BATT:RE: Battery Supply Chain Information Management for Optimized Tracking and Circularity

Public report

Project within: FFI Circularity
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Fordonsstrategisk Forskning och Innovation

Content

FFI in short

FFI, Strategic Vehicle Research and Innovation, is a joint program between the state and the automotive industry running since 2009. FFI promotes and finances research and innovation to sustainable road transport.

For more information: www.ffisweden.se

1. Summary

The BATT:RE project was a nine-month feasibility study designed to explore current practices, identify critical challenges, and address key data management issues across the EV battery supply chain. The project aimed to enhance resource-efficient sourcing, manufacturing, and end-of-life battery handling in alignment with the EU Battery Passport initiative. BATT:RE established foundational knowledge to inform a larger Research and Innovation (R&I) proposal submitted to FFI Circularity, focusing on three strategic areas: (a) traceability and digital product passports enabling transparent tracking from sourcing through end-of-life; (b) extended battery lifespan through information sharing mechanisms supporting second-life applications; and (c) logistical and regulatory harmonization addressing cross-border transport challenges.

The study examined battery circularity through three complementary analytical lenses: (i) legal, operational, and traceability analysis reviewing regulatory frameworks and existing technologies; (ii) information flow mapping identifying inefficiencies, data quality issues, and accountability gaps; and (iii) current practice assessment documenting existing initiatives while defining priority research areas. The methodological approach integrated literature review, stakeholder engagement through workshops and interviews with OEMs, recyclers, and regulators, industrial case studies combining site visits and observations, cross-case synthesis, and document analysis. The research examined practices and challenges of two heavy vehicle OEMs, facilitating cross-company learning to co-create research questions and build a robust consortium.

The project successfully delivered four primary outputs: (a) consortium presentations during project meetings and workshops; (b) peer-reviewed conference paper presented at NOFOMA 2025 (Copenhagen); (c) conference paper accepted for Swedish Production Symposium 2026 (Luleå); and (d) comprehensive FFI Circularity R&I proposal submitted in October 2025. Findings were disseminated through multiple seminars engaging students, experts, and industry representatives. Deliverables included summary reports on legal/operational frameworks, industrial pain points and information needs, individual OEM cases with cross-case analysis, and the full R&I proposal detailing research scope, deliverables, roles, and timeline.

The research revealed that while technological solutions for battery tracking existed, significant gaps remained in standardized information architectures, seamless data exchange, and alignment of operational practices with evolving regulations. Achieving effective circularity required not only technical innovation but also collaborative governance models integrating OEMs, recyclers, regulators, and technology providers within transparent, data-driven ecosystems.

The project generated academic and industrial impact through publications and stakeholder engagement validating research relevance. Future research outlined in the FFI Circularity proposal will advance information architectures and digital product passports. This pre-study represented a critical foundation for Sweden's transition toward circular

economy leadership in battery value chains, bridging academic research with industrial practice and policy development to achieve battery circularity at scale.

2. Sammanfattning på svenska

Studien undersökte battericirkularitet genom tre kompletterande analytiska linser: (i) juridisk, operativ och spårbarhetsanalys som granskade regulatoriska ramverk och befintliga teknologier; (ii) kartläggning av informationsflöde som identifierade ineffektivitet, datakvalitetsproblem och ansvarsluckor; och (iii) bedömning av nuvarande praxis som dokumenterade befintliga initiativ samtidigt som prioriterade forskningsområden definierades. Den metodmässiga ansatsen integrerade litteraturöversikt, intressentengagemang genom workshoppar och intervjuer med OEM:er, återvinningsföretag och tillsynsmyndigheter, industriella fallstudier som kombinerade platsbesök och observationer, fallöverskridande syntes och dokumentanalys. Forskningen undersökte praxis och utmaningar hos två tunga fordonOEM:er, vilket underlättade företagsövergripande lärande för att samskapa forskningsfrågor och bygga ett robust konsortium.

Projektet levererade framgångsrikt fyra primära resultat: (a) konsortiumspresentationer under projektmöten och workshoppar; (b) granskad konferenspaper presenterad vid NOFOMA 2025 (Köpenhamn); (c) konferenspaper accepterad för Swedish Production Symposium 2026 (Luleå); och (d) omfattande FFI Circularity FoI-förslag inlämnat i oktober 2025. Resultaten spreds genom flera seminarier som engagerade studenter, experter och industrirepresentanter. Leveranser inkluderade sammanfattningsrapporter om juridiska/operativa ramverk, industriella smärtpunkter och informationsbehov, individuella OEM-fall med fallöverskridande analys, och det fullständiga FoI-förslaget som beskrev forskningsomfång, leveranser, roller och tidslinje.

