

The global life cycle of rechargeable Lithium ion batteries: what natural resource savings can be gained through recycling?

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1. The relevance of rechargeable Lithium ion batteries

- Batteries: growing market:
 - Electronics: PC, mobile equipment
 - Vehicles
- Li ion batteries: crucial role
 - Cathode: LiMeO_2 with $\text{Me}=\text{Co}, \text{Ni}, \text{Mn}, \dots$
- Growing demand for raw materials:
 - Co for batteries: 700 t in 1995 to 12000 t in 2005
 - 2007: 25% of global Cobalt market
- Need for recycling: economic & ecological drivers





2. Scope of the study: what resources can be saved through recycling Li-ion batteries?

Scenario A: best practice for cathode production:

Step 1: End-of-life battery in smelter:

- Slag to concrete
- Alloy to metal refining

Step 2: Metal refining

- Fe, Cu recovery
- Ni, Co recovery: to new cathode

Scenario B: cathode production with virgin Ni and Co

3. Data acquisition and calculation for 1 kg cathode

Data acquisition from:

- Umicore for recycling and cathode production
- Data from major producers
- eco-invent

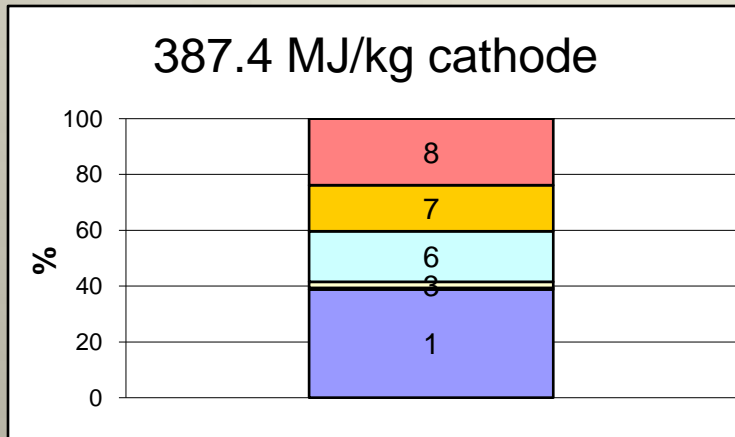
How to calculate the natural resource savings:

- Inventory of energy and mass inputs for all processes
- Calculation into the coherent and unique resource quantifier: exergy
- Calculation of all Cumulative Exergy Extracted out of the Natural Environment (CEENE)
(see Dewulf et al., 2007, 2008)



4. Results: the resource requirements in Joules of exergy to produce 1 kg cathode

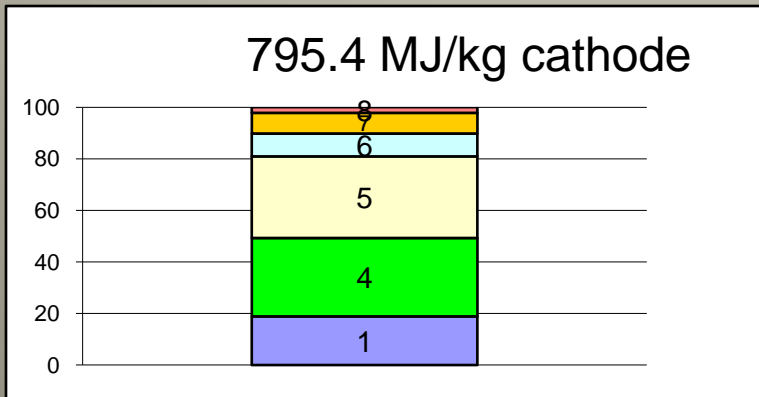
Scenario A: the recycling scenario:



Necessary processes:

- 1: MnSO_4 supply
- 2: NiSO_4 recovery
- 3: CoSO_4 recovery
- 6: Precursor production
- 7: Cathode production
- 8: Transport

Scenario B: from virgin Nickel and Cobalt ores:



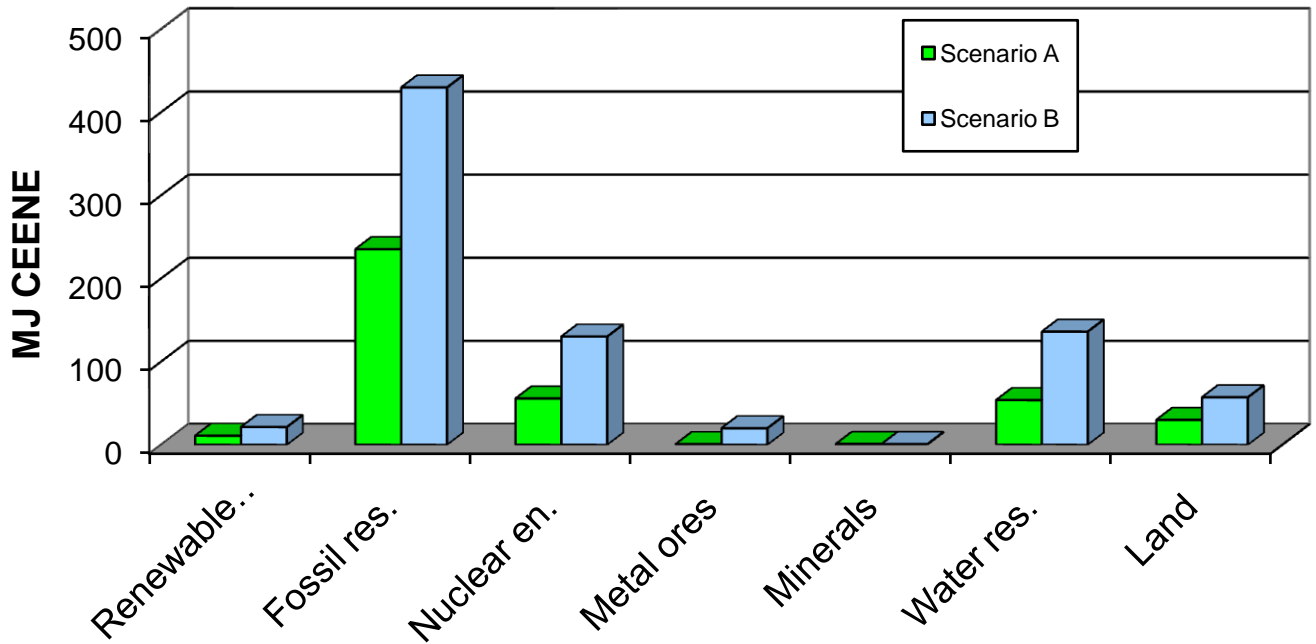
Necessary processes:

- 1: MnSO_4 supply
- 4: NiSO_4 from virgin resources
- 5: CoSO_4 from virgin resources
- 6: Precursor production
- 7: Cathode production
- 8: Transport

Saving of 51 % natural resources mainly due to:

- Eliminating high demanding Ni/CoSO_4 from virgin resources
- Moderate demand of recycling in comparison with high demand of cathode production stages

5. Results: what natural resources are saved?



Relative numbers: largest savings: Metal ores: 95%

Absolute numbers: largest savings due to reduction of energy requirements:

Fossils: 195 MJ (45% reduction)

Nuclear : 74 MJ (57% reduction)

Further information:

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- Details: Dewulf et al., *Resources, Conservation &*

Recycling, in press, 2009