Regulation on Recyclability and Recycling

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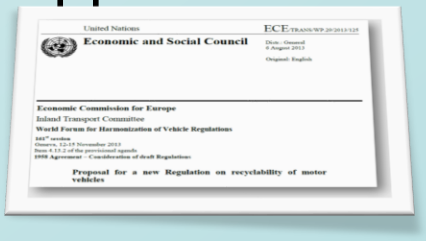
RECYCLABILITY

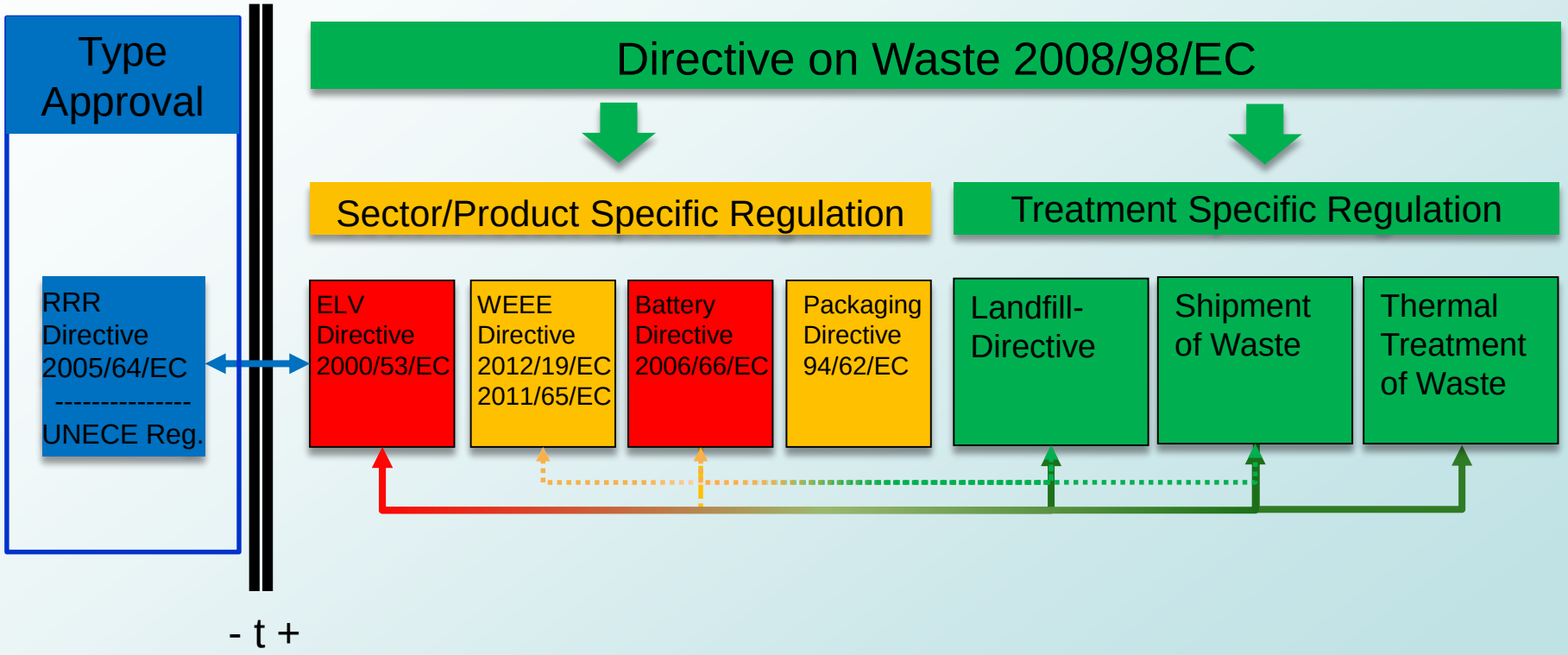
An innovative concept

Recyclability in Vehicle Type Approval

- Type Approval **Recyclability** is dealing with the theoretical **reusability**, **recyclability** and **recoverability** of the WHOLE VEHICLE based on its material composition.
  - Legislation on type approval recyclability is addressing the automobile industry (OEMs and suppliers)
- In Europe, Type Approval Recyclability has been regulated in Directive 2005/64/EC, amended by Dir. 2009/01/EC.
- At WP29 meeting Nov. 2013, a UNECE regulation on recyclability of motor vehicle has been approved ensuring GLOBAL ALIGNMENT.


