Cell Reports Sustainability

CellPress
OPEN ACCESS

Preview

What's stopping electric vehicle batteries from having a second life?

Dipti Kamath[1,*] and Annick Anctil[2,*]
[1]Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, TN 37831, USA
[2]Department of Civil and Environmental Engineering, Michigan State University, East Lansing, MI 48824, USA
*Correspondence: kamathdd@ornl.gov (D.K.), anctilan@msu.edu (A.A.)
https://doi.org/10.1016/j.crsus.2024.100080

We face the grand challenge of a growing number of end-of-life lithium-ion batteries over the upcoming years. A recent *Cell Reports Sustainability* article presents a model for effective end-of-life battery management in China for rural electrification. Here, we emphasize the need for incorporating various stakeholders early in the design phase to remove the barriers to the reuse of retired batteries.

Electric vehicles (EVs) are one of the foremost methods to decarbonize light-duty road transportation, which accounts for ~50% of all transportation emissions.[1] As EV sales grow exponentially every year, we are looking at growth in lithium-ion battery (LIB) production and, as a consequence, an increase in end-of-life (EOL) LIBs over the upcoming years. The question that then arises is whether we are ready to tackle the growing mountain of EOL batteries. There are methods to recycle LIBs effectively and multiple demonstrations of projects for reusing EOL LIBs.[2,3] Studies have demonstrated the benefits of incorporating a second life for EOL batteries.[4,5] However, multiple socio-political and techno-economic barriers exist to developing a full-fledged supply chain to successfully manage the EOL LIBs and reuse EV batteries. A recent *Cell Reports Sustainability* article by Zhu et al.[6] tackled the question of establishing a model for effective EOL LIB management in China by investigating the demand, supply, and benefits (based on Sustainable Development Goals [SDGs]) of reusing EOL LIBs for rural electrification.

China has been the global leader in EV sales for the past few years and can, therefore, be expected to deal with a significant portion of the global EOL battery stock. In this context, Zhu et al.[6] aimed to address the need to better understand the disposal issue of retired batteries with the increasing electrification of road transport in China. The study goes beyond assessing economic and environmental benefits by evaluating the full-chain battery-reusing system's contribution to multiple SDGs (1, 7, 9, 12, and 13). One of the big questions regarding battery reuse is the application itself. Zhu et al.[6] consider using EOL LIBs for rural electrification, addressing energy poverty, and other SDGs. Evaluating the contribution to multiple SDGs might be regarded as an interesting approach to comparing different applications for battery reuse and might provide researchers with a multi-criteria decision analysis-esque methodology for analysis.

A key conclusion from Zhu et al.[6] is the need for a national and perhaps global strategy to establish a feasible full-chain battery-reusing system. Some of the techno-economic and sustainability challenges that are addressed in this study can be generalized globally. In contrast, some challenges are specific to the studied location—in this case, China. One instance of a global challenge is the establishment of a subsidy-free system relying on the existence of financial mechanisms, such as time-of-use pricing and utilities accepting any and all excess electricity. While there are negative electricity prices in locations with high renewable generation on the grid, there are exceedingly more utilities now that are limiting how much electricity utilities buy back from customers, which can hinder the uptake of distributed renewable generation and, by extension, retired battery systems. Such policies must be revisited when developing strategies for feasible battery reuse at a large scale since subsidy-free battery-reusing systems can be self-sustaining without burdening local governments to provide aid.

EV battery reuse is a relatively new industry, and there is still uncertainty in EOL LIB performance, lifetime, and benefits. The techno-economic and environmental benefits have been assessed through modeling efforts or for smaller-scale projects. Hence, multiple demonstration projects are being funded to obtain data in areas of uncertainty, such as projects in California.[7] Demonstrating successful projects can also positively impact public and consumer perceptions about the reuse of retired batteries, along with providing product warranties and safety certifications. Consumer perception and acceptance are crucial for ensuring that the EOL batteries are successfully used in a second-life application, such as in residential, commercial, and industrial areas, as they can affect the demand for EOL batteries, which, in turn, can impact the capacity expansion required for repurposing facilities and retired battery hubs. Kamath et al. have included consumer perceptions through interviews and surveys when assessing the economic and environmental benefits of a battery-reusing system over time in the United States.[8] However, consumer perception and acceptance of the reuse of retired batteries can vary by country, and that information is largely unknown and needs to be gauged. A more thorough understanding of consumer perceptions of retired batteries will help justify the investment in a long-term and large-scale battery-reusing system.

