

# Using **Dynamic Energy and Material Flow Analysis** for Assessing the Potential of **Circular Approaches** to Reduce **Resource Criticality**

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SAM, Metz

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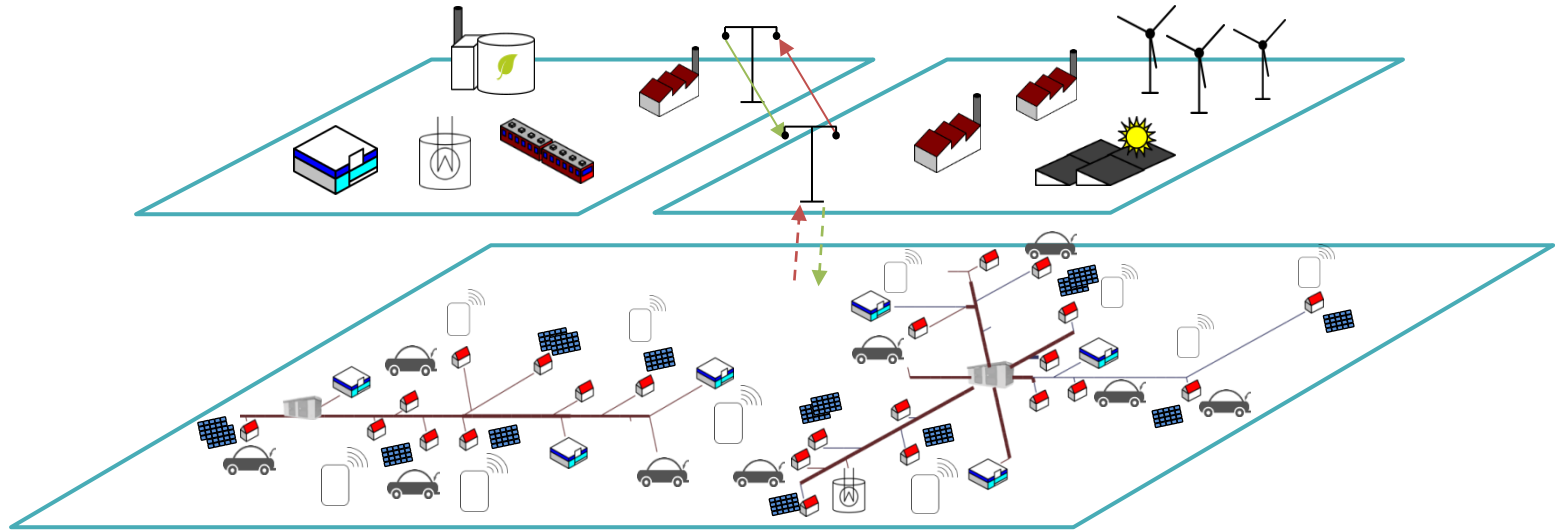
1. Motivation
2. Methodology
3. Case Study: Recycling and Second-Life of Electric Vehicle Batteries
4. Conclusion and Outlook

# 1. Motivation

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# 1. Motivation – New Resource Challenges for Future Energy Systems