United Nations
Economic and Social Council
Economic Commission for Europe
Inland Transport Committee
World Forum for Harmonization of Vehicle Regulations
Proposal for a new Regulation on recyclability of motor vehicles

Recyclability in the context of EU End-of-Life Regulation



Two Aspects of Vehicle Recycling

- Type Approval – New Vehicle Types

  - End of Life Vehicles
  - Recyclability Rate
  - Waste Treatment
  - Theoretical Approach

- End of Life Vehicles – Treatment

  - Waste Treatment of Vehicle fluids & components (incl. Battery)
  - Real Life

ELV Directive 2000/53/EC

Battery Directive 2006/66/EC

t_{-3} t_0 t_{+15}

Recyclability a Visionary Concept! Why we needed it!

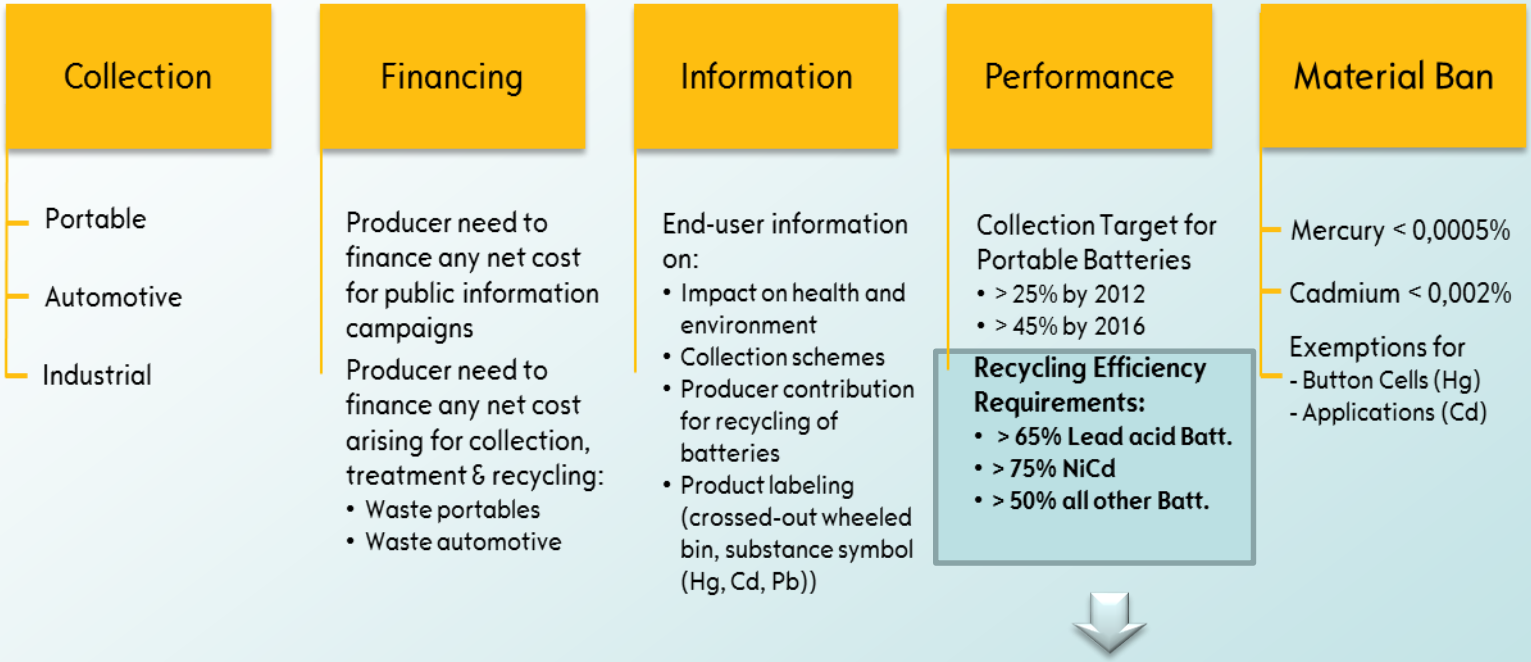
- Inauguration of ELV Directive 2000/53/EC required OEMs to achieve RECYCLING QUOTAS:

Year	Reuse & Recycling	Reuse & Recovery
2006 onwards	80%	85%
2015 onward	85%	95%

- Recyclability was introduced into regulation as early as 2001 as a bridge instrument to attain recycling performance 14 years later!

- Both RECYCLABILITY and RECYCLING QUOTA are product specific performance measurements!

Battery Directive 2006/66/EC – A Regulatory Summary



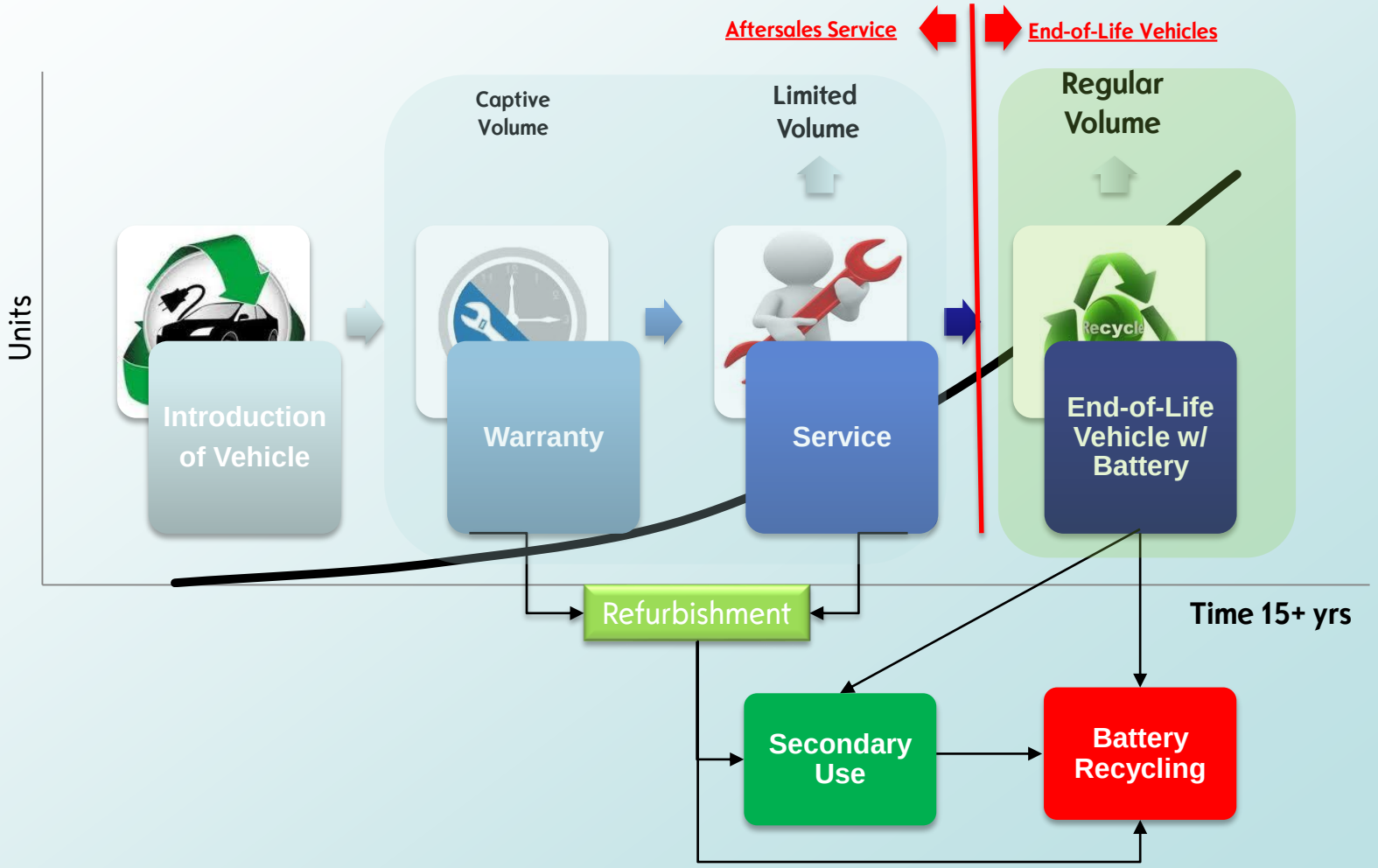
Recycling Efficiency is **NO PRODUCT** specific performance criteria! It is a **RECYCLING PROCESS** oriented performance measurement.

