Umicore Battery Recycling

Recycling of NiMH and Li-ion batteries

a sustainable new business

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Joint EC / Green Cars Initiative PPP
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Dr. Jan Tytgat - Umicore

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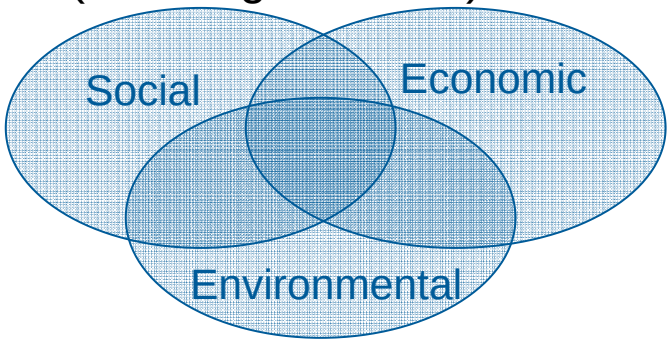
Triple bottom line (J. Elkington, 1997)

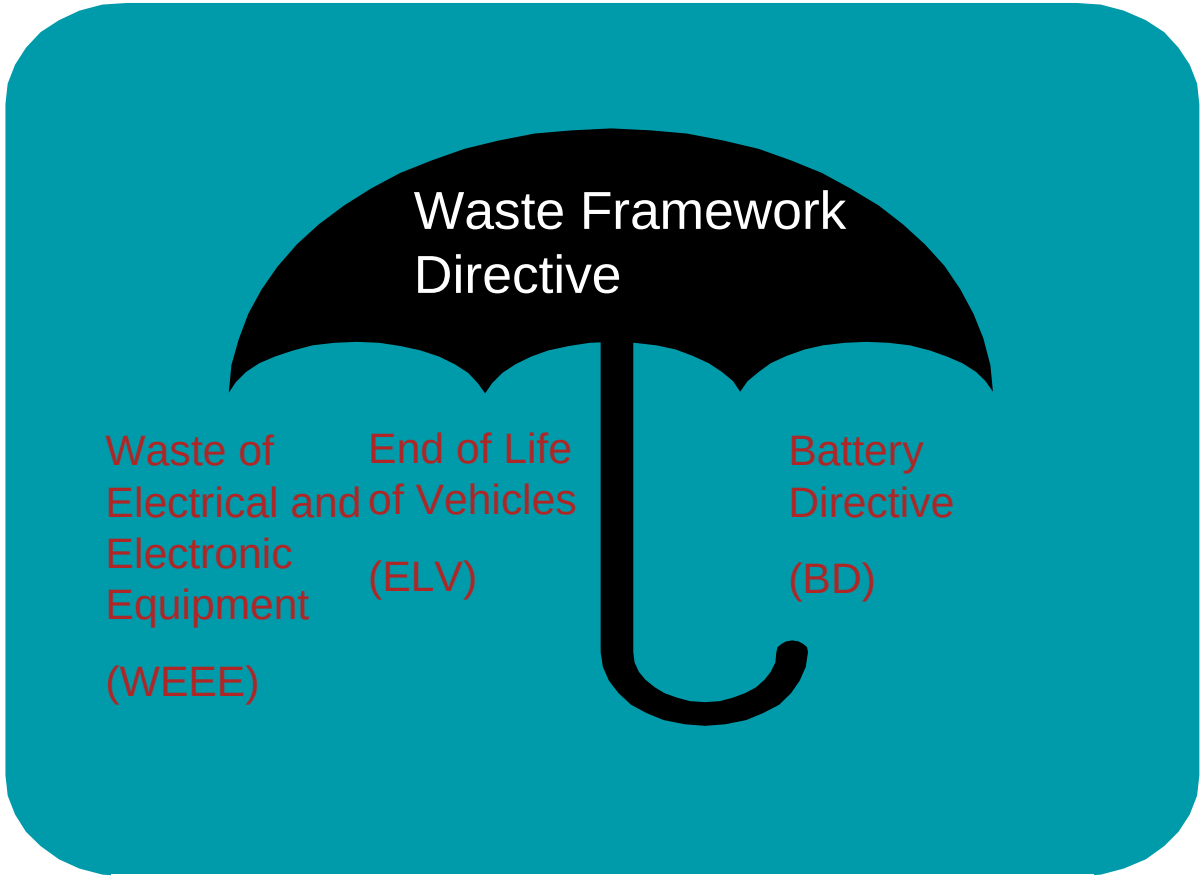


A sustainable business model is:

