

Deliverable D4.7

Delivery of battery packs



Feasible Recovery of critical raw materials through a new circular Ecosystem for a Li-Ion Battery cross-value chain in Europe

WP4 - Scaling and validation of feasible technologies

D4.7 - Delivery of battery packs

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Versions

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29.05.2026	2	AVL, CARTIF	Final version



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List of Abbreviations

ACRONYMS	DESCRIPTION
AVL	AVL List GmbH
BMS	Battery Management System
DfR	Design for Recycling
EOL	End-of-Life
LIB	Lithium-Ion Battery
TRL	Technology Readiness Level

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1. Executive Summary

This deliverable presents the final integration step of the FREE4LiB project by documenting the assembly and delivery of demonstrator battery packs based on recycled, re-used and newly manufactured components. FREE4LiB aims to establish a circular cross-value chain for lithium-ion batteries in Europe by recovering critical raw materials, reintroducing them into battery manufacturing and validating their use in practical applications. Within this context, D4.7 demonstrates how outputs from previous recovery, materials processing, cell manufacturing and design activities were combined at pack level to realise functional battery module and pack demonstrators for micro-mobility applications. The report highlights the integration of pouch cells, 3D-printed carriers and plastic parts, bus bars, sensors and a re-used housing, and thereby confirms the technical feasibility of translating circular battery concepts into a coherent system-level prototype. Overall, the deliverable provides evidence that the FREE4LiB approach can support more sustainable, resource-efficient and design-for-recycling-oriented battery systems, while also contributing to the project's broader objective of reducing Europe's dependence on primary raw materials and enabling scalable circular battery manufacturing.

2. Introduction

Deliverable D4.7, *Delivery of battery packs*, documents the final integration step of the FREE4LiB value chain by presenting how recycled and re-used materials developed throughout the project are brought together in demonstrator battery modules and packs. As defined in WP4 and particularly in Task 4.10, this deliverable captures the transition from individual recycling, re-synthesis and cell manufacturing activities to a system-level validation of battery pack assembly for micro-mobility applications. In this sense, D4.7 is a key demonstration output of FREE4LiB, since it shows how the project's circular approach moves beyond material recovery and laboratory validation toward a functional and manufacturable battery pack concept based on recovered resources and Design-for-Recycling principles.

The work reported in this deliverable builds on the upstream results generated in WP3 and WP4, including the recovery of metals, polymers and active materials, the synthesis of cathode materials from recycled precursors, the production of pouch cells, and the development of battery pack designs aligned with eco-design and traceability requirements. In particular, the deliverable reflects the integration of outputs from Tasks 4.6 to 4.9, culminating in the assembly activities performed by AVL in Task 4.10. It therefore provides



evidence that the FREE4LiB concept can be implemented at pack level by combining recycled structural materials, recovered functional materials and newly manufactured cells into coherent demonstrator systems. Beyond the physical assembly itself, D4.7 also addresses the quality assurance, manufacturability and validation logic required to assess whether the resulting battery packs are suitable for their intended use case and consistent with the project's sustainability, circularity and safety objectives.

Accordingly, this deliverable is intended to provide both a technical and integrative overview of the battery pack realization within FREE4LiB. It introduces the components and sub-systems considered for assembly, outlines the logic of the pack-level integration process, and frames the demonstrator results within the broader ambition of establishing a circular cross-value chain for lithium-ion batteries in Europe. The following chapters therefore describe the main parts and materials used, the battery module and pack assembly approach, and the main conclusions that can be drawn regarding the feasibility of pack production from recycled and re-used components. In doing so, D4.7 contributes to demonstrating that circular battery manufacturing is not only a theoretical objective of the project, but a practical pathway toward more sustainable, resource-efficient and regulation-ready battery systems.

3. Assembly of battery module



Figure 1 delivered NESSTEC cells

Cells from Nesstec. The battery cells used for the pack demonstrators were provided by NESTEC as the outcome of the pouch-cell manufacturing activities carried out in Task 4.9. These cells represent the functional core of the FREE4LiB battery packs and were produced using cathode and anode materials developed and validated within the project, including recycled and revalorised materials wherever technically feasible. In this way, the cells do not only serve as an energy storage component, but also as a proof point that recovered active materials can be reintegrated into new battery manufacturing routes. For the purposes of D4.7, the NESTEC cells form the basis for the subsequent module

and pack assembly at AVL, where their integration, handling and validation are assessed in the context of a complete demonstrator system.



