CIRCUBATT: Unlocking the value in Europe's next wave of retired EV batteries

CIRCUBATT is a Horizon Europe initiative focused on integrating battery health data, sustainable design and data-driven business models across the whole lifecycle, delivering more efficient re-use of retired power units. Coordinator Professor **Li Zhou**, of the University of Greenwich, believes this triple strategy will cut Europe's reliance on critical raw materials, reduce environmental impact and increase industrial competitiveness as reuse and recycling scale up.

Electric vehicles are growing in popularity across Europe and, with them, demand for the batteries that power them. That success brings several difficult problems: supply chains for critical materials are geopolitically sensitive; recycling recovers only a fraction of material value; and most battery packs are designed for range rather than easy dismantling, second-life use or efficient recycling. Add fragmented Battery Management System (BMS) data and uneven regulation and the system is under strain just as the first big wave of EV batteries nears "retirement" at around 80% state of health – in practice, once a battery can hold about four-fifths of its original charge, range falls, leaving the battery deemed valuable only for reuse or recycling, often in stationary storage or light-mobility roles.

These challenges are precisely why now is the right moment for CIRCUBATT, says Professor Li Zhou of the University of Greenwich, who leads this Horizon Europe project. She frames the pressure across the whole chain, materials, manufacturing, design, data and policy. "Supply is dominated by a small number of countries, with related geopolitical risks. The EU wants to reduce this dependence," she says. "Battery production also has a high carbon footprint and uses toxic solvents and the EU wants to reduce this, too," she continues. "But current recycling and recovery processes are inefficient and only reclaim a fraction of valuable materials, leading to waste and resource depletion."

With many batteries exiting vehicles at just 80% of their original charge capacity, yet still capable of useful work, CIRCUBATT's triple strategy, which includes new business models, sustainable-by-design and an AI platform that turns BMS data into decisions, aims to ensure these batteries are routed through to the right second-life or recycling path.

"The technology choices that helped EVs scale up now complicate end-of-life decisions," Zhou explains. "Today's batteries are largely designed for range and performance per charge, not for easy dismantling, second-life use or efficient recycling – our approach is looking to change that."

Creating a single, standard recycling process is hard largely due to the design evolution of EV batteries. Chemistries and pack architectures change quickly, so process lines struggle to keep up. Information to make better decisions already exists, but it is locked in battery management systems and that data is fragmented, with companies reluctant to share it. "It is this data that is so vital to prolonging battery life, predicting maintenance needs and deciding on optimum reuse or recycling pathways," says Zhou.

Today's batteries are largely designed for range and performance per charge, not for easy dismantling, second-life use or efficient recycling – our approach is looking to change that.

And this is why CIRCUBATT's triple approach is critical, deliberately cross-cutting to pull three levers at once – enabling engineering, economics, and policy to move together.

First, Zhou explains the project's new business models. "We're developing models such as Battery-as-a-Service (BaaS), Data-as-a-Service and Energy-as-a-Service, and mapping revenue pathways so companies know how to make money from retired EV batteries," she says outlining the CIRCUBATT's ambition to move EV battery makers away from "take-make-dispose" transactions toward a more service logic – who owns what, when to charge and discharge, and how value is shared along the chain. "In practical terms, BaaS shifts the user from owning a pack to subscribing to its performance, aligning incentives for durability in the first place followed by repair and reuse."

Second, Zhou describes the project's approach to design for sustainability, from cell chemistry, production process, to the mechanical battery pack itself. "We're working on cell design, cleaner production processes (to reduce toxic solvents), and pack design for easier dismantling. Partners are also developing technologies to reuse materials recovered from batteries."

So, decisions about whether a battery can be safely removed and redeployed into e-scooters or stationary systems, for example, are made at the time it is designed. "From the start, packs should be designed to make swapping, dismantling and repurposing easier," she clarifies. "That is why redesigning the pack is an important part of our work."

Finally, Zhou explains how the AI-driven, cross-sector platform the project is developing will ensure battery data is turned into actionable decisions on this reuse, recycle pathway. "Companies can upload BMS data," she says. "Our machine-learning models can predict remaining capacity (State of Health – SoH), combine this with market data, estimate value, and recommend the best route forward, which will be to reuse, repurpose or recycle the battery."