Battery Directive has no product specific recycling performance mandate!

BATTERY RECYCLING

How it is done?

Origin of HV Batteries or Battery Components for Recycling



Battery Recycling Volumes

EBRA Recycling Statistics: Comparison 2011-2012 (Tons)			
	2011	2012	Var % 11-12
Primary ZnC, Alklaine, Zn-Air	25529	26660	4%
Button cells (all types)	11	101	817%
NiCd (consumer, sealed)	3488	3264	-6%
NiCd (industrial)	3116	3367	8%
Subtotal NiCd	6604	6632	0%
NiMH (portable/consumer)	581	964	66%
NiMH (ind., non E-mobility.)	13	73	462%
NiMH (E-mobility))	9	48	436%
Subtotal NiMH	603	1085	80%
Li-primary (other than button cells)	90	581	545%
Li-secondary (portable)	2047	3386	65%
Li-secondary (ind., non E-mobility)	62	0	-100%
Li-secondary (E-mobility)	24	127	428%
Subtotal Li-secondary	2133	3512	65%
Production / Operation waste	26	21	-21%
Total recycled:	**34996**	**38591**	**10%**

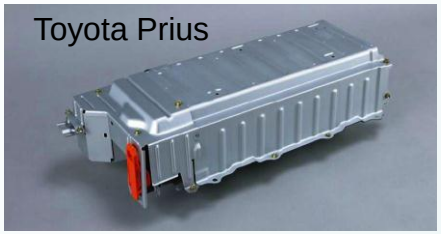
NB: EBRA Members only

Traction Battery Volume dependent on:

1. Vehicle Registrations
2. Battery System Durability
3. Battery System Reparability
4. (Innovative Secondary Use Applications)

