Old batteries and manufacturing scrap make future EV batteries

Batteries of the future need large quantities of Nickel, Lithium and Cobalt to supply the growing EV market.

Recovered battery materials are critical to making new cells and reducing the carbon intensity of manufacturing.

Sources of end-of-life EV battery cells and outcomes:

- **EV retirements (End-of-life)**: Insufficient supply for stationary storage but good for cell prod.
- **Warranty returns (e.g. recent recalls from GM, Hyundai, Ford & BMW)**: Uncertain, but provides a recycling feedstock.
- **Cell production scrap (~4-11% of output)**: Constant feedstock and growing with gigafactories.

**EV retirements cannot satisfy stationary storage supply needs**

- **21,000 tns of waste cell materials in the UK by 2026**
- **28,000 tns of waste cell materials in the UK by 2030**
- **235,000 tns of waste cell materials in the UK by 2040**

- **2 to 3 large material recovery recycling facilities in the UK, processing 10,000 tonnes pa**
- **Multiple large scale recovery & reuse facilities**
The UK will be generating 28,000 tonnes of reusable battery cell waste by 2030

- Cell production scrap
- Warranty recalls
- EV retirements

Second life & repurposing

Recycling & material recovery

UK battery capacity available for recycling and reuse

- Production scrap
- Warranty returns
- xEV retirements

Notes: Analysis based on BEV and PHEV sales in the UK from 2012, warranty recalls based on 2020 BNEF data and cell production forecasts published by the APC
By 2040, the dominant feedstock for battery materials will be from EoL vehicle retirements. A total of 235,000 tonnes will be available for recycling and reuse by 2040, almost 8 times that in 2030.

**UK battery capacity available for recycling and reuse**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cell mass (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>235,508</td>
</tr>
<tr>
<td>2024</td>
<td>28,164</td>
</tr>
<tr>
<td>2030</td>
<td>8 fold increase</td>
</tr>
<tr>
<td>2035</td>
<td>203,608</td>
</tr>
<tr>
<td>2040</td>
<td>235,000</td>
</tr>
</tbody>
</table>

**Notes:** Analysis based on BEV and PHEV sales in the UK from 2012, warranty recalls based on 2020 BNEF data and cell production forecasts published by the APC.
Extending the recovery of critical materials to include cell production scrap, has the opportunity to meet Nickel and Lithium demand but not Cobalt in 2030.

Recycled content for battery production supply in the UK

<table>
<thead>
<tr>
<th></th>
<th>Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled content needed (EU Directive)</td>
<td>1,000</td>
</tr>
<tr>
<td>Recovered materials (EV retirements)</td>
<td>2,000</td>
</tr>
<tr>
<td>Total recovered (EoL + Cell scrap)</td>
<td>5,000</td>
</tr>
</tbody>
</table>

**EV retirements (BEV and PHEV based on UK sales)**

- 169% Nickel
- 56% Lithium
- CANNOT MEET DEMAND Cobalt

Adding production scrap can fulfil the cell production demand for Ni and Li.

Cobalt may be supplied from recycled phones.

**Production scrap (based on industry average of 4-11%)**

- 1 tonne of Cobalt is approximately 90,000 iPhones (3227 mAh, 3.84V)
- ~11-16 g / iPhone
- 500 tonnes Co → 45 million iPhones

**NOTES:**

Based on battery recovery rates and minimum recycled content in batteries stated in the EU Battery Directive and UK cell production forecasts published by the APC (90GWh in 2030).

2030 recycled content: 4% Ni, 12% Co, 4% Li @ recovery rates of 95% Ni, 95% Co, 70% Li
Summary of proposed EU EV battery regulation introduction timeline

- **1 July 2024**, EV batteries will require a carbon footprint declaration.
- **1 Jan 2026**, carbon footprint performance class requirements.
- **1 July 2027**, maximum life cycle carbon footprint thresholds.
- **1 Jan 2027**, EV batteries required to declare content of recycled Co, Li and Ni.
- **1 Jan 2029**, minimum levels of recycled content (12% cobalt, 4% lithium and 4% nickel).
- **1 Jan 2030**, minimum levels of recycled content (20% cobalt, 10% lithium and 12% nickel).
- **31st Dec 2025**, 65% recycling efficiency, recovering 90% Co, 90% Ni, 35% Li and 90% Cu.
- **31st Dec 2030**, 70% recycling efficiency, recovering 95% Co, 95% Ni, 70% Li and 95% Cu.

**Recovery efficiency**
- **Regulation approval planned for early 2022**
- **1 Jan 2023**, start of QR labelling, “separate collection” symbol.
- **1 Jan 2026**, online electronically readable “battery passport” with SoH, life, performance & durability information.
- **1 Jan 2027**, full labelling of chemistry, recycled content, life, safety, collection …
- **31st Dec 2025**, 65% recycling efficiency, recovering 90% Co, 90% Ni, 35% Li and 90% Cu.
- **31st Dec 2030**, 70% recycling efficiency, recovering 95% Co, 95% Ni, 70% Li and 95% Cu.

**Carbon footprint**
- **Labelling & digital**
- **Recycled content**

**EU Battery Directive Proposal 2020**
End of life vehicle (ELV) directive and EU battery regulation proposal brings a new economic stream of activities for second life and battery recycling.

Recycled recovered metals have a 10-25% lower carbon footprint than virgin materials. Expected to be the first line of supply chain into CAM and p-CAM production and deliver OEM ESG / carbon goals.