German Environment Agency

1. December 2025

AutoRessFactsheet 8: Recycled content of battery materials: In the context of the EU Battery Regulation and the shift to electric mobility

Results from the project: Results from the project 'Resource efficient and circular electric cars' (AutoRess)

The new **EU Battery Regulation** ((EU) 2023/1542) sets out key regulatory requirements along the entire battery life cycle, from production to disposal. In addition to requirements for recycling efficiency (Art. 71, Annex 12), explicit requirements are also made for secondary content in selected battery raw materials (Art. 8). The AutoRess project allows the assessment and quantification of the set targets on recycled content in battery materials of the EU Battery Regulation using the AutoRess model developed for the German car fleet in future.

Detailed information on the AutoRess model and on the analyses of recycled content of battery materials can be found in the final report in Chapter 3.1 and 3.8.

Key findings

Testing the EU targets for secondary content in battery materials in the AutoRess model

- **Recycled material in new cars from European car fleet only:** The baseline assumes an open-loop recycling in order to meet the EU targets. If only recycling material of European cars is to be used (closed-loop), the EU targets for 2031 cannot not fully be met by 2030 due to delayed material return from recycling of scrapped battery electric vehicles. By 2040, targets may be exceeded due to a larger volume of recycled EVs. Example: Lithium can reach 3% by 2030 (target: 6%), 20% by 2040 (target: 12%).
- **Scenario 1 – Lower high-quality recycled material from end-of-life vehicles:** Though the EU targets for recycling efficiency are considerably high (2030: Lithium 80%; Nickel/Cobalt 90%) this does not directly translate into high-quality grade material necessary for cell manufacturing. A reduced share of high-quality recycling output (-50%) would lead to significantly higher primary material demand by 2045.
- **Scenario 2 – Enhanced graphite recycling:** Graphite as a material is not specifically addressed in EU Battery Regulation but it has a significant share in the mass balance of a battery. In the conventional recycling process graphite is simply incinerated, which directly generates carbon emissions. With 90% recovery efficiency by 2045, primary graphite could be saved but secondary content still remains below 30% in 2045.

Key Challenges and Policy Recommendations



Using recycled material reduces the demand for primary raw materials and usually requires less energy, lowering greenhouse gas emissions, though recycling still consumes energy and can generate GHG emissions. Effectiveness varies by sector and depends on material concentration, as low concentrations in end-of-life products challenge recovery. For batteries, technology-strategic materials at cell level such as lithium, nickel and cobalt are a crucial source for GHG emissions. Meeting rising demand for mobile and stationary batteries will require major growth in global production. At present, production relies mainly on primary sources, since high-quality standards and limited secondary supplies restrict recycling. However, with growing number of electric vehicles, recycled batteries can increasingly provide key secondary raw materials.

The EU Battery Regulation sets targets for recycled content in battery materials for 2031 and 2036. The AutoRess project analyses the mass flows of recycled material from European cars and how much this can contribute to recycled content in the German electric vehicle fleet. The analysis shows that the EU's ambitious targets cannot be met by recycled materials from European scrapped electric vehicles alone until 2035, but recycling material from other sectors is needed. After 2035 larger numbers of scrapped electric vehicles enter the recycling system and sufficient recycled material from electric vehicles can be provided in order to meet the EU targets.

The European recycling system should focus on rapid scale-up of efficient, high-quality recycling processes to prevent shortage of recycled material for battery products, especially for lithium and graphite. In the case of lithium there are not many other sectors where recycled lithium can be provided and efficient lithium recycling still lacks industrial scale capacities. In the case of graphite, the development of an efficient recycling system is even further away from industrial scale and it is still debated if the output of graphite recycling needs to be on the level of battery quality. There are no EU recycled content targets for graphite, but since it accounts for a large proportion of the battery mass, it is relevant for the overall recycling efficiency targets and should be treated in the recycling processes.



Bridging the long transition phase until larger quantities of electric car batteries reach recycling stage: A long battery life is environmentally preferable even if it delays the availability of recyclable materials on the market. In order to provide recycled material for battery manufacturing in the next 10 to 15 years other sources for recycled material need to be assessed in the light of sustainability. At the same time, preparations for higher recycling capacities for growing quantities of used batteries should not be neglected in Europe.