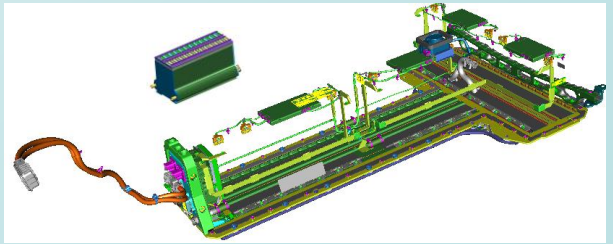
Source: EBRA

HV Battery System Design

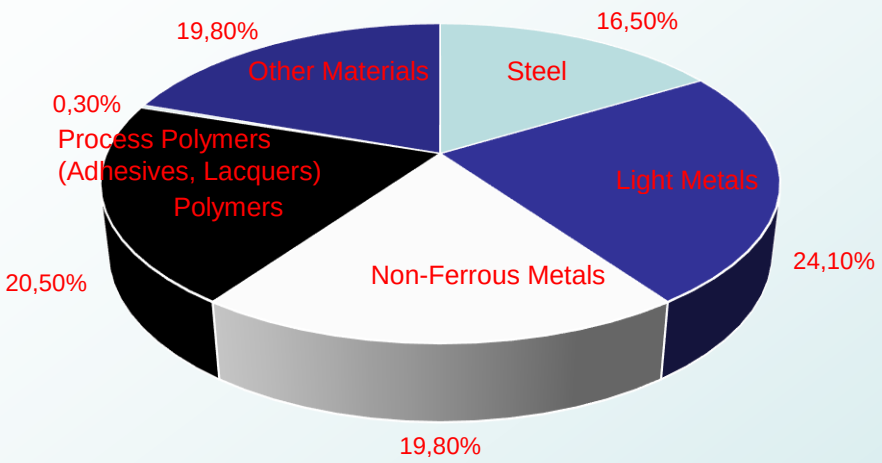


Major design elements

- Casing
- Cell
- Cooling (depending on cell chemistry)
- Electronics
- Wiring



Battery System Materials



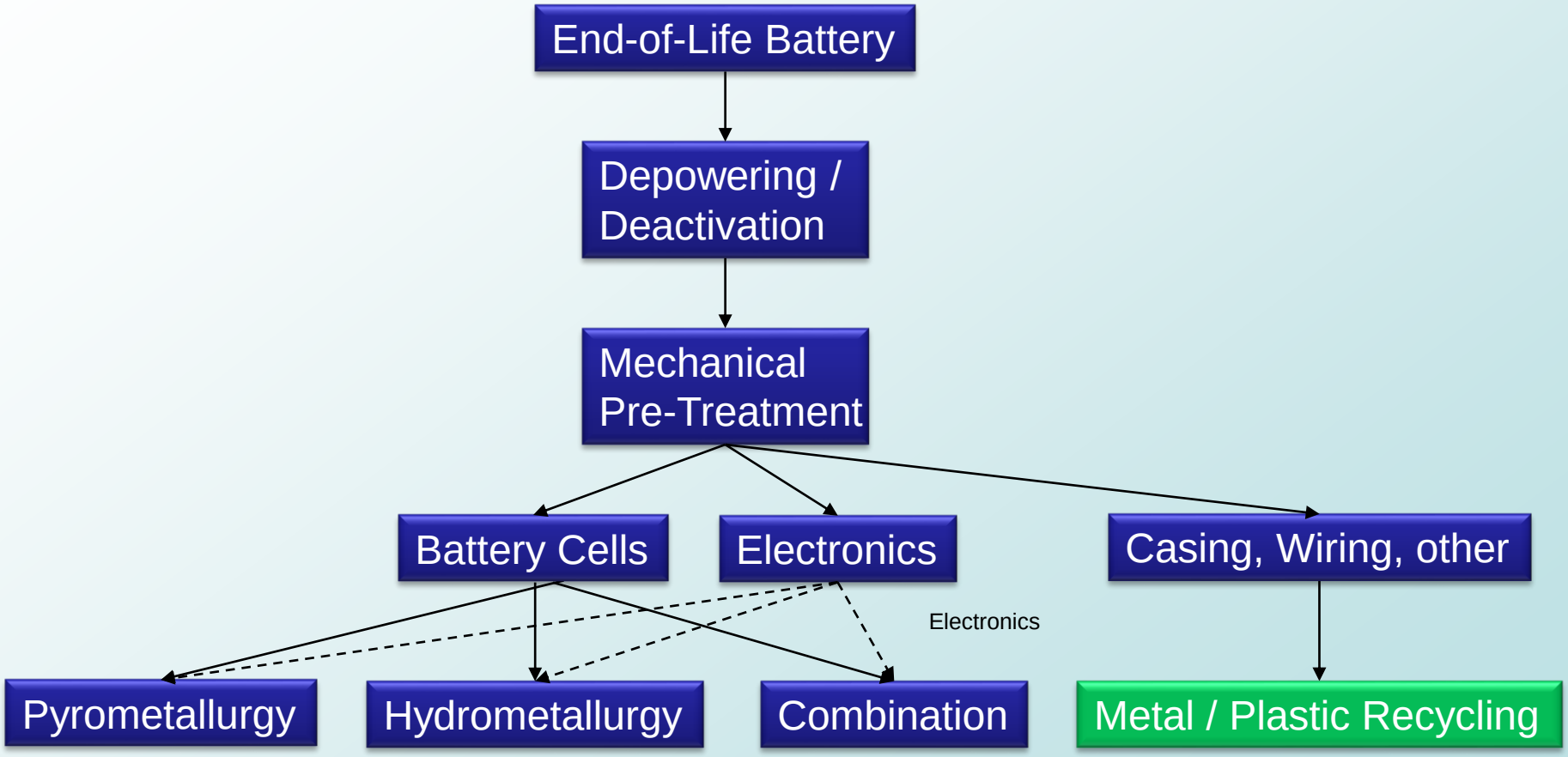
Material	Kg / KWh
Aluminium	1,50 - 5,00
Copper	1,50 - 4,20
Nickel	0,00 - 1,20
Cobalt	0,20 - 0,30
Lithium	0,07 - 0,01
Steel	1,00 - 2,00
Carbon	1,00 - 1,80
Organic Electrolyte	1,00 - 2,00
Plastic	1,00 - 3,00
Non-Metal Share	41% - 35%

