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Newsletter 5

Advanced technologies for battery lifecycle management



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In our latest newsletter edition, we're diving into two exciting fronts shaping the future of electric vehicle battery innovation. First, discover how cutting-edge state-of-health estimation techniques are revolutionising how we assess battery performance, predict degradation, and even unlock the full potential of second-life applications. Then, we shift gears to explore pioneering disassembly methods that make EV battery recycling safer, more efficient, and cost-effective, thus paving the way for a truly circular economy. Both topics are connected to ongoing activities in the R3-Mydas demo case two and contribute to a better understanding of technological capabilities and market opportunities. Stay tuned as we unpack how these advanced technologies are not only enhancing battery management systems but also opening new business opportunities in sustainable remanufacturing and recycling.

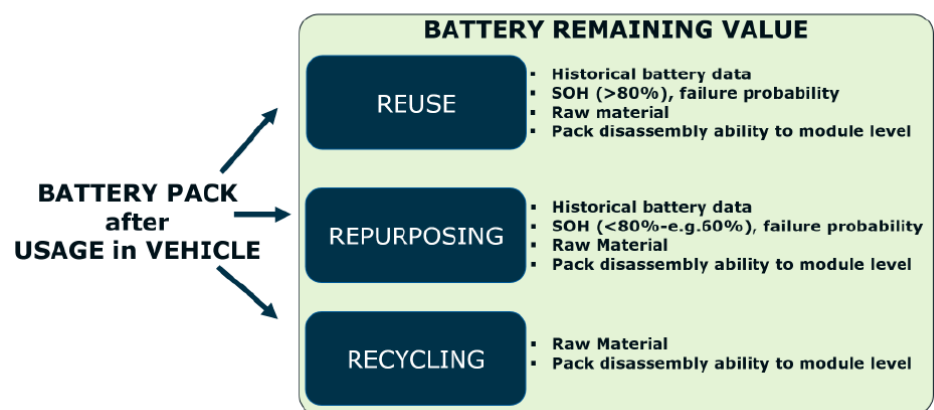
State of Health Estimation on Electric Vehicle Batteries

The estimation of the state of health (SOH) of automotive batteries is a critical factor in assessing their viability for second-life applications, such as energy storage and vehicle-to-grid (V2G) technologies. As electric vehicles (EVs) transition to their second life, the ability to accurately estimate SOH becomes paramount to ensure reliability, safety, and optimal performance in new roles. Challenges in SOH estimation stem from various factors including data collection, model adaptability, algorithm complexity, and the unique characteristics of different battery chemistries, which collectively hinder effective assessments and integration into battery management systems.

Data collection remains a fundamental challenge, as accurate SOH estimation relies on multiple health indicators influenced by battery age, temperature, and operational cycles. Inconsistent data quality from manufacturers can lead to unreliable health assessments, necessitating robust approaches such as machine learning and big data analytics to improve accuracy [1,2]. Furthermore, the complexity of selecting relevant features for SOH models introduces difficulties; redundant features may obscure significant health indicators, complicating the training of models that can generalise across various battery types and conditions [3,4].

The adaptability of SOH estimation models to diverse battery chemistries presents additional hurdles. While mechanistic models grounded in physical principles provide insights into degradation, they often require precise calibration to maintain accuracy across different usage scenarios. In contrast, empirical models may struggle with generalisation, emphasising the need for improved methods that can accommodate the variability inherent in real-world battery applications [4]. Moreover, the computational complexity of advanced algorithms, such as long short-term memory (LSTM) networks, poses practical challenges for implementation in automotive settings, highlighting the importance of balancing model sophistication with real-time operational needs [1,2].

As the market for second-life applications continues to grow, addressing these challenges is essential for ensuring the economic viability and safety of repurposed batteries. Ensuring compatibility between battery chemistries and application