Certificates for recycled materials: The international trade of secondary materials or intermediates complicates traceability and increases risk of fraud.



Raw material dependencies: While some OEMs are investing in access to raw material and recycling, most raw materials are not yet secured through long-term contracts. The supply chains of strategic battery materials are dominated by Asian companies. Setting up an European recycling industry reduces raw material dependencies.

Dynamic development of battery technologies: During the last years the battery technology has developed rapidly. Besides enhancement in performance also other material compositions (e.g. sodium based batteries) are researched or already enter the market. A regular review of the recycling targets considering market trends is necessary in this dynamic sector.

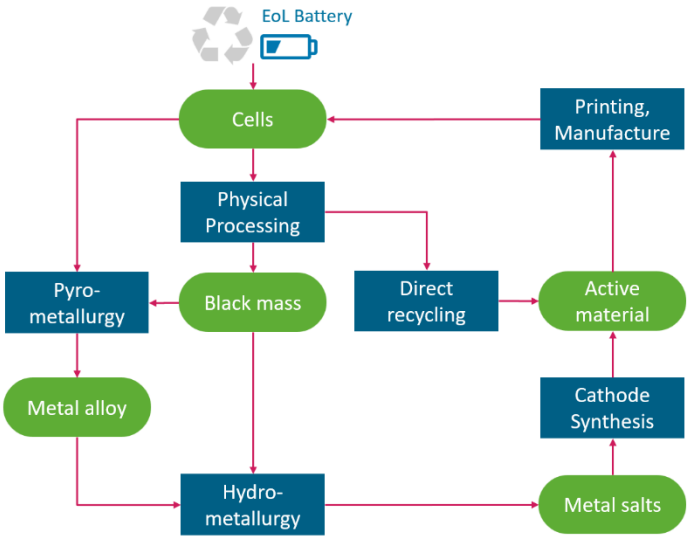
Exported used vehicles: Recycling becomes less traceable once electric vehicles leave the EU. The battery passport provides recycling facilities with important information on the product. But in order to ensure efficient recycling processes, European stakeholders should consider investment in collection systems or even recycling facilities in main destination countries of used vehicles outside the EU.

Battery Recycling Processes and Market Development

Efficient recycling systems reduce environmental burdens, limit dependency on imports, and support the EU's transition toward a circular economy. Main process steps that are now used in battery recycling, can be summarised under three basic types: Pyrometallurgy (smelting), hydrometallurgy (leaching) and direct recycling (physical/ mechanical processes). A combination of process steps is predominantly used as shown in the flow chart.

To date, the majority of lithium battery recycling capacities have been located in East Asia, particularly in China. Relevant capacities for LIB recycling are currently also being established in Europe. Stephan (2025)[1] estimates the installed recycling capacity for lithium-ion batteries (pre-treatment until production of black mass) in Europe to more than 400,000 tonnes per year by 2026[2] which exceeds the forecasted return volume including total battery scrap.

Flowchart of recycling routs



Source: Adapted from Sommerville et al. 2021[2]

[1] Stephan, M. (2025): Recycling capacities for lithium-ion batteries will exceed demand in Europe for the time being. Fraunhofer ISI. https://www.isi.fraunhofer.de/en/blog/themen/batterie-update/batterie-recycling_europa_kapazitaeten_bedarf_update_2025.html (12.09.2025).

[2] Sommerville, R.; Zhu, P.; Rajaeifar, M. A.; Heidrich, O.; Goodship, V.; Kendrick, E. (2021): A qualitative assessment of lithium ion battery recycling processes. In: Resources, Conservation and Recycling. Bd. 165. DOI: 10.1016/j.resconrec.2020.105219.

Recycled Battery Material availability in Relation to EU Battery Regulation Targets

The EU Battery regulation itself does not require that the recycling material has to be sourced from battery recycling. Thus, recycling material can be obtained from other sectors. The aim of the model analyses in AutoRess was to assess the extent to which the EU requirements for recycled content in battery materials can be achieved if only a closed-loop recycling within the automotive sector in the European Union is assumed.