Forskningen avslöjade att även om teknologiska lösningar för batterispårning fanns, kvarstod betydande luckor i standardiserade informationsarkitekturer, sömlöst datautbyte och anpassning av operativa metoder till utvecklande regleringar. Att uppnå effektiv cirkularitet krävde inte bara teknisk innovation utan även samarbetsbaserade styrningsmodeller som integrerade OEM:er, återvinningsföretag, tillsynsmyndigheter och teknikleverantörer inom transparenta, datadrivna ekosystem.

Projektet genererade akademisk och industriell påverkan genom publikationer och intressentengagemang som validerade forskningens relevans. Framtida forskning som beskrevs i FFI Circularity-förslaget kommer att främja informationsarkitekturer och digitala produktpass. Denna förstudie representerade en kritisk grund för Sveriges övergång mot ledarskap inom cirkulär ekonomi i batterivärdekedjor, genom att överbrygga akademisk forskning med industriell praxis och politikutveckling för att uppnå battericirkularitet i stor skala.

3. Background

The EU's commitment to achieving a 90% reduction in transport-related CO2 emissions by 2050 demands rapid electrification of the transport sector. EV battery demand is projected to grow from 200 GWh (2020) to 10,000 GWh (2040), yet battery production generates significant greenhouse gas emissions. Establishing circular battery systems through repair, reuse, second-life applications, and recycling is critical to reduce environmental impact and enhance resource efficiency.

The EU's 2023 Battery Regulation introduced stringent requirements for sustainable sourcing, labeling, and circularity obligations, including the Battery Passport—a key mechanism for enhancing transparency and traceability across supply chains. This regulation has accelerated industry discussions among heavy electric vehicle OEMs regarding information management and traceability systems. Prior research initiatives (LOVIS, LOVIS4C, VIVACE) demonstrated that information management is critical for circular economy strategies, yet vehicle OEMs struggle with end-to-end traceability due to fragmented data ecosystems and incomplete compliance mechanisms.

While academic literature emphasizes manufacturer and market operator responsibilities, battery recyclers' traceability requirements remain underexplored. OEMs face significant data management challenges managing logistics, designing resilient supply chains, and extending battery lifecycles across multiple regions. These gaps highlight the need for research optimizing battery traceability—particularly during recycling—to fully realize the EU's sustainability goals. BATT:RE addressed these critical gaps by focusing specifically on battery circularity for heavy electric vehicles.

4. Purpose, research questions and method

The Batt:RE pre-study worked towards enhancing end-of-life battery management in alignment with the EU Battery Passport initiative. The project established foundational knowledge to inform a larger Research and Innovation proposal submitted to FFI Circularity, addressing critical challenges in battery lifecycle management across three strategic areas: (a) traceability and digital product passports enabling transparent tracking from sourcing through end-of-life; (b) extended battery lifespan through information sharing mechanisms supporting second-life applications for EV batteries; and (c) logistical and regulatory harmonization addressing cross-border transport challenges and regulatory inconsistencies that impede circular material flows.

The study employed a multi-method research design examining battery circularity through three complementary analytical lenses:

(i) Legal, Operational, and Traceability Analysis systematically reviews regulatory frameworks (EU Battery Regulation), operational practices across value chains, and

existing traceability technologies to identify compliance requirements and implementation gaps.
(ii) Material and Information Flow Mapping for decision making during battery use and end of life handling
(iii) Current Practice Assessment documents existing circularity initiatives while defining priority areas for future R&I efforts aligned with regulatory timelines and industrial readiness.
The data collection integrates multiple approaches: Literature review examining academic publications, industry reports, and technical standards; stakeholder engagement through workshops and interviews with OEMs, recyclers, logistics providers, and regulators; industrial case studies combining site visits, observations, and document review; cross-case synthesis identifying patterns and generalizable insights; and document analysis triangulating findings across technical and regulatory sources.

5. Objective

BATT:RE, was a nine-month feasibility study that addresses challenges in information management for the electric vehicle battery supply chain. By analysing current practices and identifying pain points at two major OEMs for heavy vehicles, along with recycling company and universities, the project laid the foundation for a larger R&I project within FFI Circularity-program. The goal is to improve traceability, information systems and support EU initiatives for battery passports.