importance of new energy technologies

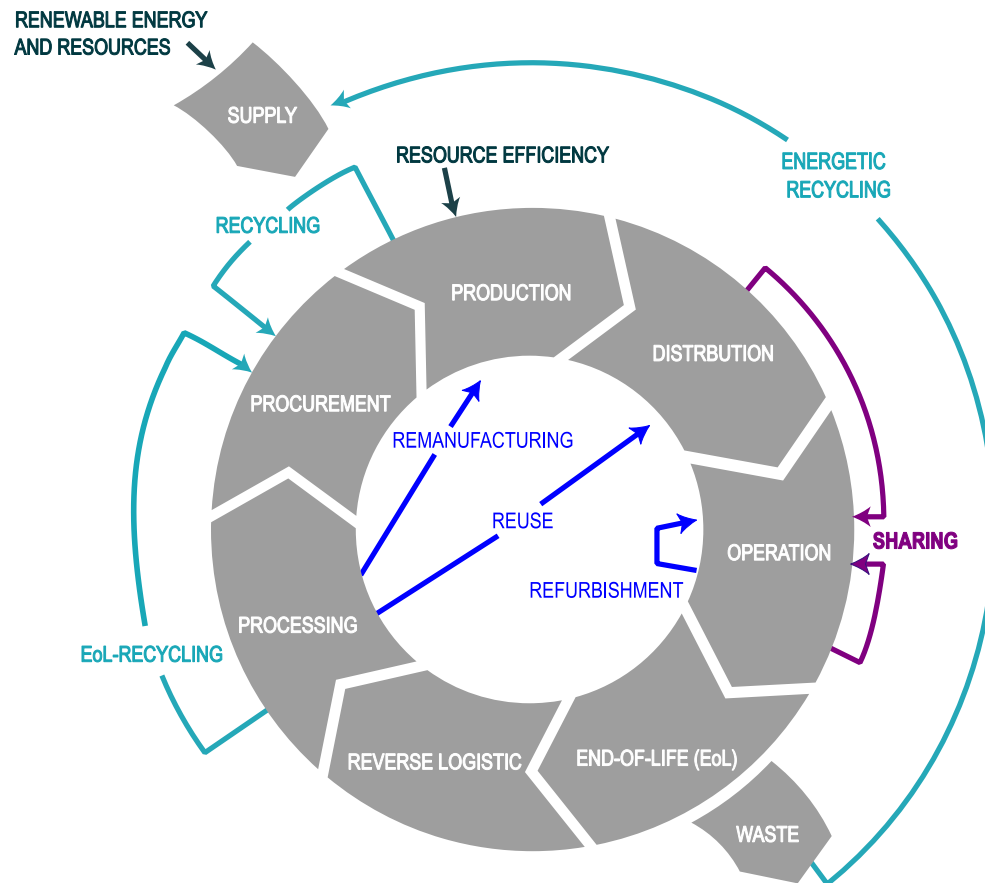


demand for critical resources



supply & environmental risks

# 1. Motivation – Circular Economy as the Solution to Resource Criticality?



Effects on resource criticality?

Consideration of system effects?

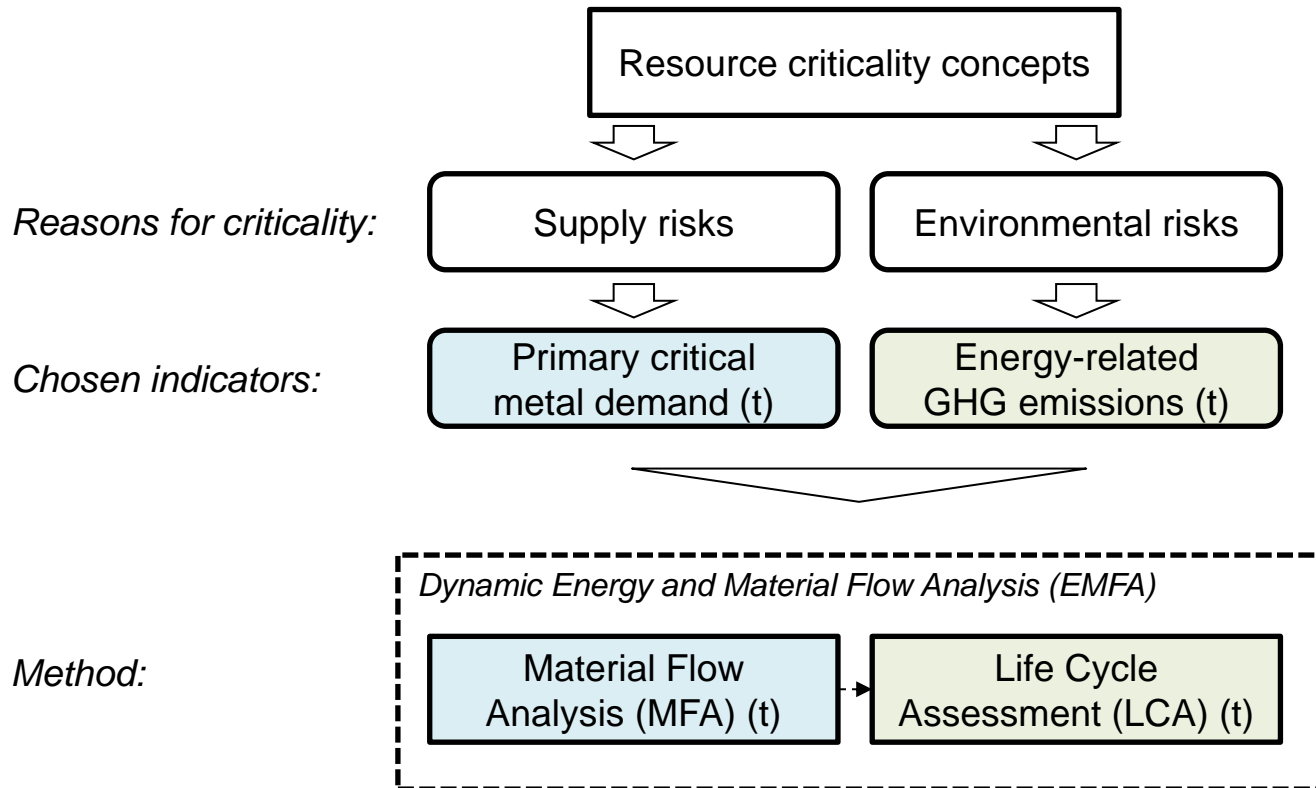
- *time delays*
- *displacement mechanisms*
- *interactions*

