evs 27

The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION.

Barcelona, Spain
17th-20th November 2013

THE RECYCLING EFFICIENCY OF Li-ION EV-BATTERIES

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Why Battery Recycling?

Part of the clean mobility global picture

clean mobility

Choice of transport mode	Clean vehicles	Clean energy

Exhaust control

Electrification

Vehicle and battery recycling

Why battery recycling?

- EHS concern: EV-Batteries = a complex mixture of chemical elements and compounds:
  - Li-ion: H, Li, C, O, F, Al, (Si), P, (Ti), Mn, Fe, Co, Ni, Cu, (Sn)
  - NiMH: H, C, O, K, Fe, Co, Ni, La, Ce, Pr, Nd
  - Electrolyte, solvent, plastics…
- Legislative context in EU
  - End of Life of Vehicles Directive (ELV): removal of batteries
  - Batteries Directive: ban on incineration and landfill of industrial batteries
    - To avoid dissemination of hazardous compounds
    - Resource efficiency
    - Quality target: recycling efficiency (RE) ≥ 50 %
      RE = (battery recycled materials)/(battery input materials on dry basis)

BD: Producers obligations regarding recycling

- Basic principle:
  - Extended Producer Responsibility (EPR) ←→ Polluter Pays Principle (PPP)
    - EPR stimulates to include End-of-Life concerns in design phase
  - Producer = *any person in a Member State that… places batteries or accumulators, including those incorporated into appliances or vehicles, on the market for the first time within the territory of that Member State on a professional basis* → for same type of EV, sold in different countries, 'battery Producer' can be different
- (H)EV batteries are 'industrial' batteries, not automotive batteries (= limited to SLI-batteries).
  - no collection target, but take-back obligation (→ reuse, recycling)
- Recycling Efficiency target (RE)
  - 50% of battery weight has to be transformed into an *output fraction that has ceased to be waste or that will be used for their original purpose or for another purpose (without undergoing further treatment).*

Calculation of the Recycling Efficiency

- the Battery Directive's RE is a process efficiency indicator
  - Calculated per calendar year
  - On process/operator level:
    - 2 operators with 'same' process = different processes
    - 1 operator with 2 processes = different processes
    - 1 operator processing different battery chemistries together = same process
  - Refers to 'recycling' only, not including other recovery (energy).
  - Including all steps until the 'end of recycling' (output fractions with a 'purpose' without further treatment)

➔ <u>All batteries processed during the same year in the same process generate 1 RE!</u>

- the Battery Directive's RE is calculated on 'battery level'
  - Non-battery materials, e.g. casing of battery packs, are excluded
  - EV-battery assemblies are not considered as 'packs' but as 'batteries'
  - Battery cells are also considered as batteries
- Reporting: responsibility of first recycler (= operator that 'breaks' the battery)
  - ➔ consolidation of all subsequent recycling operations

Calculation of the Recycling Efficiency

Non-active battery parts recycled according to existing schemes: partial RE (calculated according to BD) to be reported to '1st recycler'