6. Results and deliverables

The project successfully delivered four primary outputs that collectively fulfilled the planned deliverables and advanced knowledge dissemination in the field:
Primary Outputs
(a) Consortium Engagement and Knowledge Exchange
Regular presentations and interactive discussions were conducted with consortium members during project meetings and dedicated workshops held online and onsite, facilitating collaborative refinement of findings and alignment on strategic directions.
(b) NOFOMA 2025 Conference Contribution
A conference paper was presented at the NOFOMA 2025 conference (Copenhagen, Denmark, June 11-12, 2025), disseminating key findings on industrial information

management, traceability needs, and cross-case analysis to an international academic and practitioner audience.

(c) Swedish Production Symposium (SPS) 2026

A conference paper is accepted for presentation at the Swedish Production Symposium (SPS), scheduled for March 2026 in Luleå, Sweden. This paper synthesizes legal, operational, and information/traceability frameworks relevant to battery circularity.

(d) FFI Circularity Full R&I Project Proposal

Building on the pain points and opportunities identified during the pre-study, a comprehensive Research and Innovation (R&I) project proposal was submitted to FFI Circularity in October 2025. The proposal research area and fostered broader engagement with stakeholders. Details of these dissemination activities are documented in the Publications section.

7. Dissemination and publications

7.1 Dissemination

How are the project results planned to be used and disseminated?	Mark with X	Comment
Increase knowledge in the field	X	a) SPS conference paper (March 2026) b) NOFOMA conference paper (June 2025) + Consortium presentations c) Presented the results as part of the PhD course on Circular Economy and Industrial Systems at KTH to 17 PhD students, June 2025 d) Presented results at a Workshop on sustainable/LCA LiBs supply chain at Scania, 24 June 2025 e) Presented the BattRE project as part of the Circular Manufacturing Systems (CMS) Course at KTH to approximately 90 masters students, Sep 2025 f) Presentation the results at a seminar organised by the Swedish Manufacturing R&D Clusters, held at The Battery Centre in Gothenburg , 11 Sep 2025 g) Presentation the results at a seminar organised by KTH Battery 3PC seminar, 20 Oct 2025
Be passed on to other advanced technological development projects	X	FFI Circularity full R&I project proposal (October 2025
Be passed on to product development projects		
Introduced on the market		
Used in investigations / regulatory / licensing / political decisions	X	The results lead to a full R&I project proposal and PhD project that would be focus on DPP implementation in automobile supply chains

7.2 Publications

a) ***Authors:*** Areej Al-Sabban, Tarun Agrawal, Patricia van Loon and Patrik Jonsson
Title: Adopting Digital Product Passports in Supply Chains: Insights from the ABCDE Model and Sectoral Comparisons
Conference: SPS conference paper (March 2026)

b) ***Authors****:* Tarun Kumar Agrawal, Sayyed Shoaib-ul-Hasan, Seyoum Eshetu Birkie, Magnus Wiktorsson, Patrik Jonsson
Title: Towards Circular Battery Supply Chains: An Information Management Problem Discussion"
Conference: NOFOMA 2025 (June 11–12, 2025 in Copenhagen).

8. Conclusions and future research

This pre-study has successfully mapped the landscape of battery circularity from legal, operational, and information management perspectives, delivering critical insights into the frameworks, challenges, and opportunities that define this emerging field. Through systematic analysis of industrial cases, stakeholder consultations, and cross-case synthesis, the project identified key pain points related to traceability, data interoperability, and regulatory compliance that currently hinder the transition toward circular battery value chains.

The findings reveal that while technological solutions for tracking and managing battery lifecycles exist, significant gaps remain in standardized information architectures, seamless data exchange between stakeholders, and alignment of operational practices with evolving regulatory requirements. The research demonstrates that achieving effective battery circularity requires not only technical innovation but also collaborative governance models that integrate Original Equipment Manufacturers (OEMs), recyclers, regulators, and technology providers within transparent, data-driven ecosystems. he project deliverables not only fulfilled contractual obligations but also generated substantial academic and industrial impact through:

- Knowledge dissemination at internationally recognized conferences
- Stakeholder engagement through workshops and presentations
- Strategic impact development via the full R&I proposal, positioning the consortium for extended research funding and collaboration

These outputs collectively advance the state of knowledge in battery circularity and establish a foundation for continued innovation in circular supply chain management. Building on the foundation established by this pre-study, future research will advance along several interconnected trajectories outlined in the submitted FFI Circularity proposal

9. Participating parties and contact persons

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