Figure 2 pre-measurements of cells



Figure 3 3D printed cell carrier

3D-printed module carrier. A dedicated module carrier was manufactured by 3D printing in order to support the positioning, fixation and integration of the battery cells within the demonstrator module. As a functional interface component, the module carrier plays an important role in ensuring mechanical stability, defined cell arrangement and assembly flexibility during prototyping

and validation. Its additive manufacturing approach is particularly relevant within FREE4LIB, as it enables the rapid production of geometrically adapted support structures while also creating an application route for recycled polymer materials. The 3D-printed module carrier therefore combines design flexibility with circular material use and contributes directly to the practical realization of the battery module and pack concept described in this deliverable.

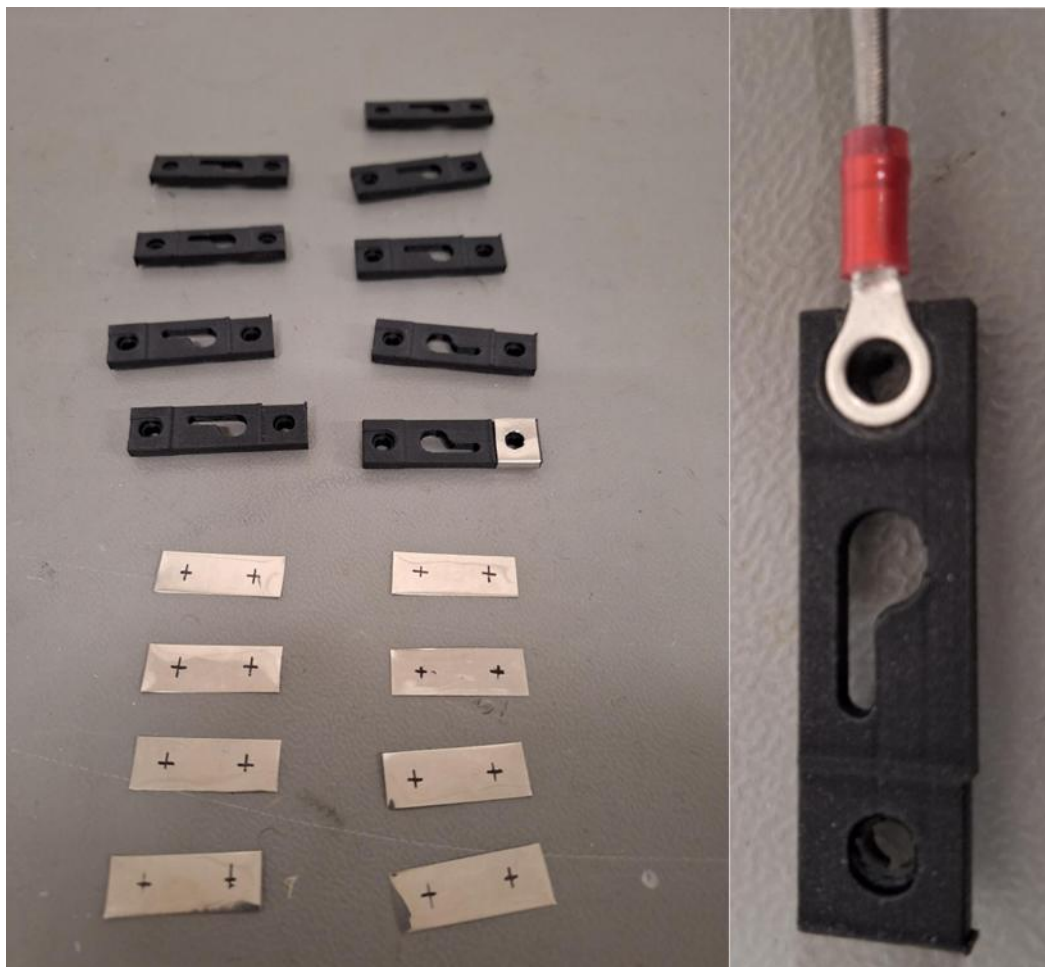


Figure 4 preparation of bus bars

3D-printed parts out of recycled plastics. In addition to the electrochemical components, selected structural and auxiliary parts of the demonstrator were produced from recycled plastic materials recovered and processed within FREE4LIB. These materials originate from polymer recycling activities in the project and were further adapted for manufacturing into battery-related components. The use of 3D-printed plastic parts demonstrates how recovered thermoplastic fractions can be transformed into functional elements for battery pack integration, thereby extending the circular use of materials beyond active components. Within the scope of this deliverable, such parts contribute to the

overall pack architecture by supporting mechanical integration, prototyping flexibility and the practical demonstration of recycled materials in real battery system applications.