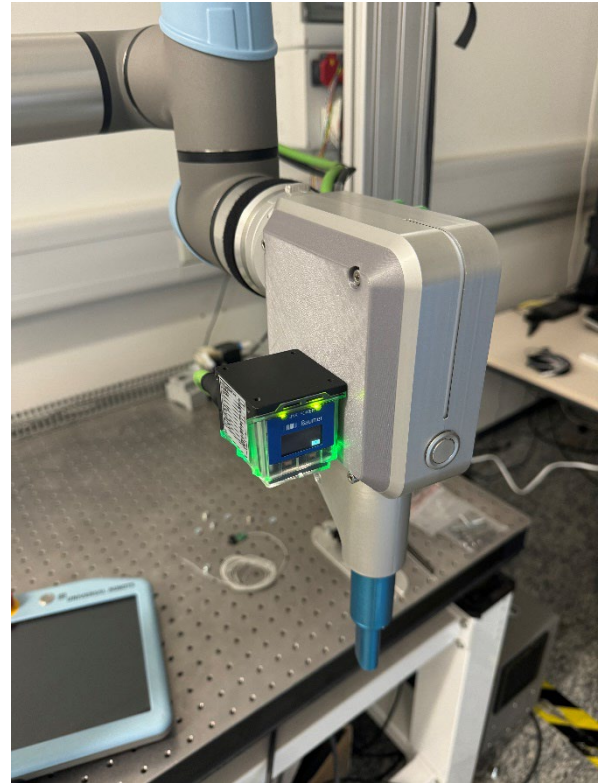


requirements, establishing standardised testing protocols, and considering environmental impacts are crucial steps in optimising the second-life utility of automotive batteries. Ongoing research efforts that combine mechanistic and data-driven approaches aim to refine SOH

estimation methodologies, ultimately facilitating better lifecycle management and supporting a more sustainable energy ecosystem [5,6,7].

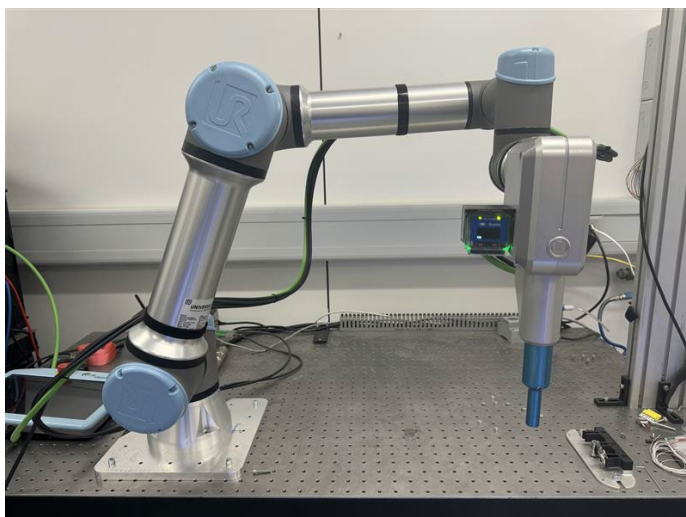
Disassembly of Electric Vehicle Batteries

The automation of the disassembly process for batteries within the automotive supply chain is emerging as a critical innovation in response to the growing demand for electric vehicles (EVs) and the imperative for sustainable practices in battery recycling. As the automotive industry pivots towards electric mobility, the necessity for efficient disassembly methods to recover valuable materials from retired lithium-ion batteries (LIBs) has gained prominence. Traditional manual disassembly techniques have proven to be labour-intensive, inefficient, and hazardous, highlighting the urgent need for automated solutions that enhance operational efficiency and safety in handling toxic materials [8,9].



Automation technologies, such as robotics and artificial intelligence, offer significant business advantages by reducing labour costs, minimising human error, and increasing throughput in battery disassembly operations. These automated systems can optimise task allocation and streamline workflows, improving productivity and cost savings [10,11]. Moreover, incorporating advanced methodologies like knowledge graphs allows for better planning and execution of disassembly processes, facilitates the recovery of critical materials and supports the principles of a circular economy [12,13].

Despite these advancements, the automation of battery disassembly faces notable challenges,



including technical limitations associated with non-modular vehicle designs, complex product structures, and the need for specific material selection to enhance recyclability [14,15]. Additionally, the financial investment required for implementing these systems can be a barrier for smaller manufacturers, especially considering evolving regulatory pressures that mandate higher recycling rates for battery materials [16]. Nevertheless, companies that

effectively integrate automation into their disassembly processes are likely to achieve a competitive edge in the automotive industry by promoting sustainability and operational excellence.

Overall, the push for automating battery disassembly reflects a broader shift towards innovative practices in the automotive supply chain, addressing economic, environmental, and safety considerations while positioning manufacturers for success in an increasingly electrified market [17,18].