## 2. Methodology

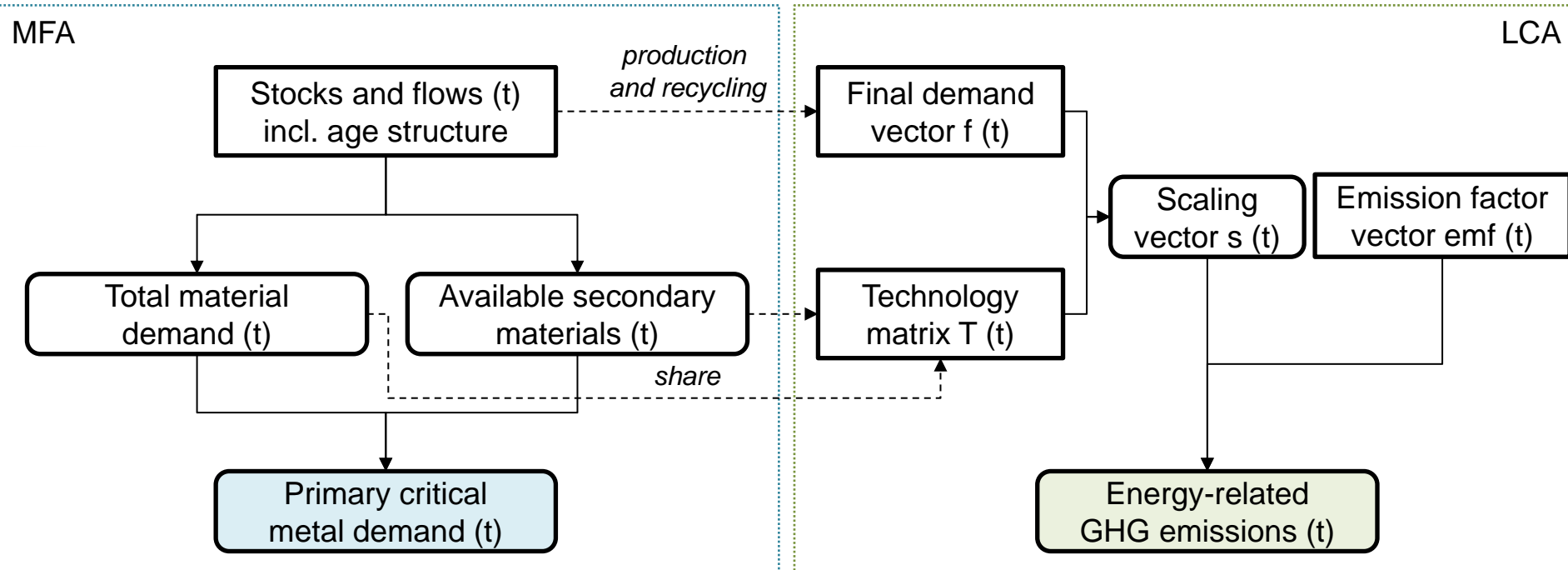
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## 2. Methodology – Using Dynamic Energy and Material Flow Analysis for Resource Criticality Assessment



