Recycling
A pure bonus

Roland Scharf-Bergmann
Head of Recycling

1. Recycling
2. Market Outlook
3. Recycling in Hydro

1 **Recycling**

2 Market Outlook

3 Recycling in Hydro

Recycling – a *pure* bonus

Utilizing aluminium as an energy bank

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Aluminium recycling, a viable business

High rates of recycling

- 95% Transport
- 95% Buildings
- 55% Packaging (64% Cans)

Long lifetime for aluminium in use

- 15-20 years for vehicles
- 40-50 years for buildings

RECYCLING GLOSSARY

Pre-consumer scrap
process scrap generated before the product‘s use phase

Post-consumer scrap
product scrap from used products at end of product life

Primary aluminium
aluminium generated from bauxite ore, via alumina refining and electrolysis

Recycled aluminium
aluminium generated from scrap sources

Remelter
recycling plant producing extrusion and rolling ingot

Refiner
recycling plant producing foundry alloys

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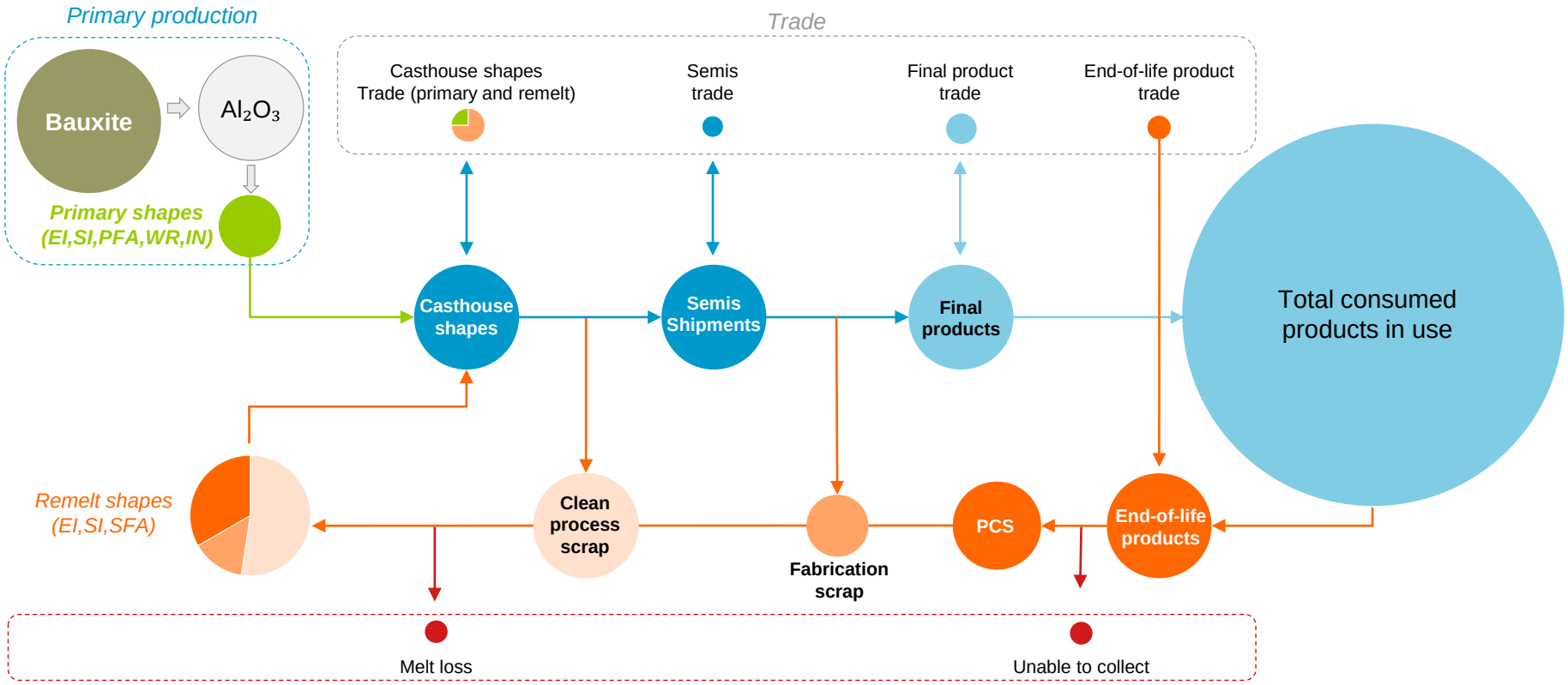
3 types of scrap are created in the regional aluminium flow

Post-consumed (PCS), fabrication scrap and clean process scrap (CPS)



Various scrap sorting techniques & technologies

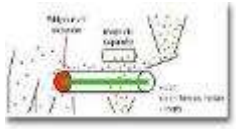
Steel, Fe

Shredding

- Cutting scrap in pieces without separating various metals
- Taking out some easy parts before shredding e.g. Wheels and engines from cars is usual
- The shredded metal can then go on to be sold as shredded scrap or be treated by sorting techniques to increase its value

Steel, Fe

Magnetic & Eddy current



- Magnets separating ferrous and non-ferrous metal scrap
- Heavy metals like steel and iron is sorted out
- Used extensively for Secondary production
- Eddy Current: Rotor with magnets to throw scrap at different distances in relation to their eddy current
- Utilizing the different conductivities of various metals