- Economically sound
- Environmentally safe
- Socially responsible

UBR-model: from recycling drivers to new business

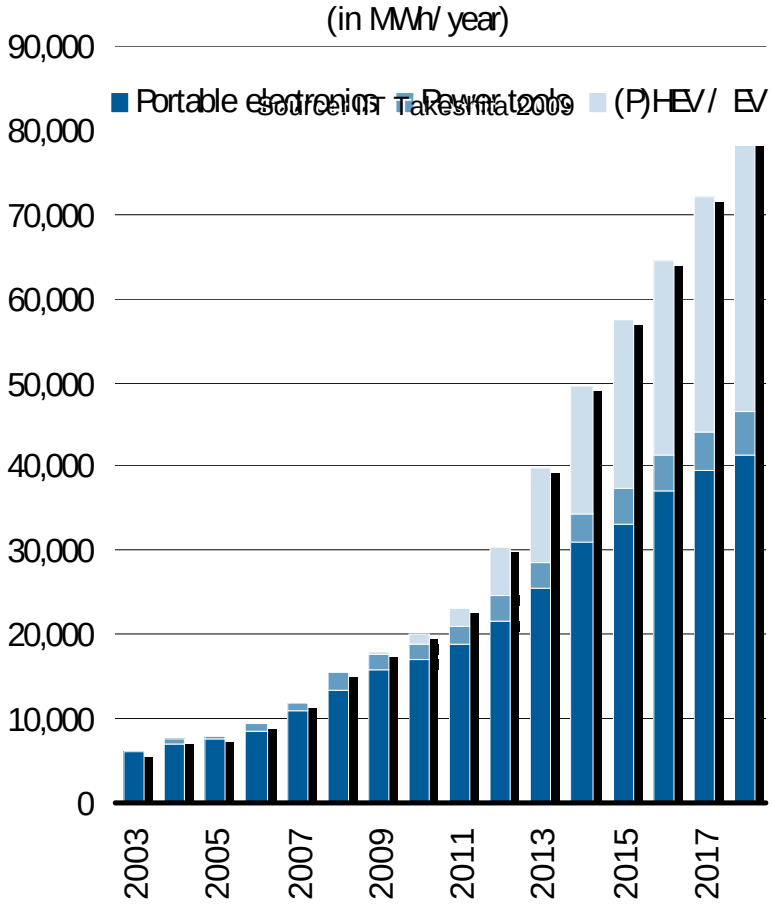
Economic aspects: **Legal Framework** as driver for recycling



Strong regulation of battery recycling is a basis for our 'service model': even for batteries having low intrinsic metal value, there is a service value