## 2. Methodology – Coupling of Dynamic MFA and LCA





### 3. Case Study:

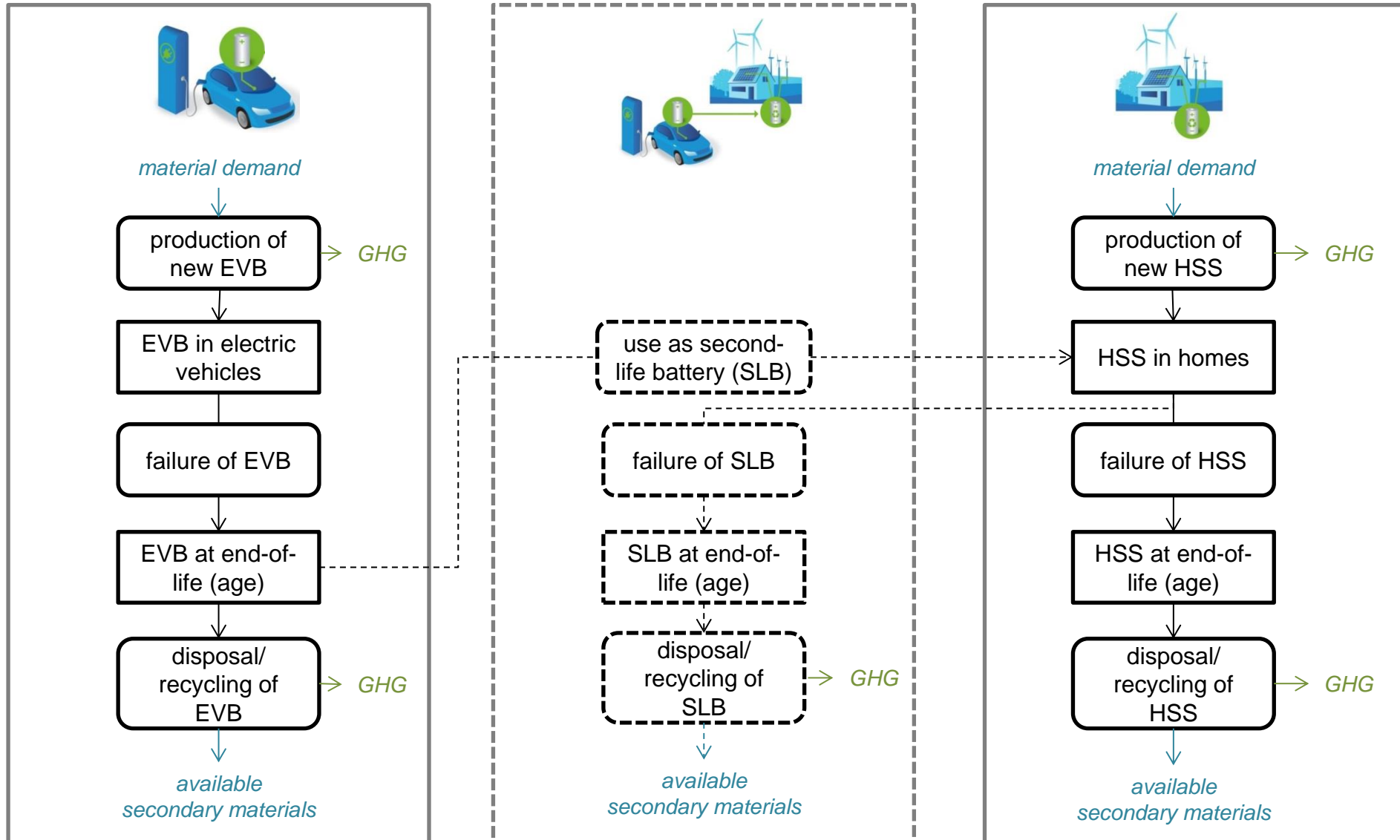
# Recycling and Second-Life of Electric Vehicle Batteries

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# 3. Case Study – Stock and Flow Model for Assessment of Recycling and Second-Life of Electric Vehicle (EV) Batteries

System boundaries: EV batteries (EVB) and home storage systems (HSS) used in Germany, t=2015, 2016 ... 2050



# 3. Case Study – “Recycling” and “Second-Life” Scenario

## “Recycling” Scenario

- Collection rate: 100%
- Process from Chinese battery recycler<sup>1)</sup>
- Recovered: nickel-manganese-cobalt, steel, aluminium and copper
- Recycling rate: ~100%
- No recovery of lithium

