal / Multi electron chemistry	< 50%	High energy density	Low cycle life, low efficency, safety issues
Sodium / Sulfur (Na/S)	For large vehicles in fleet applications only	Good cycle life, low cost	Works at 300°C
Sodium / Nickel Chloride	For large vehicles in fleet applications only	Good cycle life, reasonable cost	Works at 300°C
Redox flow batteries	< 10%	Low Cost	Low Power output, pumping of liquids
Sodium and Magnesium-ion batteries	< 20%	Low Cost	Low reversibility, lower power output
Supercapacitors / Ultracapacitors	NA	High energy density	Extremely low cycle life

Cloud PLM Eases Shifting Paradigm Pain Swiftly

New advancements in storage technologies are ushering in an era of rebirth and unlimited possibilities in renewable energy. Just recently, a company called Solid Power demonstrated proof they were close to creating a lithium metal battery that could make doubling the range of electric cars a commercial reality. Note: More electric car owners are purchasing solar panels to charge their car batteries, which in essence means you will ride along all day fuel free.

This breakthrough has the potential to dramatically change the entire electric car industry. A veritable sea change.

Smart product lifecycle management (PLM) tools allow OEMs to incorporate game-changing innovations, such as those made in batteries, in their BOM and change product design direction at the drop of a hat.

Arena Solutions, pioneer of cloud-based Product Lifecycle Management (PLM) has helped a diverse range of leading clean tech companies, including, SunLink, EnerVault, SunPower and Navitas Systems, to streamline product development processes to reduce time to market, respond to change quickly when new technologies emerge, and maximize innovative product releases.

4

New Battleground for Battery Materials Makers

Deep pocket chemical conglomerates from U.S. and Europe (BASF, DuPont, 3M, etc.) and Korea (Samsung, LG, etc.) and China promise to shakeup the market and are an emerging threat to the long-dominated battery materials suppliers from Japan.

Lithium-ion Trends and Business Drivers (continued)

Change happens fast and manufacturers must react quickly to embrace it. So ask yourself — when opportunity in clean tech knocks — will you have the right PLM solution in place to make sure your company can embrace new technologies swiftly?

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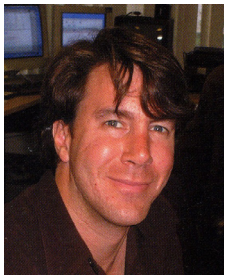
About Arena

Arena, the inventor of cloud PLM, provides an all-in-one product development platform that unites PLM, ALM, supply chain collaboration, and QMS for the design and manufacture of complex electronics. With Arena, electrical, mechanical, software and firmware engineers can collaborate with manufacturing and quality teams to manage their bill of materials, facilitate engineering change orders, and speed prototyping. As a result, Arena customers can better meet standards while they ensure regulatory compliance, improve training management, reduce costs, increase quality, and collapse time to market. Arena has been ranked a Top 10 PLM provider and won the coveted Design News Golden Mousetrap Award in 2016. For more information, please visit http://www.arenasolutions.com.



Author

John Papageorge, the author of "What's Powering the Future of Consumer Electronics," has consulted for some of the biggest names in technology, including Oracle, IBM, Hewlett Packard, Cisco, and Silicon Valley Bank, to analyze emerging consumer electronics and high tech business and technological trends.

Contact

Arena Solutions
Foster City, CA 94404
P. 650.513.3500
F. 650.513.3511

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