Currently, battery SoH is manually tested and this can take hours; CIRCUBATT aims to compress that diagnostic process. "Our machine-learning models use historical BMS data to predict remaining capacity, saving time and money," Zhou explains. "The platform then layers LCA/LCC and live market signals and we provide estimated battery value by tracking real-time demand/supply and raw-material price trends. If raw-material prices spike, recycling might be optimal; if they fall, reuse could be better."

Six routes to second-life value

With triage powered by BMS data and market signals, CIRCUBATT translates this analytics-plus-design approach into six practical routes for "where next?" for retired packs: grid optimisation; grid independence; mobile power; consumer and light mobility; large-scale energy storage systems for high-demand sites (such as AI data centres); and community/nanogrid applications. "We have many European case studies for the first four," Zhou says. "For the last two, we have strong examples from the US and China and are refining value propositions and customer demand."

The choice to make about whether to reuse, repurpose or recycle EV batteries is rarely linear. "Each path has safety, cost and profitability implications," Zhou notes. The project's aim, therefore, is to remove uncertainty at that point of decision: "Our machine-learning models use historical BMS data to predict remaining capacity, saving time and money and we then combine LCA/LCC with live market signals to steer each pack on to the right pathway."

Markets do not always move in step, however. Zhou points to a major European recycler that failed "because, although they had capacity, there weren't enough retired batteries flowing on to them." This is why CIRCUBATT is also focusing on value-chain relationships and business logic: "Some companies specialise in collecting used batteries, while others specialise in reusing batteries for energy storage and providing energy services," she explains.

"In addition, there are also business lessons to learn from how a battery is used from new, with companies like NIO using battery swapping, so you subscribe and swap your battery at a station for a fully-charged one in about five minutes. You don't own the battery and we are extending such concepts to recycled batteries where relevant."

The benefits are broad. For consumers, there can also be value in how their batteries are reused, with some consumers selling their retired batteries on eBay. Companies buy them there, so 80% SoH doesn't mean an end to the value of an EV battery.

Our machine-learning models use historical BMS data to predict remaining capacity, saving time and money and we then combine LCA/LCC with live market signals to steer each pack on to the right pathway.

For industry, faster, data-driven triage improves asset allocation and margins; for system operators and communities, modular storage enables grid balancing, backup power and local energy systems.

Timing adds urgency and Zhou is certain that we will soon see a second wave of retired batteries. "Most packs reach 80% SoH in six to eight years," making this "a good moment for this project," she says.

Policy will determine how fast Second Life scales, however. "We're reviewing policies across Europe to identify gaps and we plan to present our findings in Brussels," she says. Standards are also lacking for retired EV batteries across Europe for safety, dismantling and collection and risks like fire and toxic leaks are real.

"We are working towards two horizons," concludes Zhou. "Proof now, system change next. Companies have signed up to pilot our business models, use the platform, test new pack designs, new cells and are considering new approaches to the use of recycled materials. We will see what works and then share what we learn."

Zhou accepts that progress is mixed at this early stage of the project, with some companies doing very well, while others are struggling. But she is clear that the project's approach to use data and design will eventually ensure that every battery is sent on its highest-value next-life pathway and this will help cut costs, save resources and strengthen the grid. As she adds: "Batteries can support EV adoption and the integration of renewables into the grid, and CIRCUBATT will ensure that happens."

PROJECT INFORMATION

Project Title
CIRCUBATT – Circular Economy Innovations for Resilient, Competitive and Sustainable Battery Technologies

Project Objective
CIRCUBATT aims to enhance Europe's battery sector by integrating AI, data analytics, sustainable design, production and (re-)use across the battery lifecycle. It develops circular business models like Battery-as-a-Service, fosters second-life applications, and strengthens resilience, competitiveness, and sustainability, reducing environmental impacts and reliance on critical raw materials.

Project Duration and Timing
3 years, 01/01/2025 – 31/12/2027

Project Funding
A total of €5 million: €3.3 million from Horizon Europe, €0.7 million from Switzerland government

Project Partners
University Of Greenwich
Universitaet Müenster
University Of Essex
Kemijski Institut
Virtus Energy Ltd
Shift Materials
Efesto
Euro-funding
Battronics AG
Kopacek KG (ISL)

MAIN CONTACT

Name
Professor Li Zhou

Email
ZL14@gre.ac.uk

Web address
www.circubatt-project.eu/

CIRCUBATT