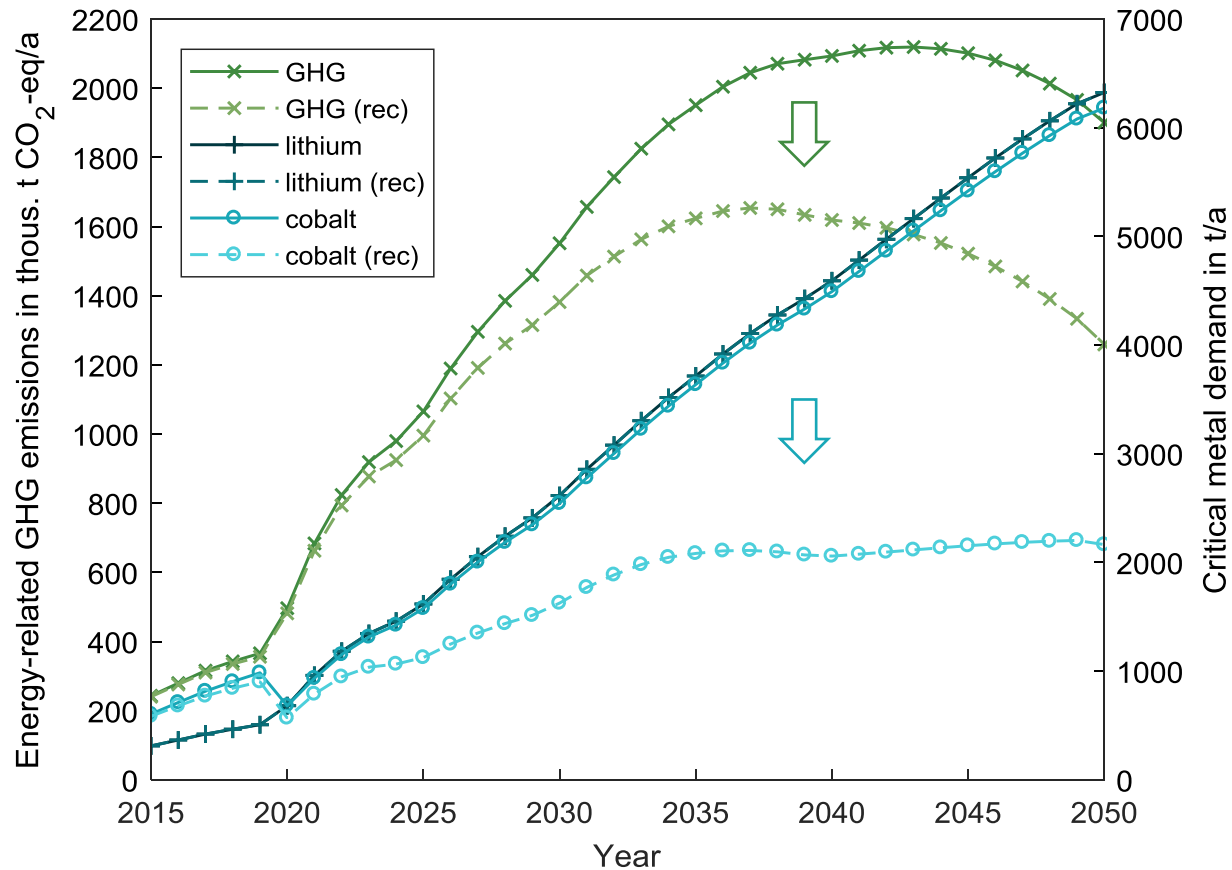


## “Second-Life” Scenario

- Collection rate: 100%
- Feasibility: 100%
- Deployment as Home Storage System
- Direct use of whole battery system without processing