Economic aspects: **Proven market** for Portable Rechargeable Batteries

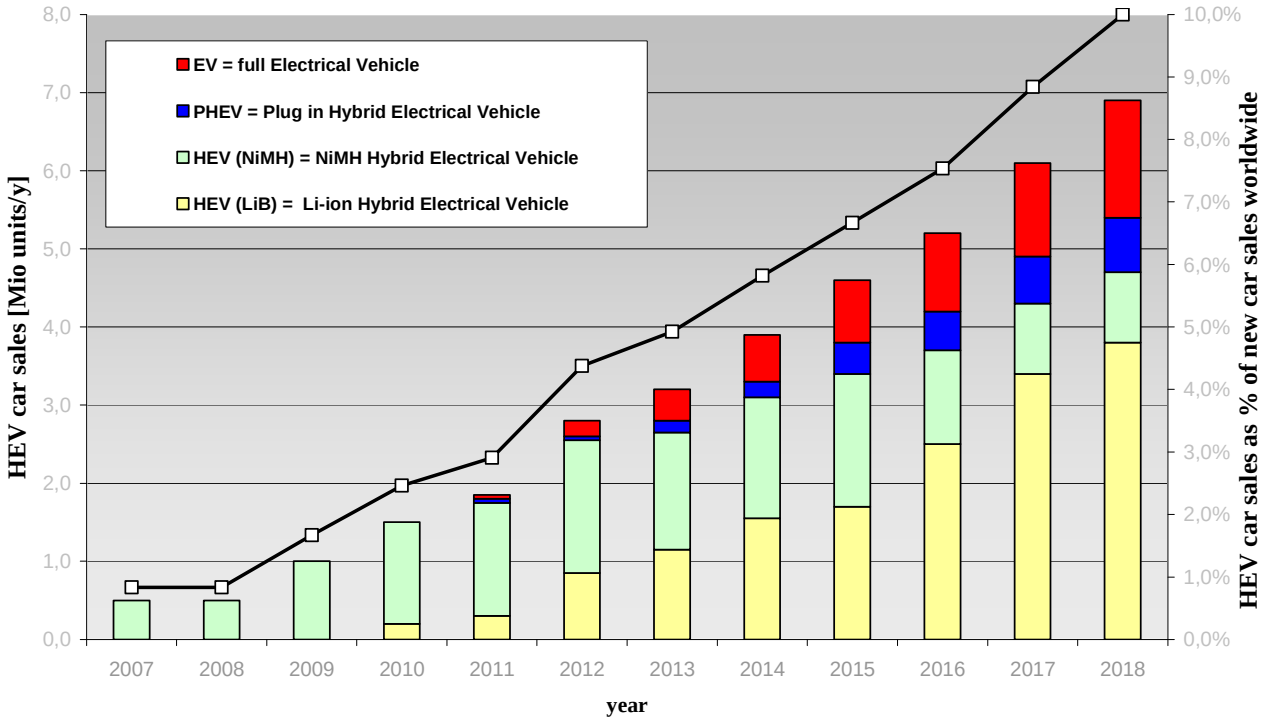
Power demand for Li-ion batteries



In the EU, the market of PRB's is about 35000 Tons/year an still growing.

- Collection target: 45 % by 2016 = target market volume of 20 000 ton
- collection today: +/- 6%
- Proven technology and position: UBR is running this business on pilot scale for 4 years before deciding in new, bigger and better installation

Economic aspects: **Expected market** for (H)EV-batteries



Source: Takeshita

Several business models expect up to 10 % (H)EV by 2020 (% of sales of new cars)

1 million e-cars = 50 000 ton batteries

First wave:
- production waste
- warranty claims
- accidents

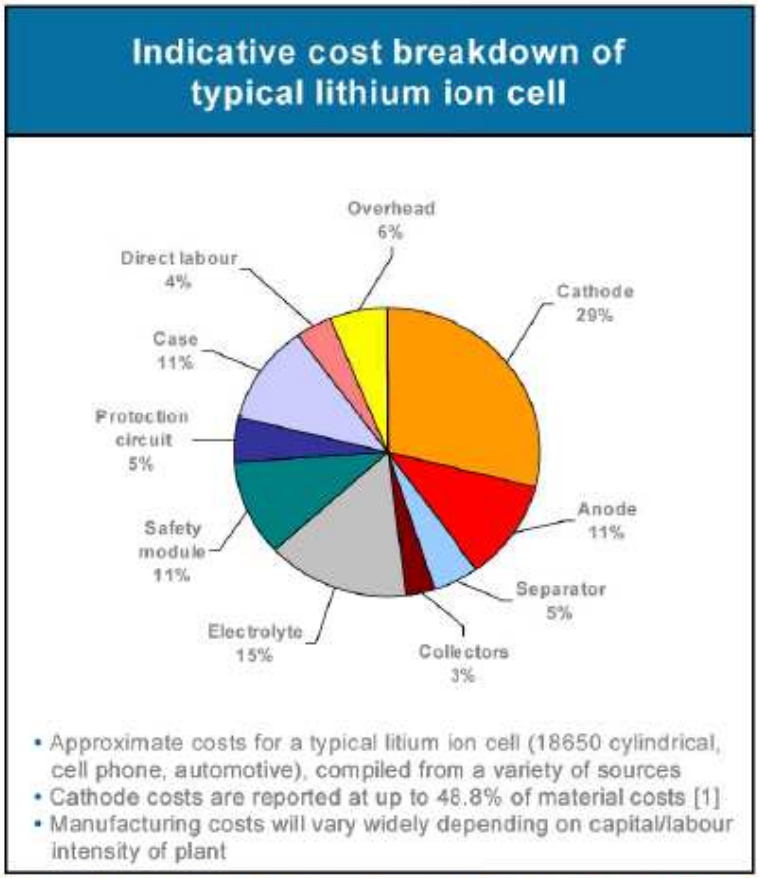
Economic aspects: **UBR market position**

