



CONSORTIUM FOR
BATTERY
INNOVATION



THE U.S. LEAD BATTERY INDUSTRY

Lead Battery Grand Challenge

Executive Summary

JUNE 2021

Introduction

The U.S. Department of Energy (DOE) has issued the Energy Storage Grand Challenge (ESGC), an effort focused on innovations in energy storage for utility services, with millions of dollars slotted to support the development of battery technologies in America. This challenge outlines the needed characteristics for domestic energy storage and the cost and performance metrics necessary to meet the demands of the future.

Using the experience of the lead battery industry in combination with the scientific skill and expertise of the national lab system can realistically yield the performance gains outlined in this text below. Potential improvements could double, or provide even greater advances to cycle life and energy density. Such dramatic discoveries would further cement lead batteries as the only energy storage solution with intrinsic safety measures, that is highly sustainable, manufactured domestically, and which meets the technoeconomic needs of the U.S. utility sector for decarbonization and distribution of the U.S. grid.

Lead batteries offer a unique blend of safety, extensive domestic manufacturing infrastructure, and unparalleled sustainability. Furthermore, lead batteries provide reliable, inexpensive energy storage in many applications. These benefits are vital to the projected deployment needs to support a more reliable, smart, and distributed U.S. utility grid. **The aim would be to innovate and improve lead battery performance for key markets, such as residential and commercial demand reduction and load response for solar generation.**



Lead battery performance must improve to maximize the benefits of the safety and recyclability offered by the technology. **Increasing total energy throughput related to cycle life of lead batteries is the main area of improvement.** Following the goals of the ESGC, a Lead Battery Grand Challenge (LBGC) document has been created to describe the industry by identifying clear performance targets and collaborative research areas for lead battery technology. Each research area consists of possible work areas, current efforts, and as starting point for further industry involvement.

Performance Category	Current	Target
Cycle life (80% DOD ¹)	4000	5000
Cycle life (100% DOD)	2000	3000
Round Trip Efficiency (%)	82	88
Acquisition Cost (\$/kWh)	~135	35
Operating cost (\$/kWh/cycle)	0.09	0.025

The goal of this document is to establish possible research areas in lead battery performance, deployment, and manufacturing to poise the industry for collaborative projects with DOE stakeholders funded by impending Funding Opportunity Announcements (FOAs) related to the ESGC. These projects aim to improve performance in the above targets while maximizing the present benefits of lead batteries.

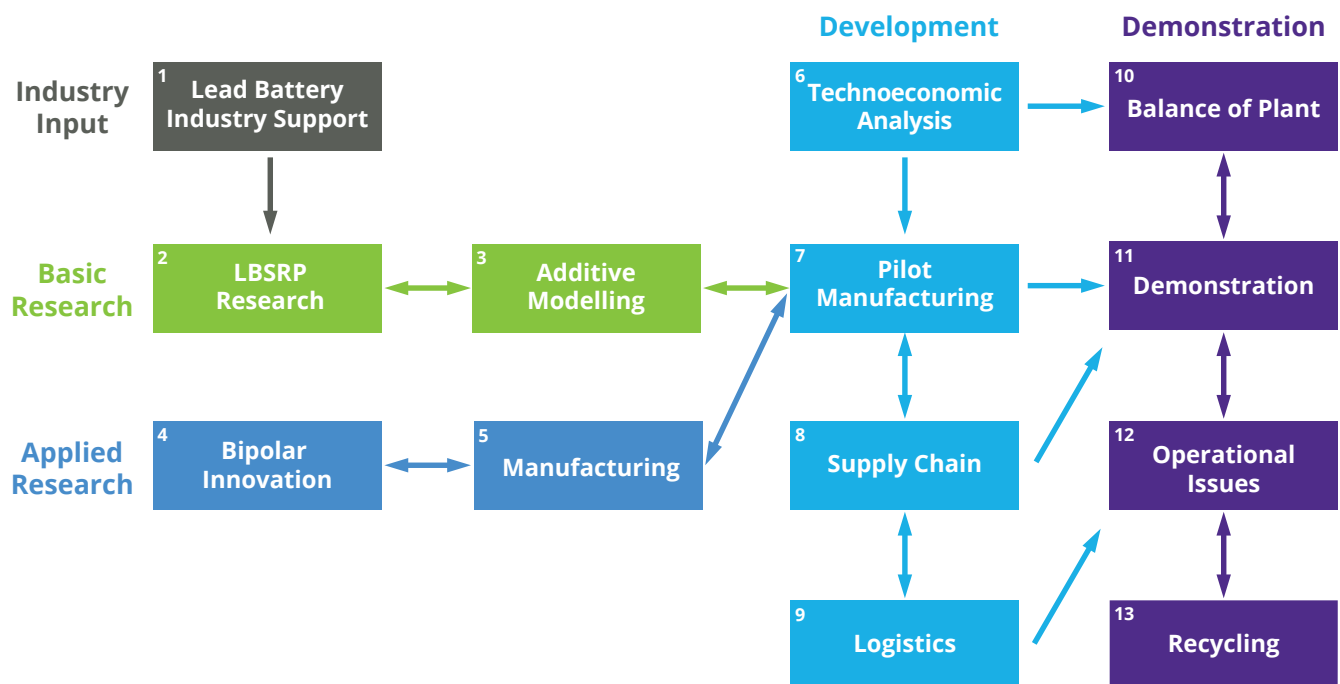
¹ Depth of Discharge

Roadmap Work Areas include:

- | | | |
|---------------------------------|------------------------------------------|------------------------------------------------|
| 1. Lead Industry Support | 6. Technoeconomic Analysis | 11. Energy Storage System Demonstration |
| 2. LBSRP Research | 7. Pilot Manufacturing | 12. Operational Issues |
| 3. Additive Modelling | 8. Supply Chain Issues | 13. Recycling |
| 4. Bipolar Innovation | 9. Logistics | |
| 5. Manufacturing | 10. Balance of Plant Optimization | |

The Lead Battery Grand Challenge (LBGC) contains an overview of each Roadmap Work Area, and outlines an integrated plan to innovate, manufacture, and demonstrate a lead battery optimized for grid energy storage. Additional Work Area details are provided in Appendices to the primary document.