Item	% of Battery System
Metals	60% - 70%
Cell Weight	~ 60%

Source: ZVEI

Global Landscape of Battery Recycling Facilities

Battery Recycling Flow



Characteristica of hydro- and pyrometallurgical routes

	Hydrometallurgy	Pyrometallurgy
Advantages	• High selectivity • Extraction of ignoble metals is possible • Carbon remains as product • Low off-gas volumes • Small plant size feasible	• ignoble metals, organics and carbon used for reduction and as energy carrier • direct recovery of metals • potential for zero-waste process • high productivity • Low space requirements
Disadvantages	• Using of chemical reagents • Water requirement, Waste water treatment • Low productivity	• intensive requirement of energy emission control needed slag – commercial risk large volume of scale
		

Source: RWTH Aachen

Example: UMICORE Battery Recycling Process

EV pack dismantling ➔ modules

EV modules

Portable Rechargeable Batteries

Production scrap

INPUT

+ Energy Valorization

Smelting

OUTPUT

Ca/Si/Al/Mn aggregates

RE's

Li

(potential to recover)

Cement industry

OUTPUT

Co / Cu / Ni / Fe granulated alloy

5 years of experience;

2011: new, improved smelter

Further Refining

$LiCoO_2$

Firing With $LiCO_3$

Pure new Battery Precursors

$Ni(OH)_2$

oxidation (Co_3O_4)

$(CoCl_2)$

Co

Ni

$NiSO_4$

SX

de-Fe

de-Cu

Fe

Cu

Co

Cu

Ni

Fe

Alloy Refining

Source: Umicore

Battery Recycling Conclusions

- Today's recycling processes are capable to recycle all types of batteries
- Battery recycling efficiency determined by process configuration
- Process up-scaling to suit automotive traction battery systems
  - Process innovation to facilitate handling of large scale automotive traction batteries for recycling

Impact Assessment: Recyclability

Influence of battery recyclability requirements on

- Battery regulation
- Vehicle recyclability process
- Innovation to further develop competitive battery systems
- Innovation to industrialize automotive battery pre-treatment for recycling
- Implementation of today's best practices likely to inhibit innovation in battery recycling processes / technology
- Increase of battery system complexity

➢ Incremental environmental benefit

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