- the only industrial Li-ion battery recycler worldwide
  - 7000 ton/year capacity up and running
  - Competition: < 200 t/y capacity and unsolved qualification issues with some recycled fractions
  - Connects a new dedicated battery smelter technology with an existing large scale refinery
- the only industrial NiMH-battery recycler worldwide that recovers Rare Earth Elements
  - Unique collaboration with Rhodia: Umicore concentrates, Rhodia refines
- Intensive contacts with car-industry (Europe, US, Japan, Korea)

TOYOTA RENAULT NISSAN DAIMLER TESLA

  - Published relations, others under NDA

Economic aspects: compound ➔ element ➔ service



Sources: [1] „Costs of Lithium-Ion Batteries for Vehicles" (ANL/ESD-42) Gaines and Cuenoa; Generics estimates; industry sources

Compounds = "added value molecules" ➔ Compound Cost > Σ Element Cost

e.g.: $LiCoO_2$ cost > (Co + Li + O) cost

➔ Recycling model based on <u>compound value</u> recovery makes sense

➔ But, due to:

- ➔ High diversity of battery materials
- ➔ Rapidly changing specifications and long lifetime for EV batteries
- ➔ Contamination risks
- ➔ Low risk minded battery industry, heavy qualification process

Theoretical compound value hard to valorize: small market for recycled battery compounds

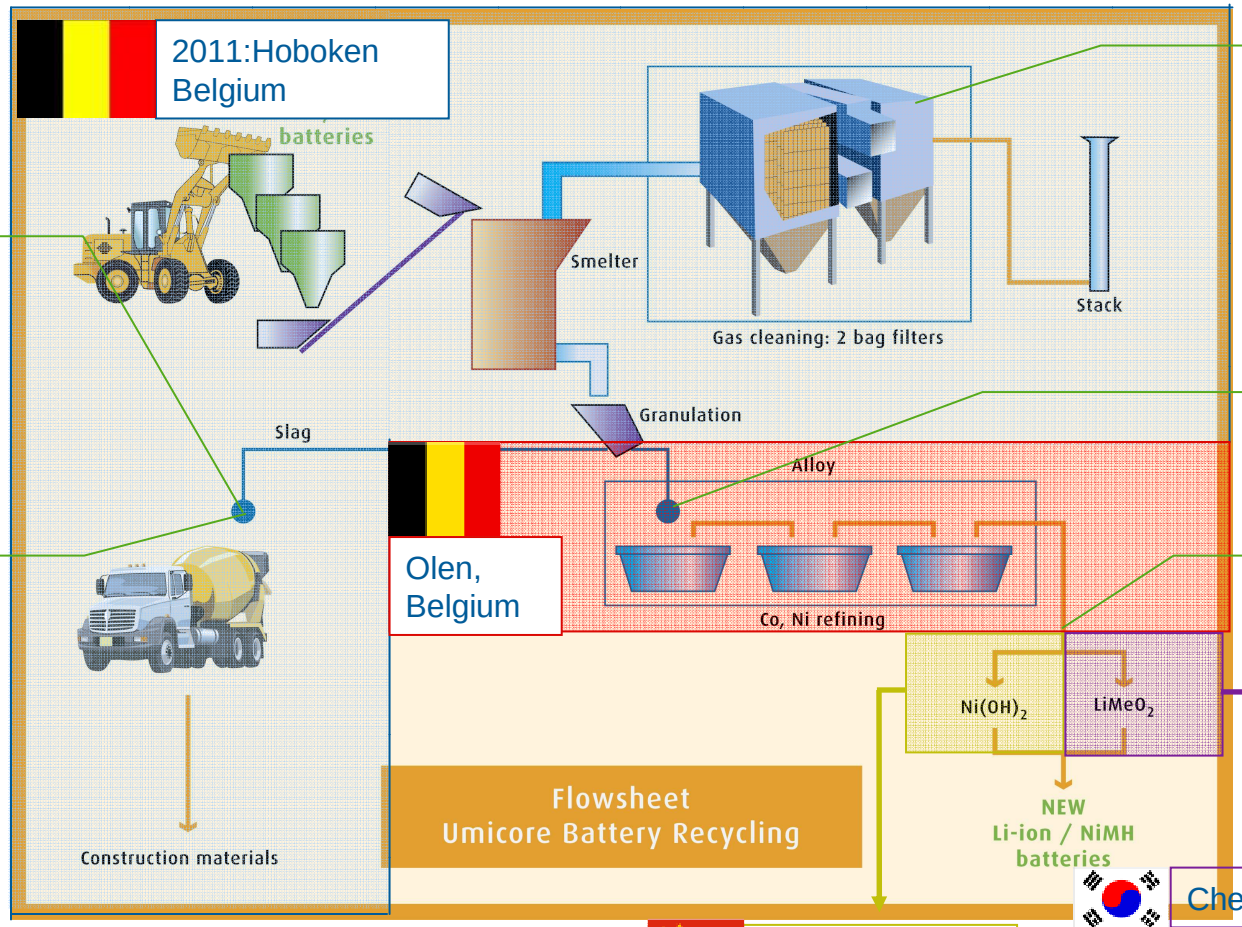
➔ **Umicore strategy = 'element recovery' and service**