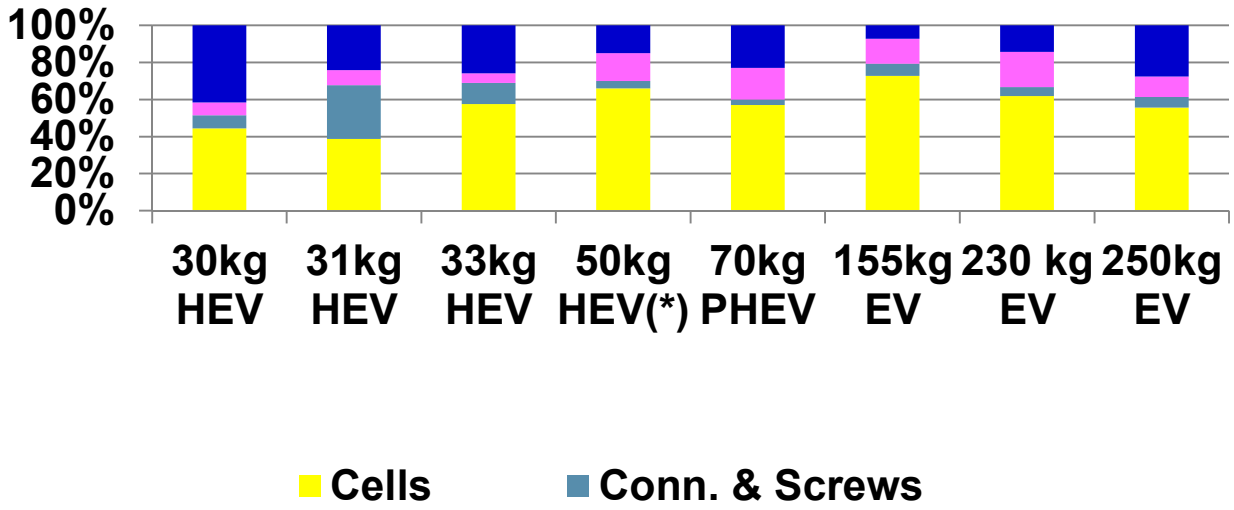
Considered as 'battery': breakdown of battery = 1st recycling step; agglomerated RE includes partial RE of all subsequent process steps

Active battery parts recycled according to dedicated battery recycling schemes: partial RE to be reported to '1st recycler'

Calculation of the Recycling Efficiency

Impact of material choices of non-active parts

- Based on interviews, Recharge[1] concluded that relative % (w/w) of cells varies between 40-70% of (H)EV battery assembly weight; metals: 15-40%; plastics: 10-15%. Main difference is OEM's choice for protective casing material (metal or synthetic fibres)
- For same partial RE for each material flow, resulting agglomerated RE can vary significantly



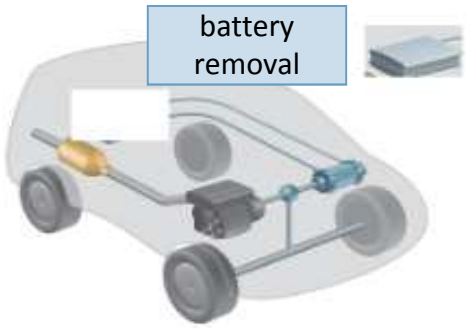
	Cells	Metals	Plastics	Agglomerated RE
Partial RE (%)	*50*	*95*	*10*	
Composition (%)	50	40	10	
Partial RE	25	35	1	**61**
Composition (%)	70	15	15	
Partial RE	35	14.25	0.15	**49.40**

[1]Recharge is the European sector association for the advanced rechargeable batteries industry (http://www.rechargebatteries.org/)

Consolidation of batteries RE in ELV reporting

1) Battery to recycling

To car recycling



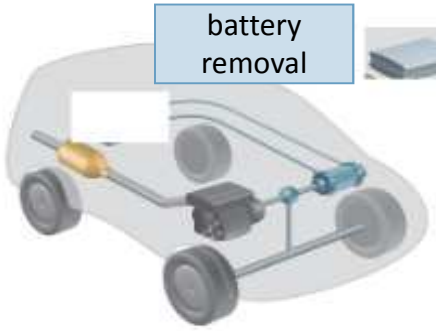
battery removal

To battery recycling; recycling target = 50%

Battery recycling to be included in ELV reporting

Car recycling target = 85%; reuse&recovery target = 95 %

2) Battery to refurbishment for reuse



battery removal

To car recycling

To battery refurbishment

Rejected cells/modules subject to recycling target 50%

Battery considered as 100 % reused for ELV reporting

Car recycling target = 85%; reuse&recovery target = 95 %

Consolidation of batteries RE in ELV reporting

- BD RE and ELV recycling rates are other concepts

BD	ELV

• Process focus
  • Including process steps until end of recycling of all fractions
  • Possible to treat also non-vehicle batteries in same process
• Recycling only
	• Product focus
	  • Materials flow reporting (weight fractions to recycling or landfill)
	  • Does not include recycling steps until the 'end of recycling' as defined for batteries
	• Also reporting reuse and energy recovery