Plastics, foam

Air seperation

- Using air to separate scrap streams
- Also called windsifting, air-knives, elutriation, winnowing and air columns
- Conveyor belt system with air flows pushing away light weight materials like e.g. plastics
- This technique could result in loss of light and small aluminium scrap such as UBC scrap

Mg, Cu, Zn, Pb

Sink float

- Separates scrap in various baths with various specific gravities
- Possible to sort based on the various metal's density, but also based on alloy (Scrap will sink or float based on density)
- Separating heavy and light materials from the wrought and casting aluminium scrap

Wrought vs Casting

Hot crush

- Thermal-mechanical separation method
- Successfully separates wrought and casting alloys by looking at the eutectic temp. as castings has a lower melting temp (because of higher Si content)
- First warm, then crush to separate whether the metal breaks or not
- 96% effective in separating the scrap

Metals & alloys

Color sorting

- Hand sorting based on different colors of metals. Can also sort wrought vs. casting alloys
- Only possible with low labor costs. 99% accuracy estimated for China
- Can also be done by a computer, can sort by alloy when using etching chemicals making alloys stand out in color
- Environmental and economic barrier

Metals & alloys

Spectroscopy

- X-ray, neutron flux or pulse laser detectors scan the metal (must be free of lubricants, paint and coating)
- The metal returns various emissions when hit by the detector source. The differing emissions are read and forms the basis for the scrap sorting
- The system can then direct the piece of scrap to an appropriate bin using a mechanical arm or air flow
- Recently possible at high speeds

Source: Improving aluminum recycling: A survey of sorting and impurity removal technologies (Gabrielle Gaustad et. Al.)

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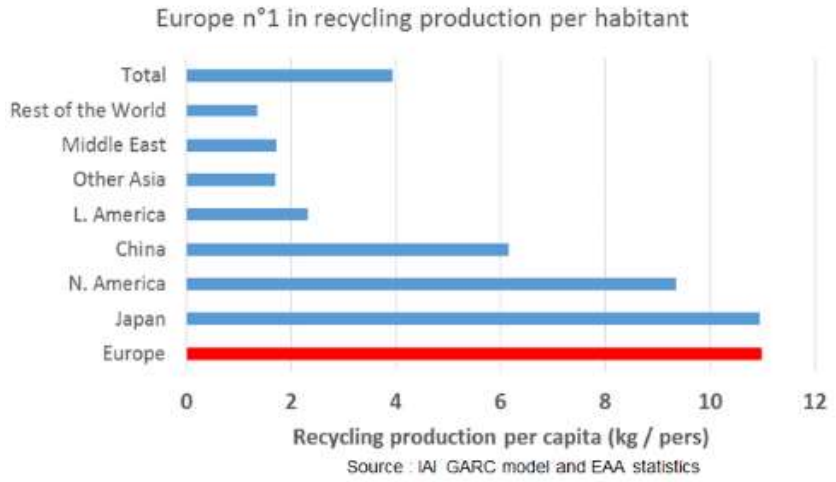
1 Recycling

2 **Market**

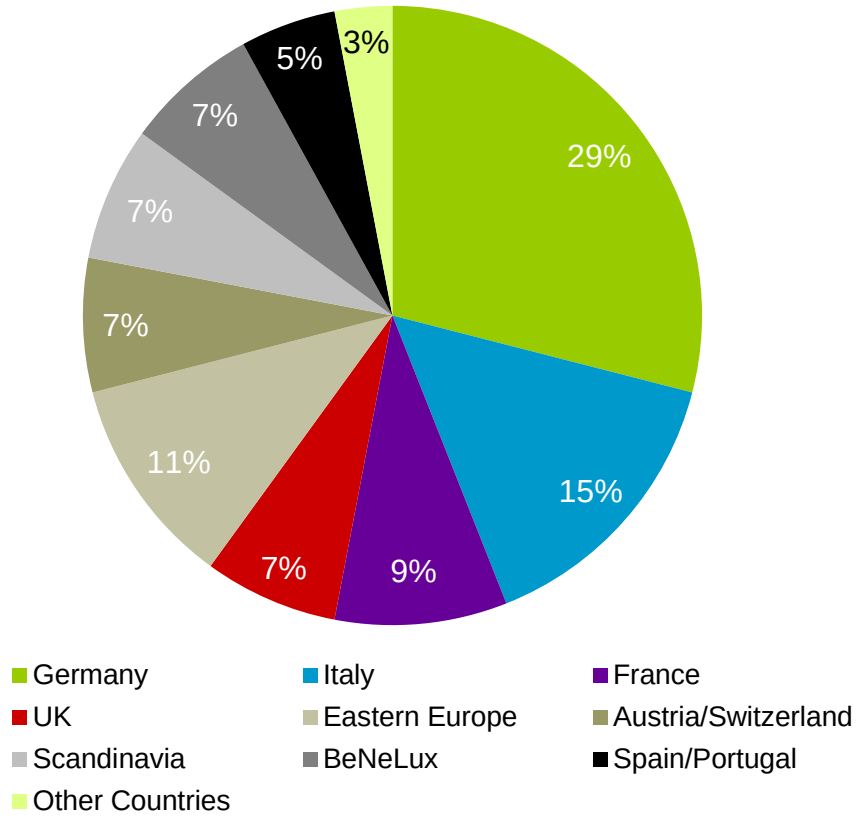
3 Recycling in Hydro

Europe is the world leader in recycling

- 10,5 million mt recycling production in 2014.
  - An increase of 6,1% from the year before,
  - Primary production in Europe fell by 3,0%