Recycled content achievable in battery production for the German passenger car market using closed-loop recycling

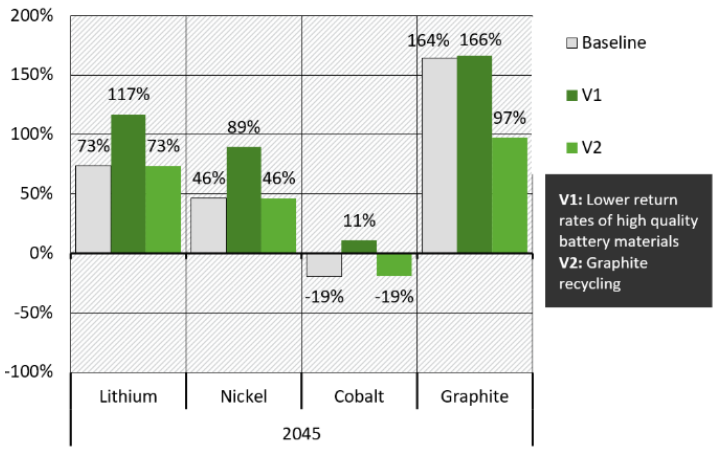
Material	2025	2030	2035	2040	2045
Lithium	0%	3% (6%, 2031)	7% (12%, 2036)	20%	33%
Nickel	1%	4% (6%, 2031)	9% (15%, 2036)	23%	40%
Cobalt	1%	7% (16%, 2031)	15% (26%, 2036)	32%	46%
Graphite	0%	0%	0%	1%	2%

Source: Baseline results, AutoRess model 2025. Numbers in brackets EU Battery Regulation Art. 8.

The table with baseline results of AutoRess indicates that the EU requirements for battery materials will not be fulfilled by 2031 if only closed-loop recycling is assumed. In the case of lithium (3%), the percentage required by the EU Battery Regulation is 6%. The figures for nickel and cobalt in 2030 are also clearly below the 2031 targets. The EU targets for 2031 will only be achieved in 2035, but the higher targets applicable from 2036 onwards will still be significantly missed. In order to meet the 2036 EU targets at least two thirds of recycling material have to be obtained from other sectors. However, in 2040, when a significant number of end-of-life BEVs are scrapped, the recycled content targets are more than fulfilled by European electric vehicles alone (Li: 20%, Ni: 23%, Co: 32%).

Two further variations are additionally analysed in AutoRess: (1) A lower return rate of high-quality battery grade material and (2) encouraged graphite recycling. The bar chart illustrates the alterations in primary material demand for electric vehicle batteries across the two variations in 2045 comparing to the baseline scenario of 2025. The impact of a reduced return rate of high-quality material (- 50%) has a significant impact in 2045 since closed-loop recycled material will overfulfil the EU targets. If secondary material from other sectors cannot be obtained, the lack of recycled material from European electric vehicle batteries will increase the primary material demand (lithium by 44% points, nickel by 43% points and cobalt by 30% points). Graphite recycling demonstrates a notable decline in primary graphite demand, with a reduction of 67% points compared to the baseline scenario with no graphite recycling assumed.

Change in primary material demand for cars in 2045 compared to 2025



Source: own illustration (ifeu)

Imprint

Publisher

Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
buergerservice@uba.de
Internet: www.umweltbundesamt.de
/umweltbundesamt.de

Editorial office

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Section I 2.2 Pollution Abatement and Energy Saving in Transport
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Regina Kohlmeyer

DOI

https://doi.org/10.60810/openumwelt-8449

Completion: 12/2025

Authors, Institution

Claudia Kämper, Frank Dünnebeil, Kirsten Biemann, Birte Ewers, Sonja Limberger, Monika Dittrich and Florian Petri

ifeu – Institut für Energie- und Umweltforschung Heidelberg gGmbH, Heidelberg

Based on the final AutoRess report. All AutoRess documents are published on http://umweltbundesamt.de/themen/verkehr/ressourcenschonung-im-verkehr

Project partners: Oeko-Institut, ifeu gGmbH, Mehlhart Consulting, team ewen GbR

Project long title: Motor vehicles in support of sustainable resource use and circularity: Instruments and measures to reduce the demand for raw materials in the transport sector through circular economy in parallel with an energy transition in transport

FKZ-number: 3722 57 101 0