Advances in Repurposing and Recycling of Post-Vehicle-Application Lithium-Ion Batteries

Charles R. Standridge, Ph.D., Lindsay Corneal, Ph.D., and Nicholas Baine, Ph.D.

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SJSU Research Center
210 N. Fourth St., 4th Fl.
San José, CA 95112

Tel // 408.924.7560
Fax // 408.924.7565

transweb.sjsu.edu

The use of lithium-ion batteries in vehicles is growing in order to support electrification and meet increasing average gas-mileage targets and decrease greenhouse gas emissions. Thus, the development of processes for the remanufacturing, repurposing, and recycling of post-vehicle-application lithium-ion batteries is urgent. This project involves demonstration of the use of repurposed post-vehicle-application lithium-ion batteries in a stationary energy storage system for a household goods recycling center, as well as extensions of a recycling process to batteries produced by multiple manufacturers for the recovery of aluminum and copper.

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Study Methods

A fundamental question is what to do with post-vehicle-application lithium-ion batteries that have fallen below industry standards for use in on-road vehicles. Such a battery has additional economic value that can be reclaimed in one of three ways: 1) Remanufacturing for reuse in vehicles; 2) Repurposing by reengineering for an off-road, stationary storage application; and 3) Recycling, disassembling each cell in the battery and safely extracting the metals, chemicals, and other byproducts. Advances have been made in repurposing applications and recycling of spent batteries.

A mathematical model estimates the manufacturing capacity needed for each of these activities, as well as new battery production capacity. The model has a single parameter: the percentage of vehicle batteries that are remanufactured. Simulation results indicate that a full commitment of all post-vehicle-application batteries to remanufacturing results in an approximate reduction of 25% in the demand for new batteries by 2030. The sum of repurposing and remanufacturing capacities is approximately constant, supporting the idea of building capacity that is flexible between repurposing and remanufacturing tasks. The need for recycling becomes significant for the first time between 2022 and 2024, growing steadily over time thereafter.

Findings

Advances in repurposing were demonstrated in a joint project with Hastings Township, MI and supported by industrial partner Global Battery Solutions. An energy management system was constructed to support a mobile recycling platform constructed from a repurposed over-the-road tractor trailer. In this prototype, solar energy is collected using an array of solar panels mounted on the top of the trailer; this energy is stored in a set of repurposed post-vehicle-application lithium-ion batteries. The energy is used to power lighting and monitoring equipment, and a commercial off-the-shelf battery management system was used to control the system.

Advances in recycling focused on showing the applicability of a previously developed approach to post-vehicle-application lithium-ion batteries from different manufacturers with different chemistries. This approach uses acid baths to separate the coatings from the collecting foils: carbon coatings are separated from the copper foils of the anode using sulfuric acid, and the various coatings from the aluminum foils of the cathodes are separated using nitric acid.

These results have shown that it is possible to identify a common acid concentration and temperature that will separate the differing active materials from the current collecting foils in a reasonable length of time (3 min or less), relative low acid concentrations, (2mol/L or less), and relatively low temperatures (70°C or less). Once separated, the copper and aluminum foils can then be recycled.

Layout of a Disassembled LiFePO4 Cell with an Unopened Cell
Source: Authors' photo, 2013.

Policy Recommendations

1. Remanufacturing and repurposing manufacturing capabilities should be integrated to minimize the need for capacity development.
2. Recycling processes can focus on approaches that will work across battery chemistries and battery suppliers.
3. Immediate attention to the development of the capability for post-vehicle-application lithium-ion battery remanufacturing, repurposing, and recycling is required.

About the Authors

Charles R. Standridge, PhD is the Associate Dean of the Seymour and Esther Padnos College of Engineering and Computing at Grand Valley State University and the principal investigator for this project. Lindsay Corneal, PhD is an Assistant Professor in the School of Engineering at Grand Valley State University. She led the recycling process development and demonstration. Nicholas Baine, PhD is an Assistant Professor in the School of Engineering at Grand Valley State University. He led the energy systems development for the repurposing project.

To Learn More

For more details about the study, download the full report at ***transweb.sjsu.edu/project/1238.html***

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