There are more than 220 plants in 24 countries in Europe



Source: EEA

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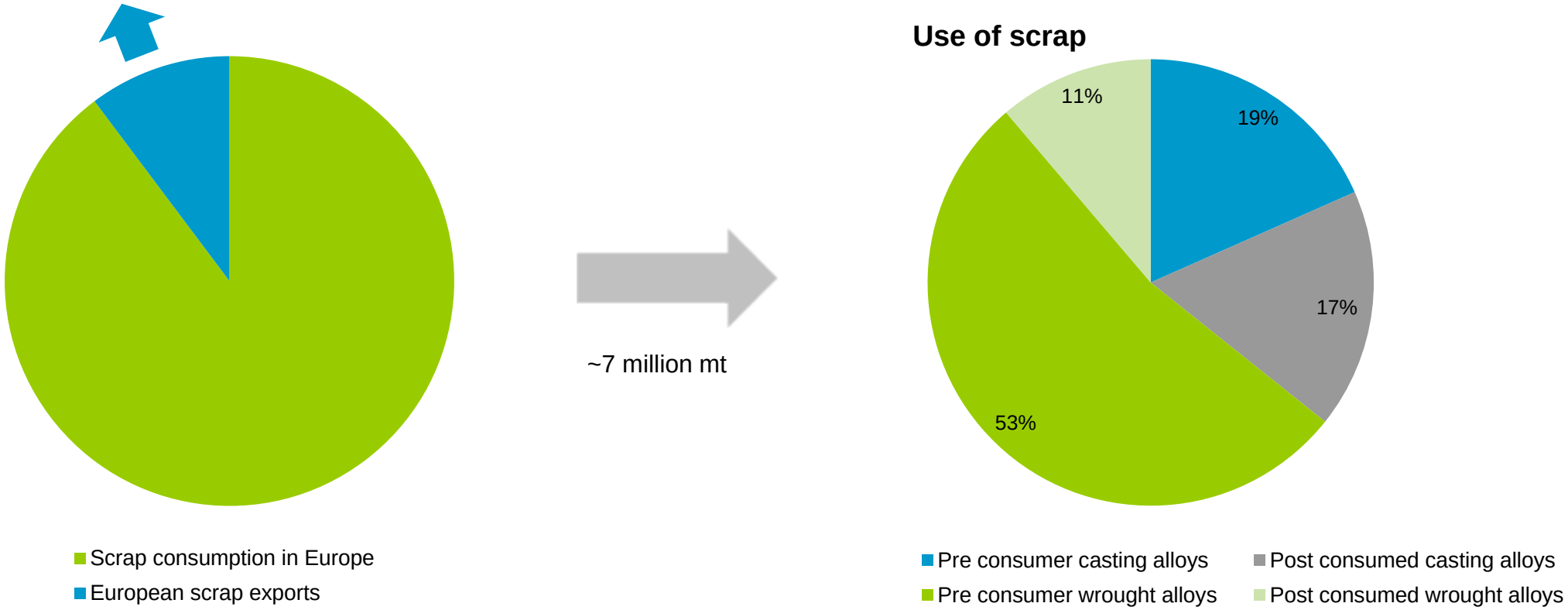
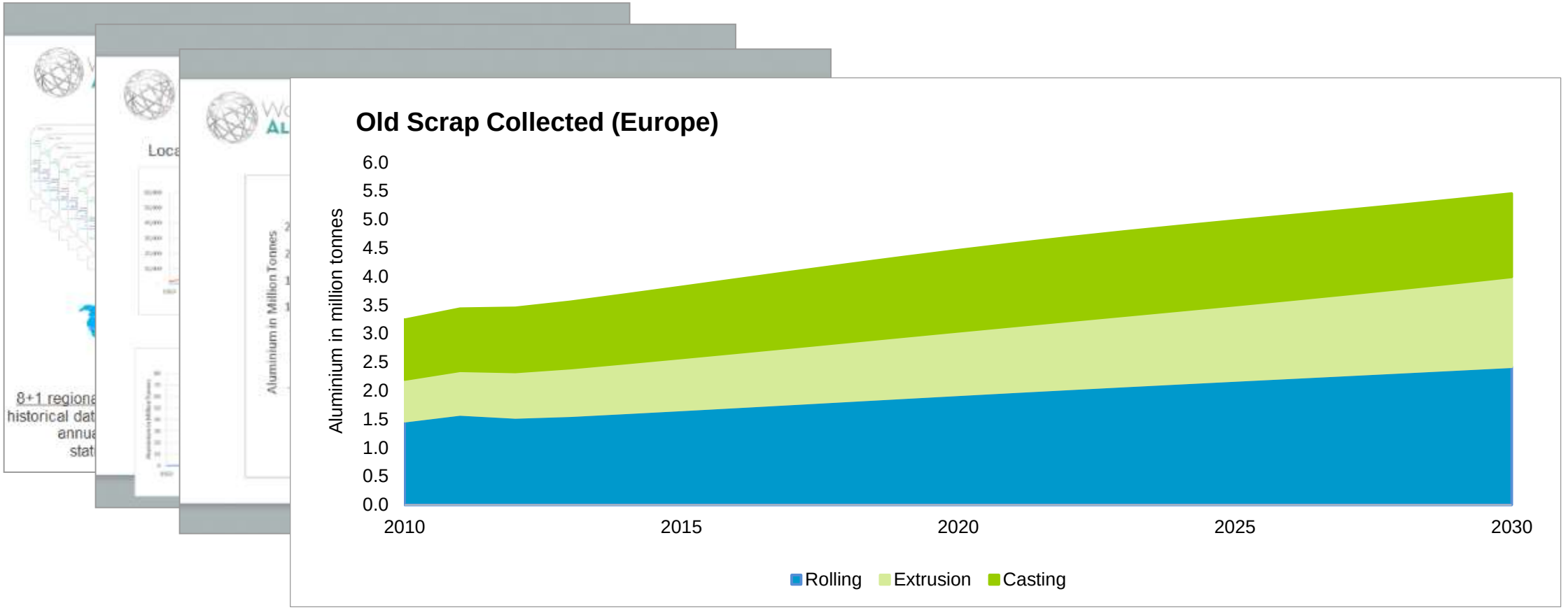
89% of scrap is used in Europe (EU27+EFTA)