References

- [1] Montes, T., Etxandi-Santolaya, M., Eichman, J., Ferreira, V. J., Trilla, L., & Corchero, C. (2022). Procedure for Assessing the Suitability of Battery Second Life Applications after EV First Life. *Batteries*, 8(9), 122. <https://doi.org/10.3390/batteries8090122>.
- [2] Li, M., Xu, W., Zhang, S., Liu, L., Hussain, A., Hu, E., Zhang, J., Mao, Z., & Chen, Z. (2025). State of Health Estimation and Battery Management: A Review of Health Indicators, Models and Machine Learning. *Materials*, 18(1), 145. <https://doi.org/10.3390/ma18010145>.
- [3] Chen, K., Wang, D., & Guo, W. (2024). A Method for Estimating the SOH of Lithium-Ion Batteries Based on Graph Perceptual Neural Network. *Batteries*, 10(9), 326. <https://doi.org/10.3390/batteries10090326>.
- [4] Soyoye, B. D., Bhattacharya, I., Anthony Dhason, M. V., & Banik, T. (2025). State of Charge and State of Health Estimation in Electric Vehicles: Challenges, Approaches and Future Directions. *Batteries*, 11(1), 32. <https://doi.org/10.3390/batteries11010032>.
- [5] Second Life Batteries – Engineering Cheat Sheet, <https://engineeringcheatsheet.com/second-life-batteries>.
- [6] Patel AN, Lander L, Ahuja J, Bulman J, Lum JKH, Pople JOD, Hales A, Patel Y and Edge JS (2024) Corrigendum: Lithium-ion battery second life: pathways, challenges and outlook. *Front. Chem.* 12:1414996. doi: 10.3389/fchem.2024.1414996.
- [7] Kostenko, G., & Zaporozhets, A. (2024). Transition from Electric Vehicles to Energy Storage: Review on Targeted Lithium-Ion Battery Diagnostics. *Energies*, 17(20), 5132. <https://doi.org/10.3390/en17205132>.
- [8] Li, J., Qu, W., Zheng, H., Zhang, R., & Liu, S. (2024). Generation of human–robot collaboration disassembly sequences for end-of-life lithium–ion batteries based on knowledge graph. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 38, e13. <https://doi.org/10.1017/S0890060424000143> .

[9] Rehman, S., Al-Greer, M., Burn, A. S., Short, M., & Cui, X. (2025). High-Volume Battery Recycling: Technical Review of Challenges and Future Directions. *Batteries*, 11(3), 94. <https://doi.org/10.3390/batteries11030094>.

[10] Garg, A. (2020). Battery pack recycling challenges for the year 2030: Recommended solutions based on intelligent robotics for safe and efficient disassembly, residual energy detection, and secondary utilization. *Energy Storage*.

[11] Battery: The Great Recycling Challenge - DirectIndustry e-Magazine, <https://emag.directindustry.com/2025/02/13/battery-the-great-recycling-challenge/>

[12] ATS Helps a Leading Auto Manufacturer Redefine EV Battery Assembly, https://atsindustrialautomation.com/case_studies/ats-helps-leading-auto-manufacturer-define-ev-battery-assembly/

[13] 5 Automation Advantages for EV Battery Production, <https://convergixautomation.com/5-automation-advantages-for-ev-battery-production/>

[14] Designing for Disassembly: Enhancing Automotive Sustainability, <https://automotivequest.com/designing-for-disassembly/>

[15] 5 Strategies for Increasing Efficiency in the Automotive Industry, <https://www.innovationnewsnetwork.com/the-ultimate-guide-to-the-ev-battery-supply-chain/30592/>

[16] Klohs, D., Offermanns, C., Heimes, H., & Kampker, A. (2023). Automated Battery Disassembly—Examination of the Product- and Process-Related Challenges for Automotive Traction Batteries. *Recycling*, 8(6), 89. <https://doi.org/10.3390/recycling8060089>

[17] How AI is shaping the future of automotive manufacturing, <https://www.automotivemanufacturingsolutions.com/smart-factory/how-ai-is-shaping-the-future-of-automotive-manufacturing/46607.article>

[18] Enhancing Disassembly Practices for Electric Vehicle Battery, Beghi, M., Braghin, F., & Roveda, L. (2023). Enhancing Disassembly Practices for Electric Vehicle Battery Packs: A Narrative Comprehensive Review. *Designs*, 7(5), 109. <https://doi.org/10.3390/designs7050109>.