Figure 5 charging port assembly



Figure 6 pre-adjustment of cells in the carrier



Figure 7 stacking pouch cells

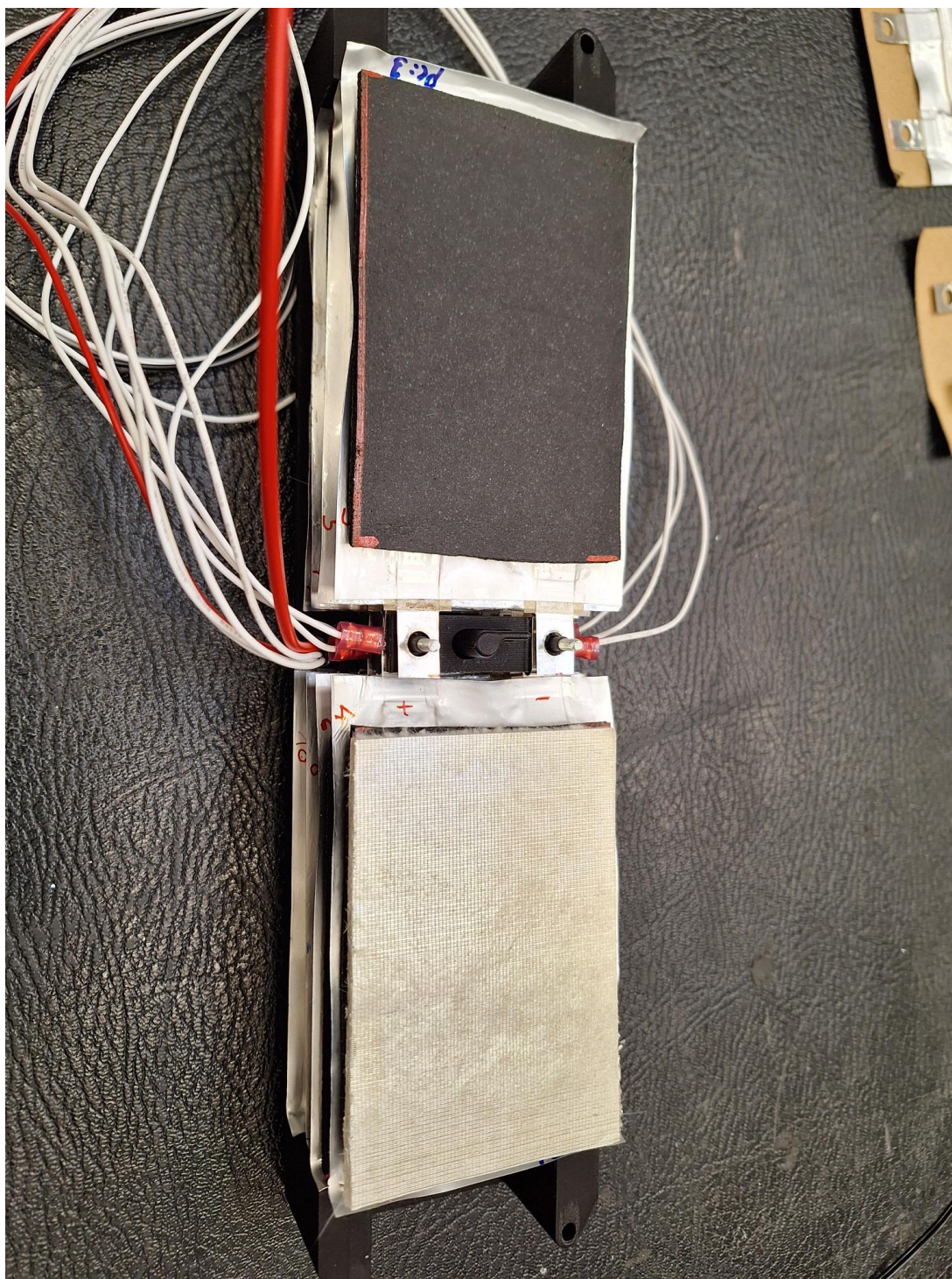


Figure 8 stacking of pouch cells

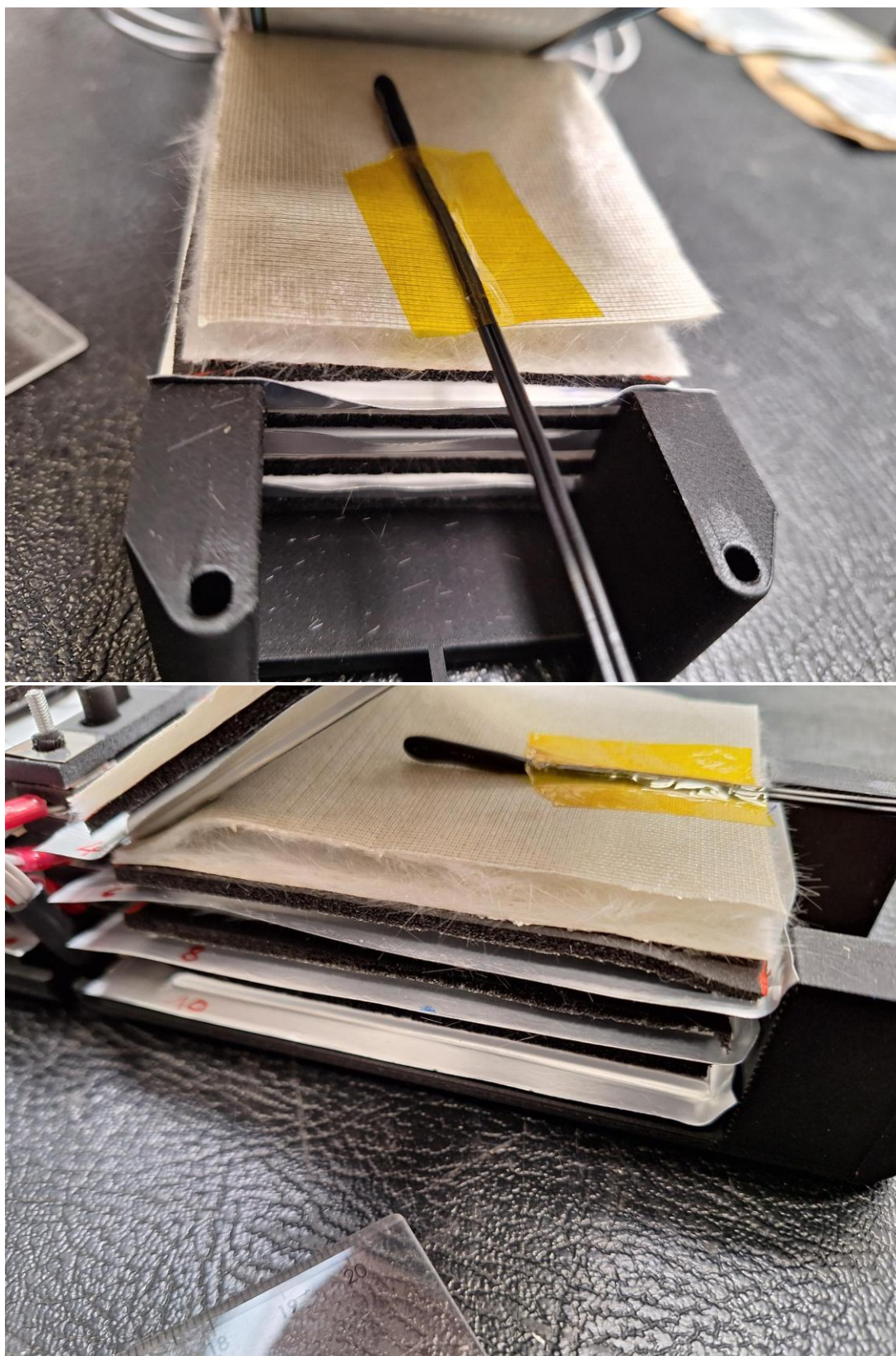


Figure 9 temperature sensor placement

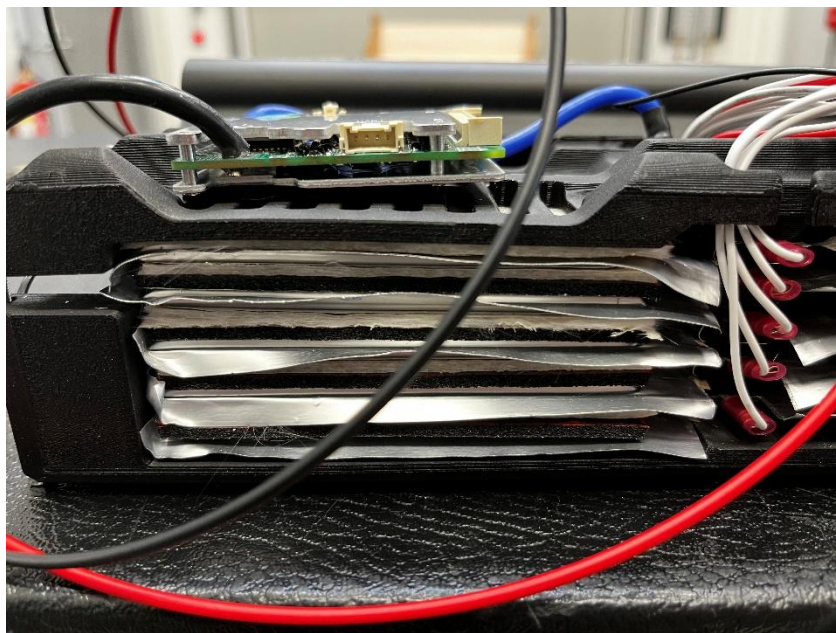


Figure 10 stacekd module

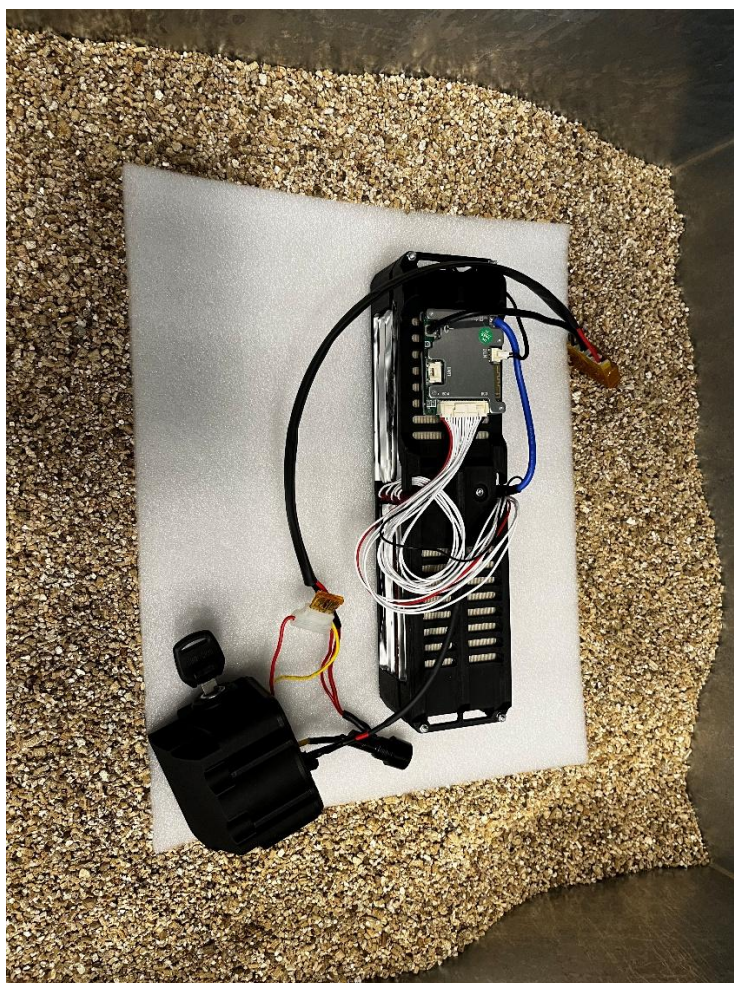


Figure 11 first charging within safe environment



Figure 12 last step before inserting into housing

Re-used housing. The demonstrator battery pack also incorporates a re-used housing element, highlighting the FREE4LIB ambition to extend circularity not only to materials, but also to larger structural components wherever technically and functionally feasible. Re-using the housing contributes to reducing the need for newly manufactured enclosure parts and demonstrates the potential of

retaining existing value in battery system components beyond first life. Within the context of D4.7, the re-used housing provides the main structural enclosure for the integrated module or pack assembly and serves as a practical example of how second-use or recovered components can be combined with newly manufactured and recycled parts in a coherent battery pack architecture.



Figure 13 final assembly measurement