Economic aspects: UBR's **new Battery Smelter**

- New UHT smelter in Hoboken, opened September 7, 2011 has a 7000 T/y capacity (= 140 000 (H)EV batteries or 250 Million cell phone batteries
- Sufficient for EU- and world wide market for coming years
- New installations will be geographical spread (N-America, Far East)
- Plant size will be determined by
  - Technology: physical limits, risks
  - Economy: investment and exploitations costs versus transport costs
  - Ecology: LCA methodology to balance between recycling and resource efficiency versus transport burden
- Commitment to have installed capacity to cover all customer needs
- Robust process, compatible with all Li-ion battery chemistries

Environmental aspects: **process description**

The Unique Closed Loop Solution for batteries



Added value because of Li and Possibility for closed loop recovery of Li

Closed loop for REE's

Possibility to recover F

Recovery of Co Ni Fe Cu

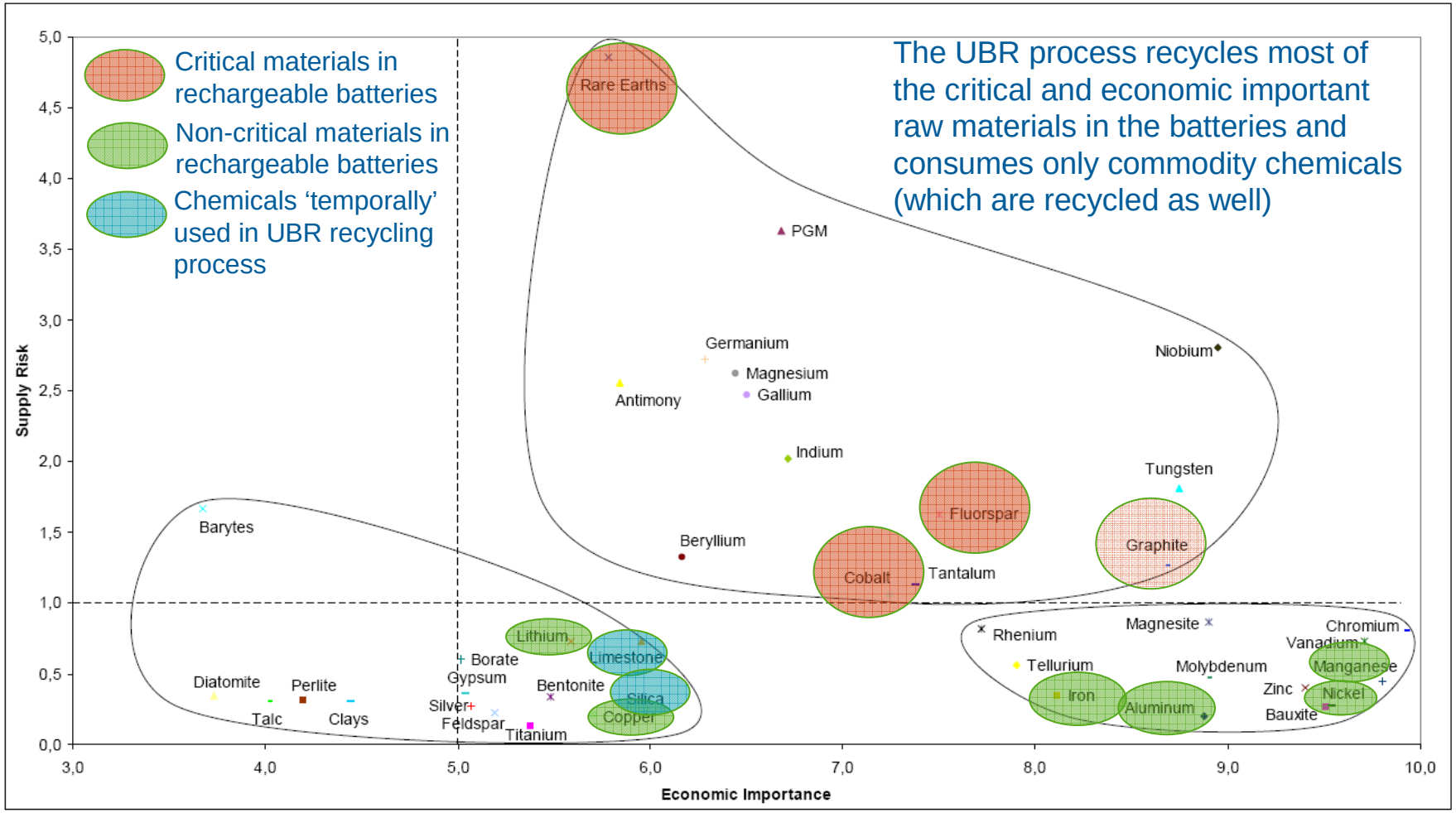
Closed loop for Co Ni Cu

Cheonan, South Korea

Jiangmen, China

Kansai, Western Japan

Environmental aspects: **resource efficiency**



Environmental aspects: Resource efficiency and CO_2-footprint

- Battery recycling increases the ‘green image’ of e-mobility
  - Several LCA’s, together with customers, tackle some environmental objections against e-mobility:
    - Recycling reduces global warming, acidification eutrophication and ozone depletion potential of EV’s (impact reductions from 20 to > 90 %)
    - The plant has a very low CO_2-footprint and nearly no external energy has to be added to the process; even if transport of batteries is included in the LCA –scope
  - Resource efficiency:
    - Study by University of Ghent shows more than 50 % resource efficiency credits
    - Chemicals used in the process are recycled for construction; hereby reducing the CO_2-footprint of construction materials as well