Suggestion: to consider batteries as 100 % recycled if delivered to compliant battery recycler

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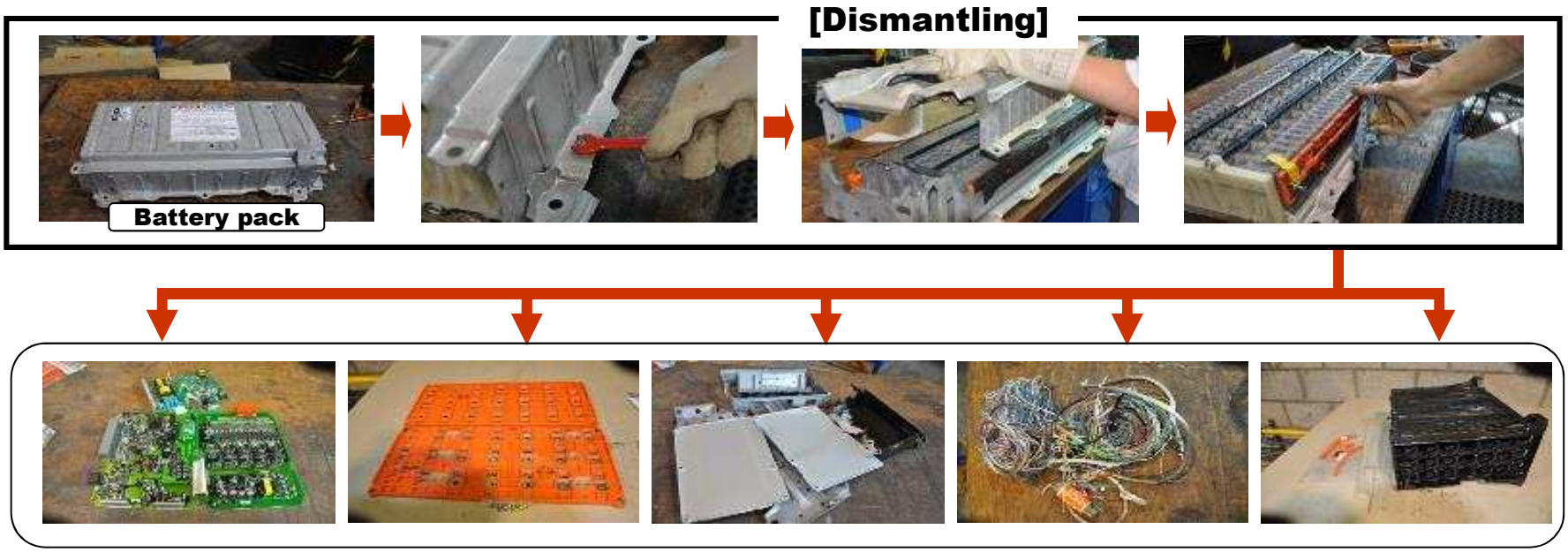
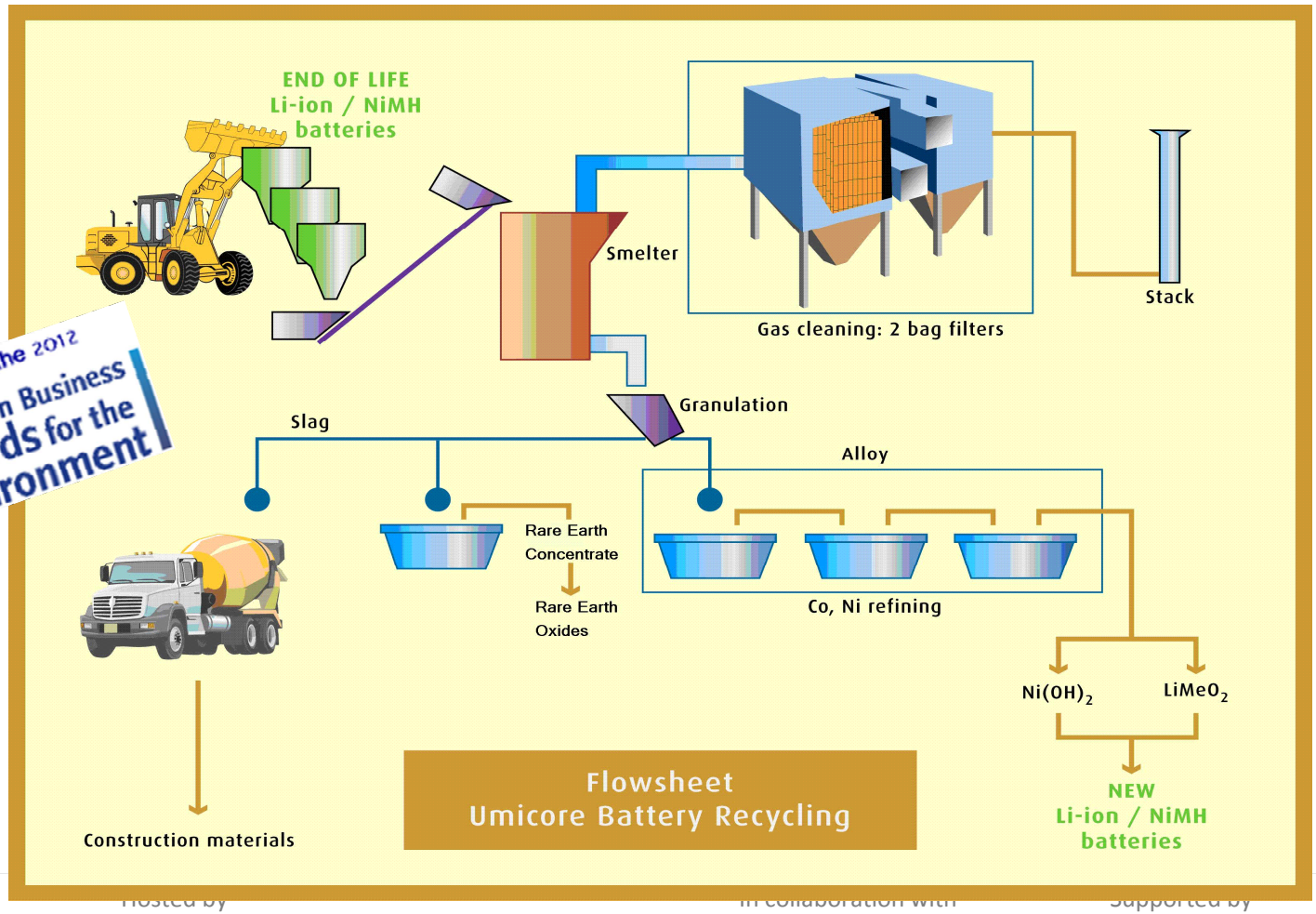
Umicore battery recycling technology

Umicore Process description - Dismantling



- Dismantling/discharging facility for (H)EV in Germany since January 2011.
- Another dismantling/discharging facility in US is operational since mid 2012.
- Industrial-scale UHT smelter in Hoboken, Belgium. Operational since mid 2011.

Umicore Process description - metallurgy



Winner of the 2012 European Business Awards for the Environment

Conclusions

- Huge diversity of Li-ion battery chemistries requires a robust recycling process
- The Batteries Directive is the first EPR-directive that includes recycling efficiency targets until the final stage of recycling
- The Umicore recycling process complies with the BD's RE target

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