11% of the scrap generated in Europe in 2014 was exported



Source: EAA

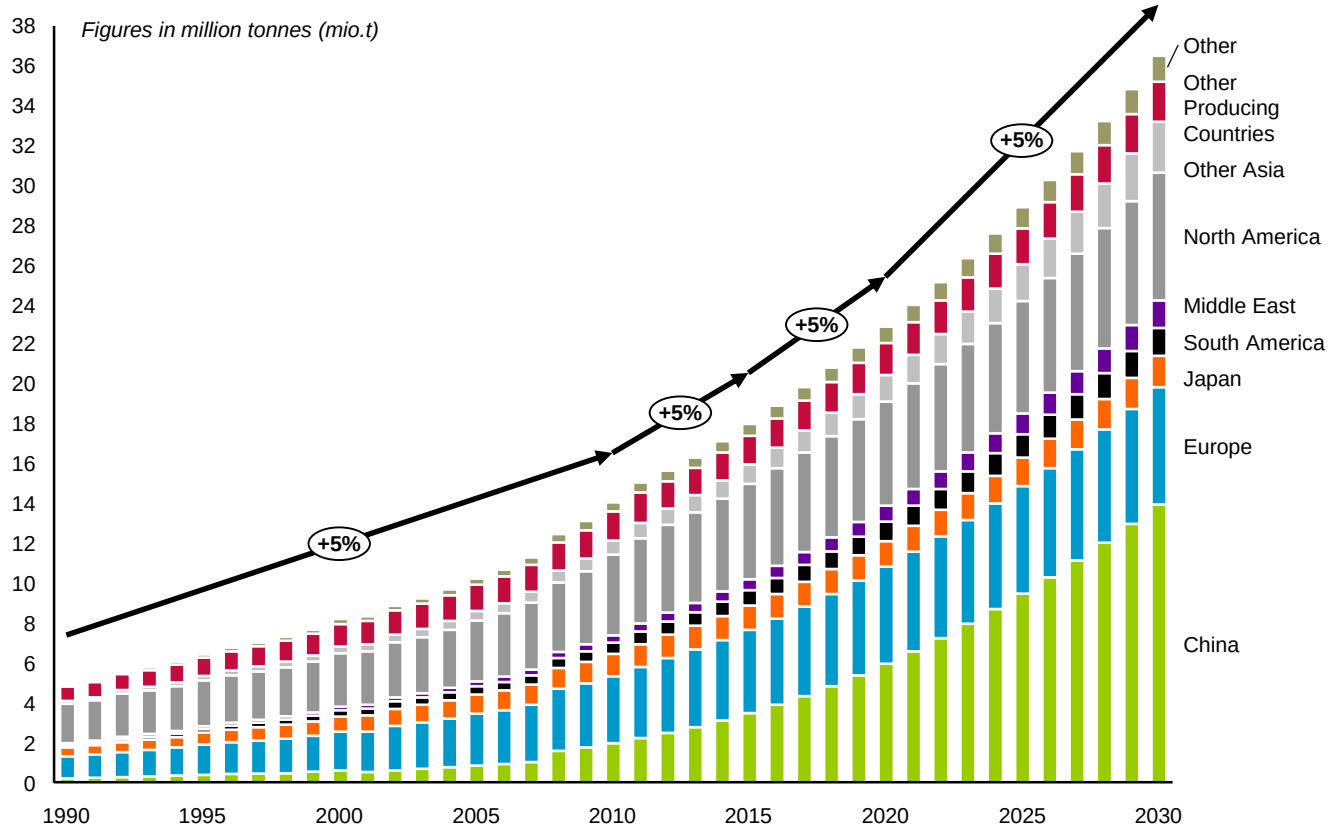
Advanced modelling reveals long term supply growth



Available post-consumed scrap expected to increase.