Environmental aspects: **Recycling Efficiency**

Recovered

C

Emitted

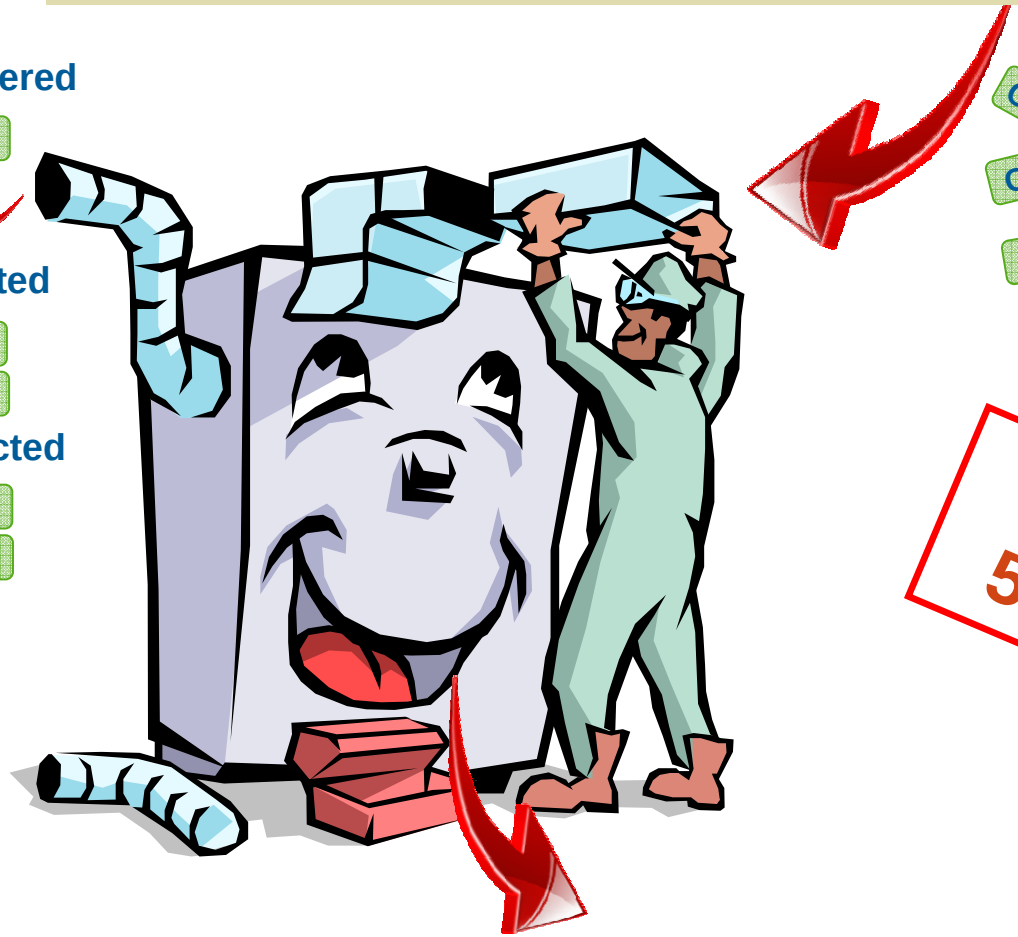
H

O

Collected

F

Cl



Co Ni REE Mn K Cu Li P Al Cl B C O F H Fe

Ongoing discussion on:

- **use of C als reducing agent**
- **dry or wet basis**

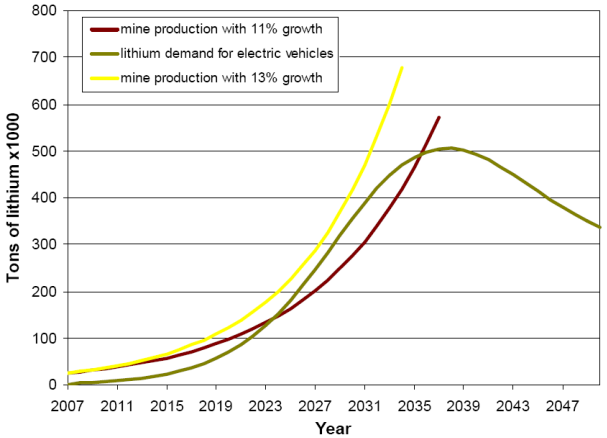
→ RE: Above 50% EU target

Fe Co Ni Cu Mn Al REE K Li P B O

Recycled as products and by-products

Environmental aspects: **Li-recovery**

Can lithium extraction keep up ?



Source: R. Klein (U. Leiden)

Li: No immediate shortage, nevertheless, be prepared:

- geopolitical strategy
- sustainability considerations

UBR's position today:

- through the UBR process, Li is recycled according to BD definition
- higher added value in special case because of Li-content (anti concrete cancer agent)
- possibility to extract Li

Li (in slag) added to concrete mitigates concrete cancer

Environmental aspects: **REE-recovery**

NiMH batteries contain REE's

- defined as critical raw materials for EU, because dependency on Chinese supply

Joint project with Rhodia:

- Umicore makes a REO-concentrate
- Rhodia refines the concentrate into pure REO's
- These REO's can be used for batteries again, or for other high end applications

Rare earth oxides. Clockwise from top center: **praseodymium**, **cerium, lanthanum, neodymium**, samarium, and gadolinium (**bold** = in NiMH batteries)

REE = Rare Earth Element
REO = Rare Earth Oxide

Social aspects: **creating labour** on several educational levels

- Dismantling and sorting of (H)EV batteries and portable batteries




- (H)EV dismantling at Umicore: manual job, today only in Hanau, but to be rolled out world wide
- WEEE dismantling:
- Dismantling avoids transport of parts which are ‘easy’ to recycle locally
- Creates valuable jobs for lower educated personnel on several places

Social aspects: creating labour on several educational levels

- smelting of batteries

  - Highly specialized jobs in limited centers of competence
  - Avoids ‘backyard’ recycling with high EHS risks

Conclusions

Economic aspects

- Proven market for PRB's, market for (H)EV still to be demonstrated, but generally accepted to grow to 10 % of new sales by 2020
- Unique position because of technology and business relations

Environmental aspects

- Low carbon footprint,
- LCA-proven resource efficiency and very good results on all investigated impact categories
- Closed loop for most critical elements; possibility to close the loop for other strategic elements

Social aspects

- generates quality labour on several levels of education
- possible to roll out to several area's worldwide

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