講演番号	266

Battery recycling technologies and end-of-life material recovery for the UK battery supply chain

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KEY WORDS: **Battery, end-of-life (EoL), recycling, black mass**

As battery electrification becomes mainstream in automotive transport, attention is increasingly turning to the full lifecycle impact of electric vehicle (EV) battery storage systems. The batteries are made of key critical materials that are mined and refined from various regions of the world. Regulations are a key driver of battery recycling worldwide. Countries like India, China and the EU have updated their waste battery and recycling regulations this year. The European Battery regulation (2023), the recycling value chain, technology pathways, barriers to meeting recycling targets, and the economic challenges facing recyclers.

Recycling material can be sourced from two pathways: 1. Production scrap: arises from the losses within battery manufacturing plants, and 2. End-of-life batteries. Gigafactory scrap and end-of-life battery scrap are recycled in similar ways through mechanical pre-treatment and shredding into black mass.

From end-of-life battery perspective, the black mass availability from vehicle retirement plays a crucial role. Batteries from other application, such as battery energy storage systems (BESS) and portable batteries and micromobility traction battery sources will also contribute in to black mass availability. Until 2031, most of the UK's secondary battery materials will come from gigafactory production scrap containing valuable critical materials for re-use. After that, end-of-life vehicle batteries will become the main source of recyclable battery material (Fig 1).

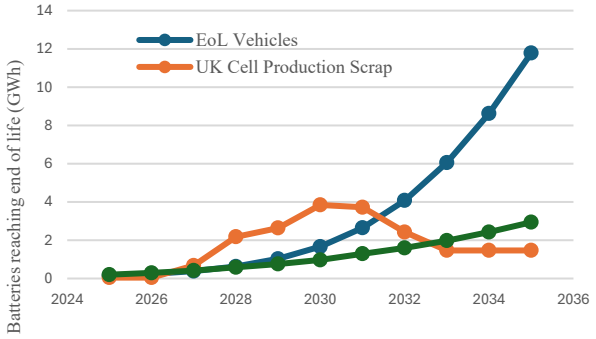

Fig. 1 Black mass availability from vehicle retirement and gigafactory scrap in the UK

In the UK, if all available gigafactory scrap and end-of-life battery material is recovered and refined, secondary battery materials could meet up to 20% of the UK's automotive battery demand by 2035, as shown in Fig. 2.

In March 2025, the European Commission classified waste batteries, including black mass, as hazardous waste. This classification restricts exports to non-OECD (Organisation for Economic Co-operation and Development) countries, aiming to keep valuable battery materials within the European economy.

While the EU's classification of black mass as hazardous waste may help to retain battery materials within the region, the lack of refining capacity to process the waste is a key bottleneck, as shown in Fig 3.

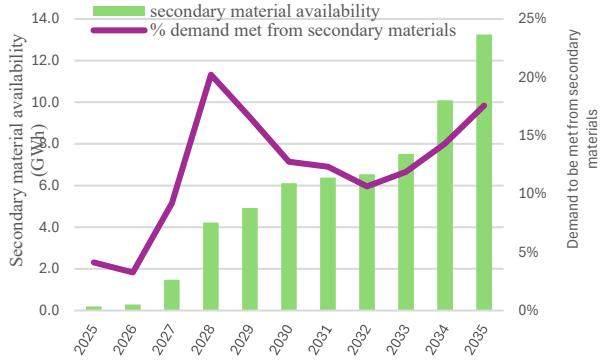

Fig. 2 Secondary material availability and battery production demand met by secondary materials in the UK

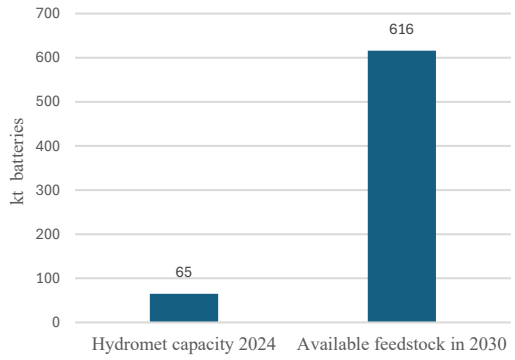

Fig. 3 Europe's recycling refining capacity constraints

The paper considers two sources of the battery materials for recycling, providing secondary materials, namely production scrap and end-of-life EV batteries. Utilizing a techno-economic methodology, the paper highlights that up to 20% of the UK's automotive lithium-ion production demand could be met by secondary materials in 2035.