China as main source of old scrap generation growth

GARC: Global old scrap to scrap market (Before trade and remelt loss)



CAGR:

Region	10-15	15-20	20-25	25-30
Other (Residual)	7 %	6 %	5 %	4 %
Other Producing Countries	-1 %	2 %	2 %	2 %
Other Asia	6 %	7 %	7 %	7 %
North America	3 %	2 %	1 %	3 %
Middle East	8 %	8 %	6 %	6 %
South America	6 %	5 %	4 %	4 %
Japan	2 %	1 %	2 %	2 %
Europe	4 %	3 %	2 %	2 %
China	12 %	11 %	10 %	8 %

Source: IAI

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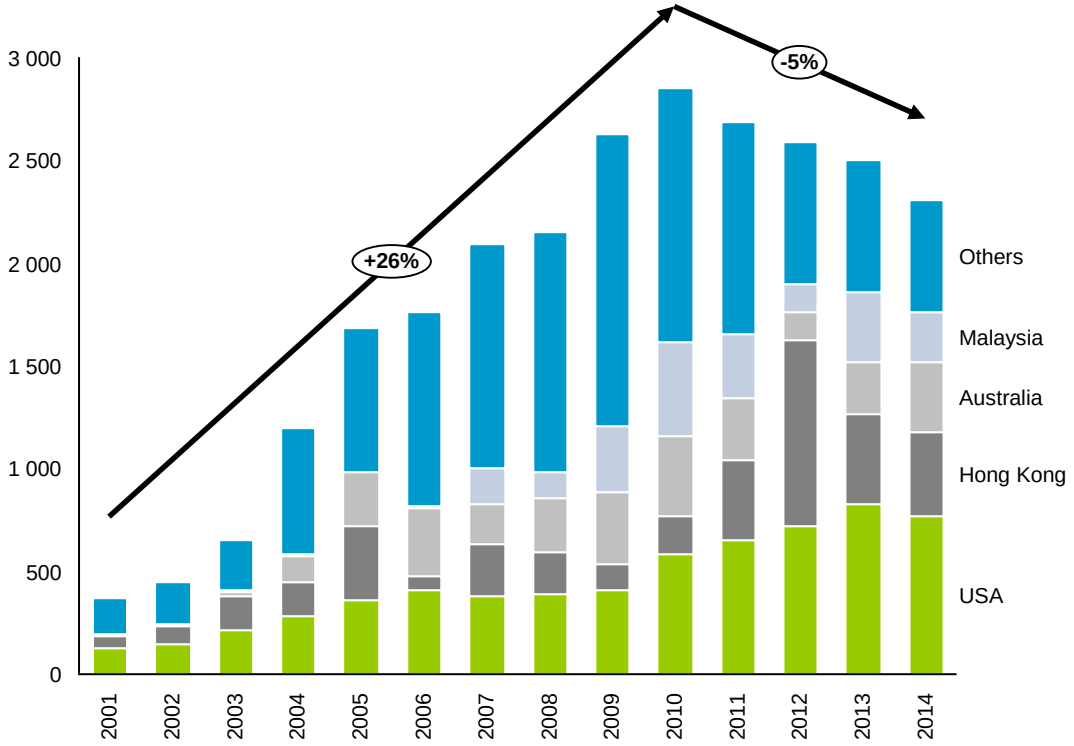
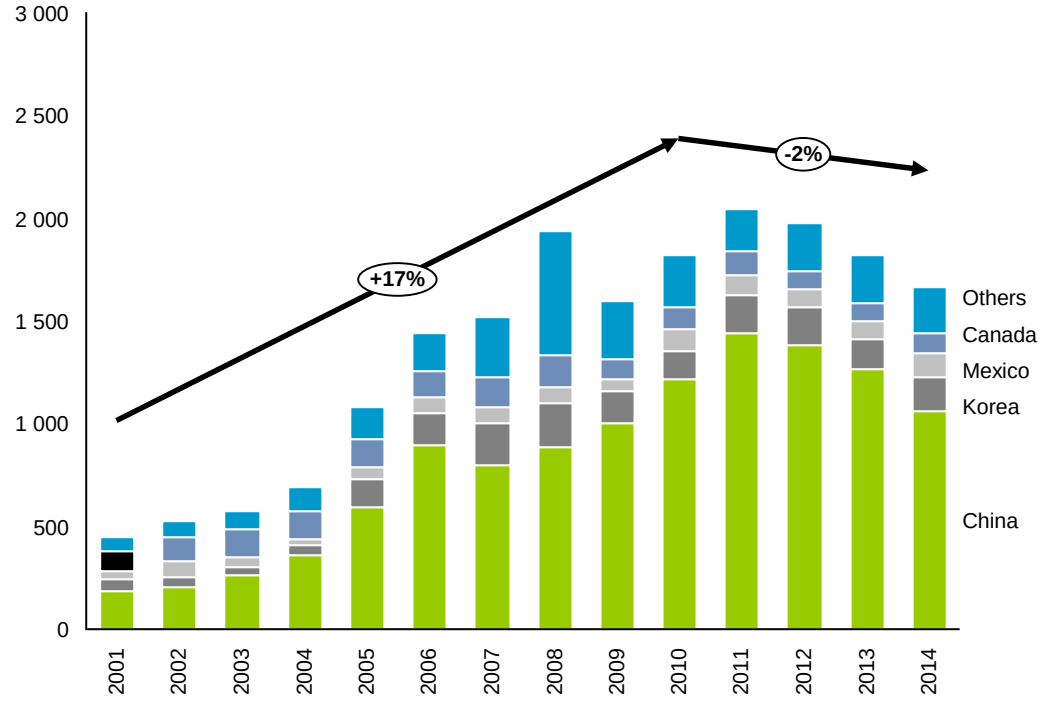
Current scrap trade levels not sustainable due to shrinking Chinese imports