Multiple other barriers can hinder battery reuse, and these need to be considered in the feasibility analysis of second-life applications of EOL LIBs. Zhu et al.[6] address barriers, such as demand-supply matching at a spatial level and standardized processes and procedures, by advocating for retired battery hubs that can collect from and dispatch batteries to different locations based on the supply and demand of EOL LIBs. These hubs can help standardize the dismantling, testing, remanufacturing, and storage of EOL LIBs. There is also an aspect of ensuring the safety and reliability of retired batteries in second life through procedures developed and codified in standards, such as UL 1974, allowing facilities to be certified.[9] Standards, such as UL 1974, and certifications can increase the efficiency of the process and system, improve costs, and build trust among the stakeholders, especially the consumers.

Standardization should not be limited to the EOL LIB management stage. Successful implementation of circular economy approaches requires looking at all life cycle stages of a product, including the design stages. Design for EOL can potentially aid in the successful reuse of LIBs. Designing battery packs that can easily be dismantled and separated into higher and lower state-of-health modules and cells can help with faster and more efficient repurposing. Such a design will help not only reuse but also recycling if battery chemistry details are provided. Research is also ongoing to support safe and easy battery pack removal and dismantling using automated disassembly lines.[10]

There are ongoing efforts across the globe to address the different barriers that are hindering a second life for EOL EV batteries; these bids come from different stakeholders, such as governments, non-profits, and industries. As presented by Zhu et al.,[6] reusing EV batteries has considerable potential to provide low-cost renewable electricity, alleviate energy poverty, reduce mining of virgin materials, and reduce carbon emissions. Evaluating the barriers and challenges of reusing batteries is crucial to address them early in the design and planning phases. Involving different stakeholders to ensure that we address as many barriers as possible can help maximize the contributions from such reuse toward sustainable development and carbon neutrality.

DECLARATION OF INTERESTS

The authors declare no competing interests.

REFERENCES

1. Tiseo, I. (2023). Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2022, by sub sector. https://www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/.
2. Hanna, F., Yuan, L., Somers, C., and Anctil, A. (2024). Spatio-Temporal Life Cycle Assessment of NMC111 Hydrometallurgical Recycling in the US. In Technology Innovation for the Circular Economy: Recycling, Remanufacturing, Design, Systems Analysis and Logistics, N. Nasr, ed. (Wiley)), pp. 297–308. https://doi.org/10.1002/9781394214297.ch23.
3. Chen, M., Ma, X., Chen, B., Arsenault, R., Karlson, P., Simon, N., and Wang, Y. (2019). Recycling End-of-Life Electric Vehicle Lithium-Ion Batteries. Joule *3*, 2622–2646. https://doi.org/10.1016/j.joule.2019.09.014.
4. Shafique, M., Rafiq, M., Azam, A., and Luo, X. (2022). Material flow analysis for end-of-life lithium-ion batteries from battery electric vehicles in the USA and China. Resour. Conserv. Recycl. *178*, 106061. https://doi.org/10.1016/j.resconrec.2021.106061.
5. Kamath, D., Shukla, S., Arsenault, R., Kim, H.C., and Anctil, A. (2020). Evaluating the cost and carbon footprint of second-life electric vehicle batteries in residential and utility-level applications. Waste Manag. *113*, 497–507. https://doi.org/10.1016/j.wasman.2020.05.034.
6. Zhu, L., Yao, X., Su, B., Ang, B.W., Hao, H., Zhou, P., and Wang, S. (2024). Reusing Vehicle Batteries Can Power Rural China while Contributing to Multiple SDGs. Cell Reports Sustainability *1*, 100060. https://doi.org/10.1016/j.crsus.2024.100060.
7. Kendall, A., Slattery, M., and Dunn, J. (2020). Lithium-ion Car Battery Recycling Advisory Group Final Report (California Environmental Protection Agency). https://calepa.ca.gov/wp-content/uploads/sites/6/2022/05/2022_AB-2832_Lithium-Ion-Car-Battery-Recycling-Advisory-Goup-Final-Report.pdf.
8. Kamath, D., Moore, S., Arsenault, R., and Anctil, A. (2023). A system dynamics model for end-of-life management of electric vehicle batteries in the US: Comparing the cost, carbon, and material requirements of remanufacturing and recycling. Resour. Conserv. Recycl. *196*, 107061. https://doi.org/10.1016/j.resconrec.2023.107061.
9. Johnson, M.H. (2022). UL Certification Helps Promote Repurposing of Electric Vehicle (EV) Batteries. UL Solutions. October 10, 2022. https://www.ul.com/news/ul-certification-helps-promote-repurposing-electric-vehicle-ev-batteries.
10. Oak Ridge National Laboratory (2021). Automated disassembly line aims to make battery recycling safer, faster. https://www.ornl.gov/news/automated-disassembly-line-aims-make-battery-recycling-safer-faster.