# Feature—Ensuring a Clean Grid—Batteries Not Excluded


*EPRI Examines Environmental Aspects of Grid-Scale Battery Deployment*

***By Chris Warren***

One of the great modern-day environmental success stories is found under the hood of most cars: lead-acid batteries. While it may seem unlikely that anything containing flammable acids and lead could reflect environmental stewardship, consider that 96% of lead-acid batteries are recycled—surpassing paper and aluminum.

"It is recycling done well and a model for other industries," said Brittany Westlake, an EPRI engineer scientist who leads cost and technology assessments of energy storage. "Lead is toxic, and the acid in batteries is hazardous. But the lead-acid battery industry has well-established recycling processes and protocols for neutralizing the hazards and reusing valuable materials."

Replicating such success in the electric power industry is a pressing matter. As the power system incorporates growing capacity of variable solar and wind generation, battery storage becomes essential. Understanding the spectrum of potential environmental issues well before they become a problem is key to addressing them.

"Battery recycling and disposal are important but not the only considerations," said Westlake. "Equally critical is understanding the impact of mining the minerals that go into batteries as well as the energy and resources used to make them."

It will take time to develop the infrastructure and processes to recycle and dispose of large numbers of grid-scale batteries and their diverse materials. Fortunately, recycling companies can draw on decades of experience in the lead-acid battery industry to build an effective recycling model.

Many industry observers believe that lithium ion batteries will become widely used by utilities. Already, two companies—Retriev Technologies and Umicore—have taken substantial steps towards creating a recycling infrastructure for this technology. Given a surge in the demand and production of lithium ion batteries, Westlake expects that recycling companies, engineering firms, and others will rise to the challenge.

One helpful aspect: grid-scale batteries have a long life. "The good news is that most batteries are expected to last 10 to 15 years, giving us time to get ahead of environmental concerns," said Westlake. "But preparing the infrastructure could take that long, so utilities have to start planning now."

## Many Battery Flavors, Many Challenges

If lead-acid batteries were the only choice for future energy storage, there wouldn't be such an urgent need to figure out disposal and recycling. The reality is that battery technologies are as varied as ice cream flavors. Also, it's possible that multiple technologies will be needed to meet varying grid applications, which could require many processing methods for recycling.

There are numerous environmental issues to consider with lithium ion batteries. Lithium can pose significant disposal hazards. While many lithium compounds used in industrial processes are harmless, even a small amount of elemental lithium reacts violently, sparking flames in contact with water. This makes it critical to prevent leaching from landfills into groundwater. Flammable organic solvents in lithium batteries can be ignited by a spark, also making them potentially dangerous in landfills.

"The good news is that these issues can be readily addressed," said EPRI Project Manager Rachna Handa, who conducts energy storage research. "Lithium can be processed so that it doesn't react with water, and the solvents can be neutralized. Properly handled, they're relatively safe."

Of course, recycling the batteries is preferable to disposal. "Nobody wants millions of batteries in landfills," said EPRI Program Manager Haresh Kamath, who leads efforts to develop and assess energy storage technologies. "We believe cost-effective reuse and recycling strategies are possible for all battery technologies, including lithium ion."

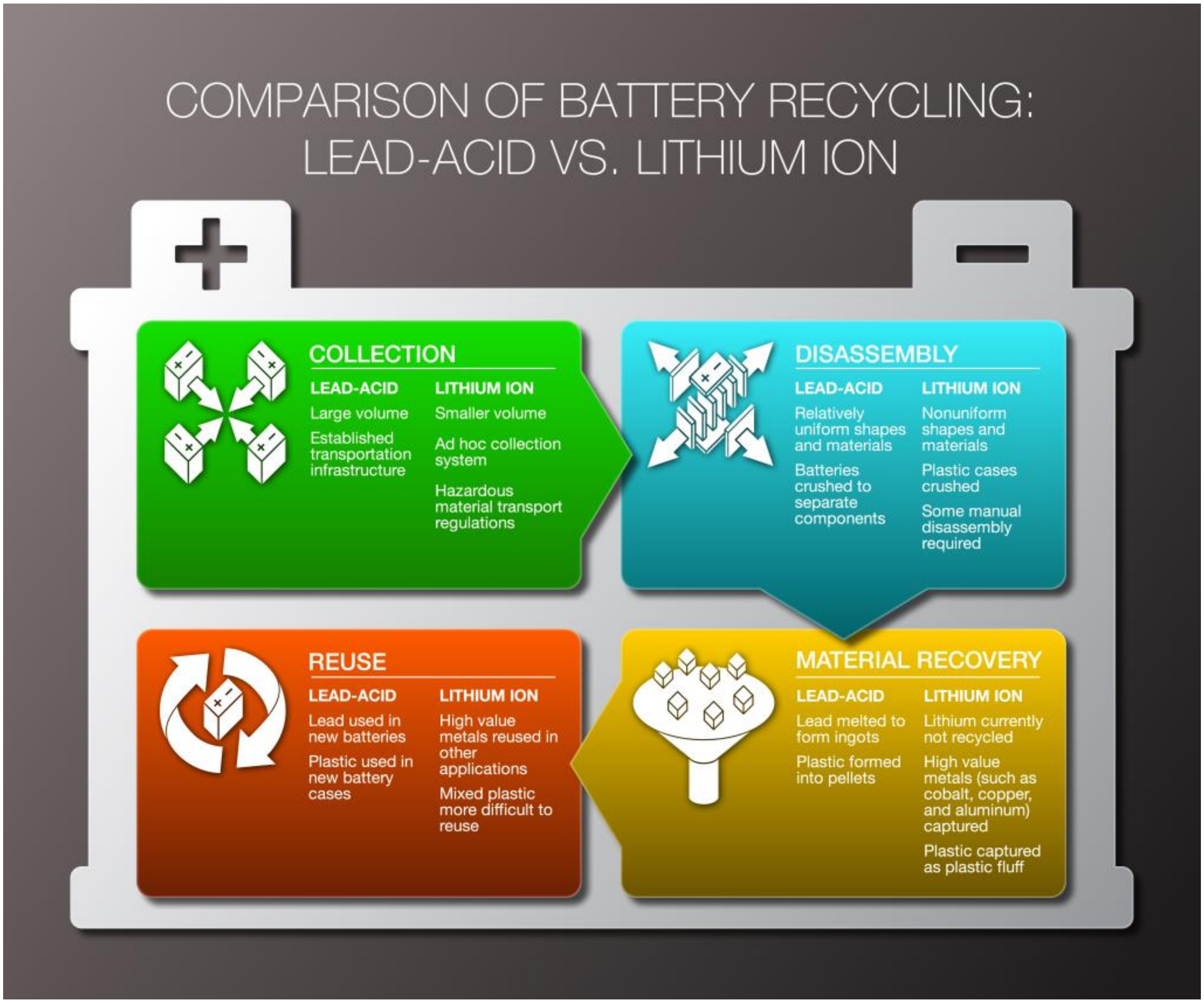
Responding to increasing production of lithium ion batteries, EPRI completed a comprehensive survey of the current methods, costs, and hurdles to recycling and disposal. An important finding: replicating the lead-acid battery industry's infrastructure of independent recycling companies for lithium ion batteries will be no easy task. Lead-acid batteries are easier for recyclers to process because they are more uniform in chemistry and configuration. While prohibitions on the disposal of lead-acid acid batteries in the United States create a powerful incentive to recycle them, lithium ion battery disposal is permitted.