Declining US exports as an effect of this

China scrap import
Figures in kt



US scrap export
Figures in kt



Source: UN COMTRADE: 7602 Aluminium waste and scrap

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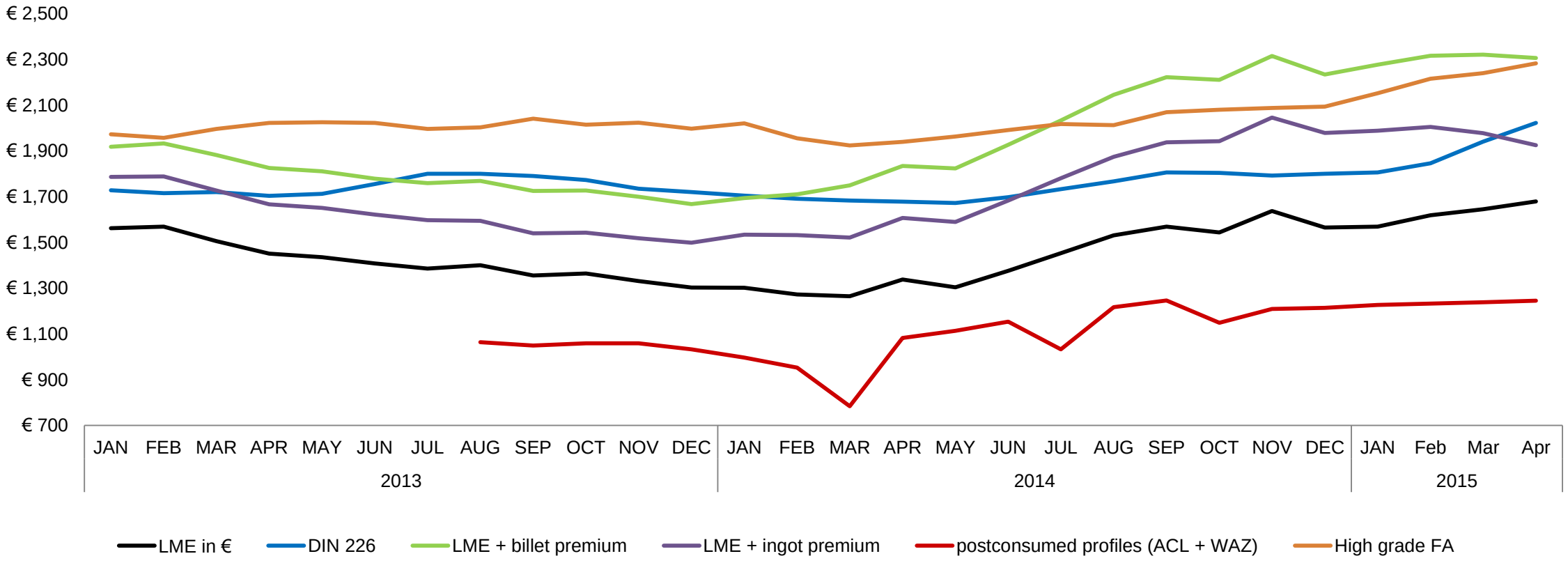
Scrap and alloy prices principally follow LME

Time-lags for scrap may cause imbalances

Price development in € 2013 - April 2015



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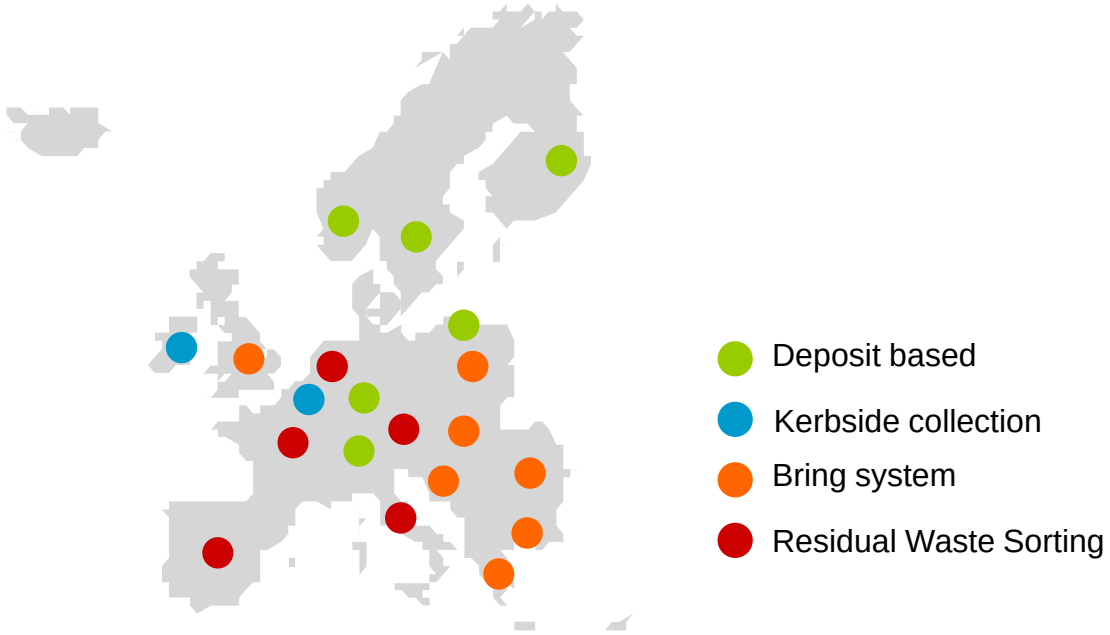
1. Recycling
2. **Market (UBC)**
3. Recycling in Hydro

UBC scrap market in Europe

280 kmt of UBC are collected in Europe from a variety of collection systems based on EAA figures.