### 3. Case Study – Results „Reference“ vs. „Recycling (rec)“ Scenario

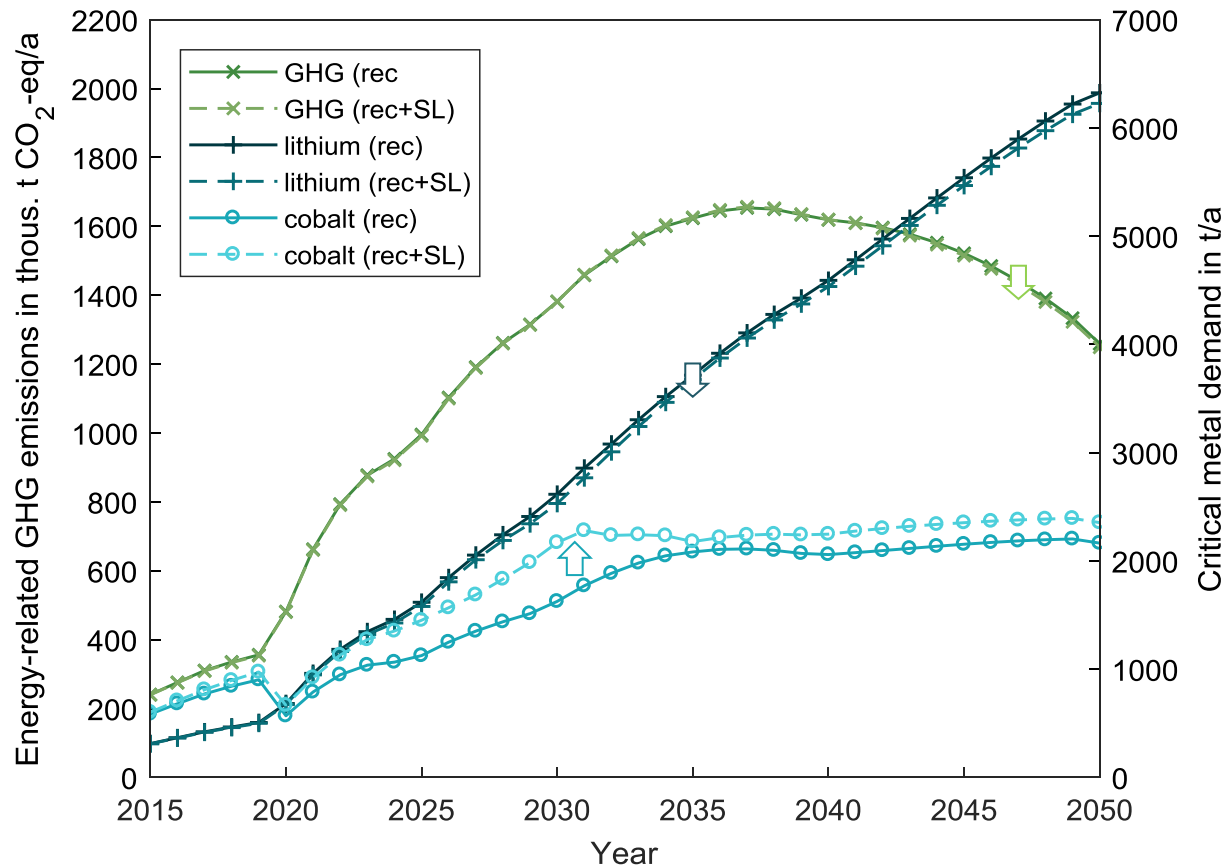


In the analysed recycling scenario the ...

- ...energy-related GHG emissions are reduced due to the use of secondary materials.
- ...primary cobalt demand is decreased significantly, but is still substantial due to the increase in battery demand.

### 3. Case Study – Results

## „Recycling (rec)“ Scenario vs. „Second-Life (SL)“



In the analysed Second-Life scenario the ...

- ...primary lithium demand decreases because of avoided stationary battery production.
- ...primary cobalt demand increases due to delayed recycling of cobalt-rich traction batteries.
- ...decrease in total energy-related GHG emissions is small.

## 4. Conclusion and Outlook

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# 4. Conclusion and Outlook

1 Scenario-based dynamic energy and material flow analysis can be used to assess the potential of circular economy approaches to reduce resource criticality while considering system effects.

↳ Simulation of additional scenarios and improvement of input data

2 Depending on the framework conditions Second-Life applications can lead to trade-offs between different criticality indicators.

↳ Sensitivity analysis to systematically identify critical parameters

3 In this case the Second-Life application leads to a short-term increase in cobalt demand because of a delayed recycling process and the substitution of a less resource-critical technology.

↳ Additional displacement logic based on capacity

# Thanks for your attention

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