There are three Roadmap Work Areas of special importance: Lead Battery Science Research Program (LBSRP), Supply Chain Issues, and Energy Storage System Demonstration.



Lead Battery Science Research Program

Research continues at Argonne National Laboratory (ANL) under a U.S. industry Cooperative Research and Development Agreement (CRADA) consisting of the majority of North American major battery manufacturers and suppliers. The combination of world-class structural characterization equipment and facilities, like the Advanced Photon Source, and the expertise and insight offered by the extensive cross-disciplinary team at ANL has resulted in new pathways for performance improvement for lead batteries.

The focus on dynamic charge acceptance (DCA) for automotive lead batteries and cycle life for energy storage systems (ESS) has uncovered new formation treatments, active material additive developments, and key understanding of discharge processes that impact both charge acceptance and the longevity of lead battery electrodes. The work at ANL could be augmented by the ESGC – creating strong opportunity for further advancements and translation of some of these findings into the market.

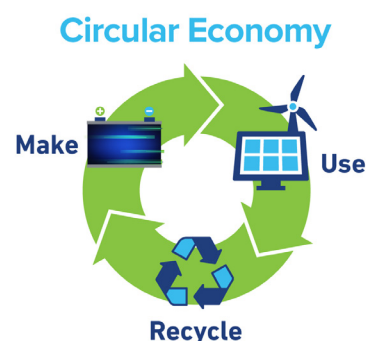


U.S. Department of Energy's Argonne National Laboratory (ANL)

Supply Chain Issues

The lead battery supply chain is spread across the U.S., with manufacturing and recycling operations spread across 38 states. The 99% end of life recycling rate of lead batteries results in stable streams of metal, plastic, and electrolyte for the battery technology. U.S. battery manufacturers and lead battery recyclers provide a framework for an almost completely sustainable form of energy storage. Even with strong recycling infrastructure, a well-developed scrap market, and the transition to recycled metal as the main provider for active material in lead batteries, there are major concerns with the lead battery supply chain.

1. The export of lead battery scrap to other countries results in a 400,000-ton deficit in recycling streams. There are concerns with battery scrap leaving the U.S. and not being properly stewarded and reintroduced back into the supply chain.
2. More than 75% of the lead demand is fulfilled by secondary, recycled lead – continued development of recycling facility technology would be beneficial in further improving secondary supply, but also energy and recycling efficiency.



Energy Storage System Demonstration

Lead batteries offer many advantages for energy storage system units for a more distributed utility grid:

1. Extensive infrastructure for recycling and production with a mature secondary supply chain.
2. A safe, reliable technology from a single monobloc to 100 MW installations.
3. Sustainable with a 99% end-of-life recycling rate.

The U.S. lead battery industry is poised to fill many of the distributed energy needs for the ongoing electrification and decarbonization of the utility grid. Information related to the impact of recyclability on the total cost of ownership needs to be gathered. Lead battery technology, while used in ESS applications around the world, needs a comprehensive and current technoeconomic analysis (TEA) of the system. A TEA would be beneficial to mapping the performance enhancements that would be necessary to meet DOE technoeconomic based performance metrics (i.e., \$/kWh or \$/cycle/kWh).

Innovations, such as bipolar configurations and new electrode substrates, still remain untested in ESS applications. Understanding how these advancements benefit lead battery energy storage would be the primary focus – with complementary work centered around how these advancements may be introduced on the mass scale. Pilot manufacturing of innovative lead batteries would be important to further developing information for a long-term solution to the U.S. need for energy storage.

About Us

Battery Council International

Battery Council International (BCI) is a not-for-profit trade association formed in 1924 to promote the interests of the lead battery industry. BCI has member companies worldwide engaged in every facet of the industry: lead battery manufacturers and recyclers, marketers and retailers, suppliers of raw materials and equipment, and expert consultants. As the industry's principle association, BCI's member services have a global impact.



BCI brings together the leading lead battery manufacturers in North America and other major players from around the world. BCI members account for over 98% of U.S. lead battery production and recycling capacity. BCI establishes technical standards for battery manufacturing and actively promotes workable environmental, health and safety standards for the industry.

The U.S. lead battery industry employs approximately 24,700 workers and spends \$1.7 billion annually on payroll. In addition to the workers the lead battery industry directly employs, it supports 30,900 supplier jobs and 36,600 jobs from worker spending in different industries. Together, these impacts total 92,200 jobs, providing more than \$6 billion in labor income and more than \$26.3 billion in economic output in 2018. BCI member companies invested \$100.4 million on research and development in 2018.

Consortium for Battery Innovation

The Consortium for Battery Innovation (CBI) is a pre-competitive research organization funding research into lead batteries for energy storage, motive and automotive applications.



For more than 25 years, with its membership of battery manufacturers, industry suppliers, research institutes and universities, CBI has delivered cutting-edge research pushing the boundaries of innovation in lead battery technology. CBI membership comprises the majority of U.S.-based companies from the entire lead battery value chain.

Through research partnerships with scientific institutions including Argonne National Laboratory and UCLA, CBI is setting the standard for advanced lead batteries and the next generation of energy storage.

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