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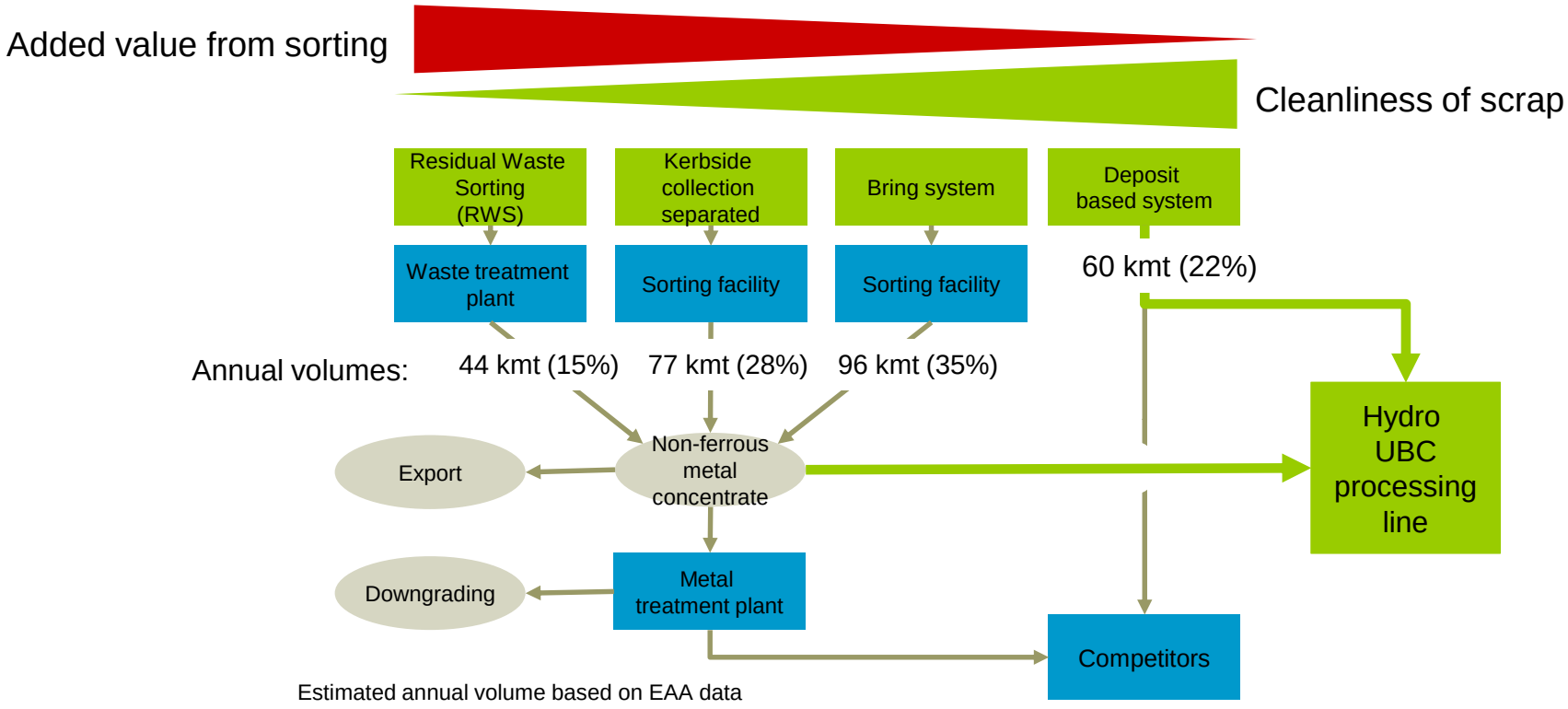
Volumes from different collection systems



More than 80% of European UBC come from return systems with elevated levels of mix up and contamination.

1 Recycling

2 Market Outlook

3 **Recycling in Hydro**

The industry's most ambitious climate strategy: Carbon-neutral by 2020

Supported by the three pillars of Hydro's technology strategy

Energy and primary production

Reduce emissions, increase efficiency

Aluminium in use

Maximize user-phase benefits

'End-of-life'

