Battery Second Use Analysis and Demonstration

Cooperative Research and Development Final Report

CRADA Number: CRD-13-537

NREL Technical Contact: Kandler Smith

NREL is a national laboratory of the U.S. Department of Energy
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Contract No. DE-AC36-08GO28308

Technical Report
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NOTICE

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Cooperative Research and Development Final Report

In accordance with Requirements set forth in the terms of the CRADA agreement, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the DOE Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: BMW Group

CRADA number: CRD-13 -537

CRADA Title: Battery Second Use Analysis and Demonstration

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resourcesa/k/a Government In-Kind
Year 1 Year 2 or Modification # Year 3 or Modification # Year 4 or Modification #	$107,595.00 $92,984.00 $94,303.00
TOTALS	$294,882.00

Abstract of CRADA Work:

The goal of this project is to test the performance of used automotive batteries providing stationary energy storage services to the grid, identifying barriers and opportunities for widespread battery second use strategies. These goals will be achieved by the installation and testing of an energy storage system comprised of used EV batteries and supporting data provided by BMW. The National Renewable Energy Laboratory (NREL) will complete test planning, modeling, and analysis tasks in support of this effort. Once complete, results will be applied to make recommendations on use strategies for used EV batteries, and to identify areas requiring further research.

Summary of Research Results:

NREL performed analysis of aging behavior of batteries in BMW's first generation Mini-E electric vehicle. Results were used to calibrate lifetime models and forecast health of Li-ion batteries at the end of an electric vehicle's useful life. Modeling of similar heritage battery technology (Neubauer et al. 2015, doi:10.4271/2015-01-1306) predicted EV batteries would have 65% to 75% remaining capacity at year 15. Battery lifetime average temperature, strongly dependent on climate and thermal management design, was the single largest factor controlling state of health at end of vehicle life. Data from six Mini-E batteries showed 0 to 6% capacity loss and 0 to 16% power loss over 2.5 years of service, with greater losses in higher ambient

temperature regions, confirming battery life modeling assumptions underlying the conclusions of NREL's paper. Based on model predictions and the BMW in-service data, battery energy and power capability are both deemed sufficient to warrant introduction of used vehicle batteries into 2nd use stationary energy storage applications. Furthermore under the CRADA, NREL and BMW worked with University of California at San Diego (UCSD) to install a container of used Mini-E batteries on UCSD's microgrid where the batteries underwent multiple years of performance testing, performing a variety of services (https://cer.ucsd.edu/research/energy-storage/index.html). The system had 6 Mini-E battery packs in parallel with a 100 kW Princeton Power inverter. The total system capacity at the beginning of 2nd-life was rated at 162 kWh. Each battery pack, rated at 27 kWh in 2nd-life, had its own battery management system (BMS), which was controlled by a super battery management system (sBMS) integrated with a microgrid controller. At the conclusion of the CRADA, testing was still ongoing at UCSD. Modeling studies predict the used EV batteries could last another 10 years in some second use applications and have profitable value ranging from $20-$50/kWh if refurbishing costs are less than $20/kWh. Challenges remaining in implementing are found to be: cost of repurposing; lower prices of new batteries; warranty issues and chain of ownership; predicting expected life in 2nd-use applications; and lack of local, state, and federal guidance for disposal of end of life batteries.

Subject Inventions Listing:

None

ROI #:

None

Report Date:

20 October 2017

Responsible Technical Contact at Alliance/NREL:

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DOE Program Office:

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