The variety of lithium ion batteries presents a major challenge. They don't come in standard shapes or sizes. The different chemistries include lithium manganese oxide—found in first-generation electric vehicles such as the Chevrolet Volt and Nissan Leaf—and lithium nickel cobalt aluminum oxide in Tesla vehicles. "Different chemistries will have slightly different processes for dismantling and preparing the battery systems for recycling, and that's a challenge for the recyclers," said Handa.

Another challenge is the lack of resale value for the battery components. The commodity price for lithium has hovered consistently at about $3 per pound over the past few years, making it cheaper to mine than to recycle. Several factors could improve the economics of recycling: regulations requiring lithium ion battery recycling, a massive spike in demand, or geopolitical unrest disrupting lithium mining in South America. Today there's little economic incentive for recycling companies to set up infrastructure, with the exception of cobalt in Tesla's lithium cobalt batteries: It costs about $20 per pound and can be resold for use in electronics.

These factors could result in niche lithium ion battery recycling markets rather than one large one. "The biggest problem short-term is that there are no economies of scale for recycling," said Westlake. "It's easier to make a business case if you know you are going to get a steady stream of batteries with the same chemistry and configuration."

There is also uncertainty about which technology will become dominant. "We're working to set up a recycling infrastructure while the production infrastructure is still being established," said Kamath. "We are still looking at various scenarios of battery deployment and recycling needs."




This graphic compares various aspects of lead-acid and lithium ion battery recycling.

Evaluating these issues is integral to EPRI's work to help utilities determine the role of energy storage in long-term planning. "Instead of picking the winning technology, we are investigating which technologies work best in specific applications," said Westlake. "For example, which batteries could help a utility defer an investment in an expensive new transformer at a substation?" Aligning battery technologies with applications and understanding recycling costs can help utilities make better decisions about energy storage.

This work can aid utilities as they plan for managing surging battery deployment, and help state and federal regulators formulate effective handling and recycling rules.

## Going Beyond Recycling and Disposal

In 2016, EPRI will begin developing a model to assess the cradle-to-grave life cycle of lithium ion grid-scale batteries. Previous life cycle analyses conducted by EPRI, the U.S. Environmental Protection Agency (EPA), and Argonne National Laboratory focused on electric vehicle batteries and were limited to energy consumption during a few select phases of a product's life. Potentially sited near homes and businesses, grid-scale batteries are larger and subject to different regulations than vehicle batteries. A multi-disciplinary effort with EPRI's Environment and Power Delivery & Utilization research sectors, the new model will examine environmental impacts of grid-scale batteries comprehensively, including human and ecological health effects, energy and water consumption in mineral extraction, battery manufacturing, and recycling and disposal.

To guide model development, EPRI will first assess existing cradle-to-grave life cycle assessment tools and research on lithium ion batteries to identify knowledge gaps. EPRI will modify these tools to apply to different battery chemistries and technologies, then test the model and incorporate input from utilities, battery manufacturers, mining companies, and battery recyclers.

Along with the model, EPRI will publish a study summarizing existing knowledge about the various chemistries of grid-scale lithium ion batteries. By identifying and quantifying the range of environmental impacts of batteries, EPRI aims to provide utilities and society with information to decide when and where energy storage is a good choice.

Kamath believes that starting this work now is the best way to prepare for broader deployment of grid-scale battery storage. "We are at the front end of a very big opportunity in energy storage and looking at a new world unfolding before our eyes," he said. "Unexpected technical challenges and technologies will emerge. We are mapping the most likely futures so that we are prepared for the spectrum of environmental issues."

## Key EPRI Technical Experts

Brittany Westlake, Haresh Kamath, Rachna Handa, Stephanie Shaw, Arnout ter Schure