Increase recycling, back to the loop

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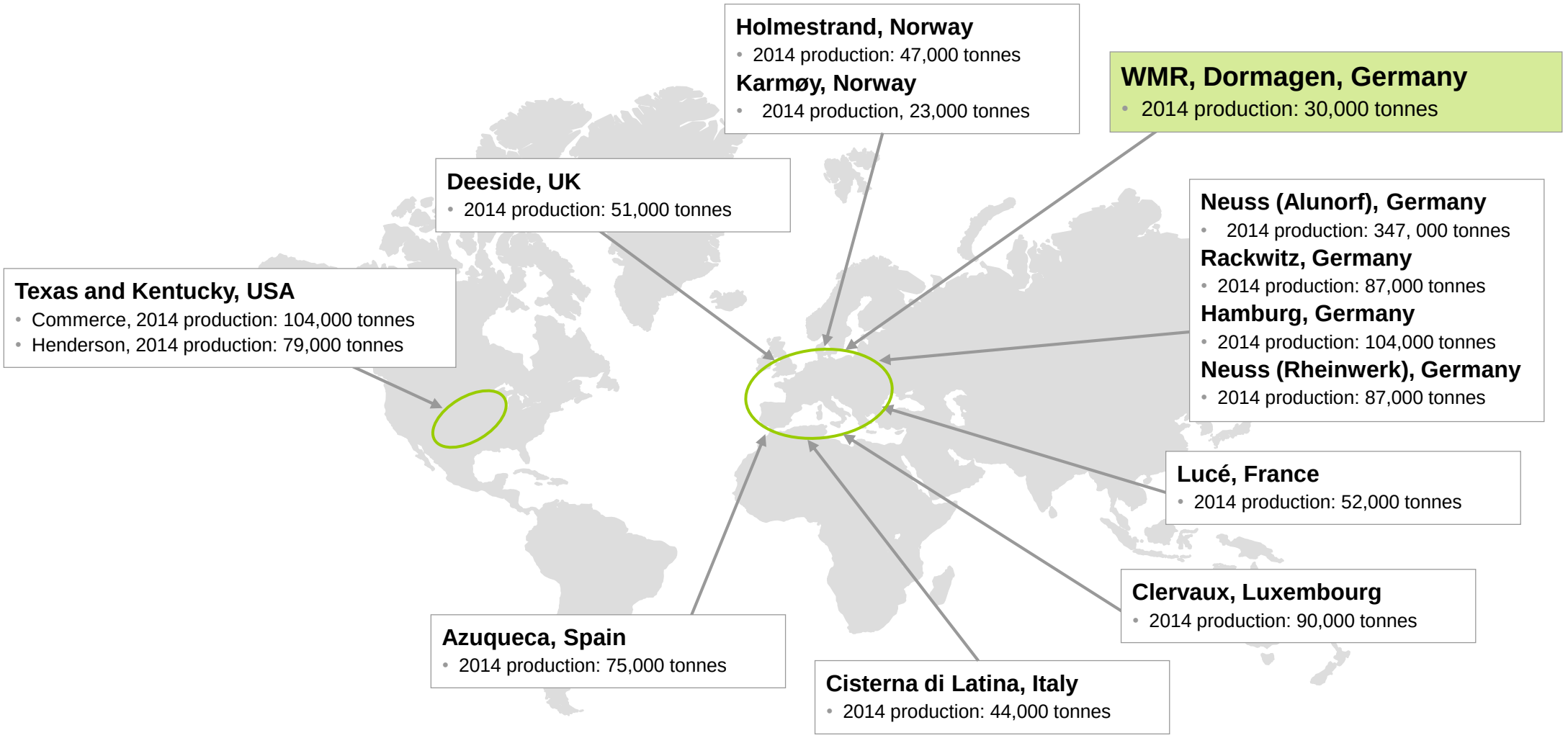
Hydro’s recycling facilities



Hydro has developed leading scrap capabilities the last years

Key elements in scrap procurement and handling

Material Flow Analysis
Scrap availability modelling based on dynamic stock analyses and growth scenarios

Hydro leading in state-of-the-art scrap flow model development

Scrap Receival & Sampling
Best practices for receival and sampling, supplier evaluation, chemistry and recovery database

Best practice sharing across plants on scrap receival and sampling

Tools

Scrap portal → System optimization long term → Charge optimization on batch level

Hydro in-house developed tools are differentiating elements

Technology

Scrap processing: Shredding, magn. & EC separation, X-ray sorting → Continuous delacquering & hot transfer → Furnace concept: Cont. feeding, submerged melting, electromagn. stirring

Leading competence in furnace operation

Significant scrap processing competence built last years

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Our Recycling Strategy – in short

✓ **Build on leading remelt capability to expand use of post consumed and lower priced scrap**

Enablers

- Access to processing capacity for post consumed and difficult scrap
- Increased sales of Recycling Friendly Alloys (RFA)

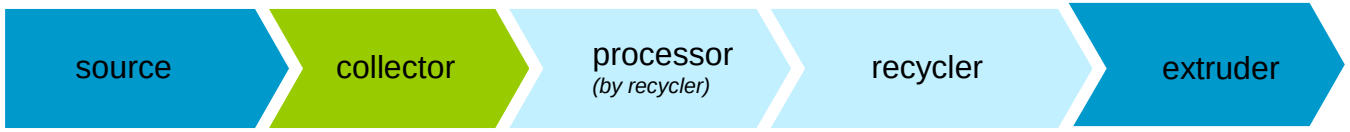
→ **Increased used of post consumed scrap** →

Strategic Objectives

- Better (improved margins)
- Bigger (increased capacity utilization)
- Greener (Recycling/RFA)

✓ **Establish cooperation models for scrap sourcing and processing, possibly with asset ownership**

Alt 4: Hydro investing in own processing capabilities



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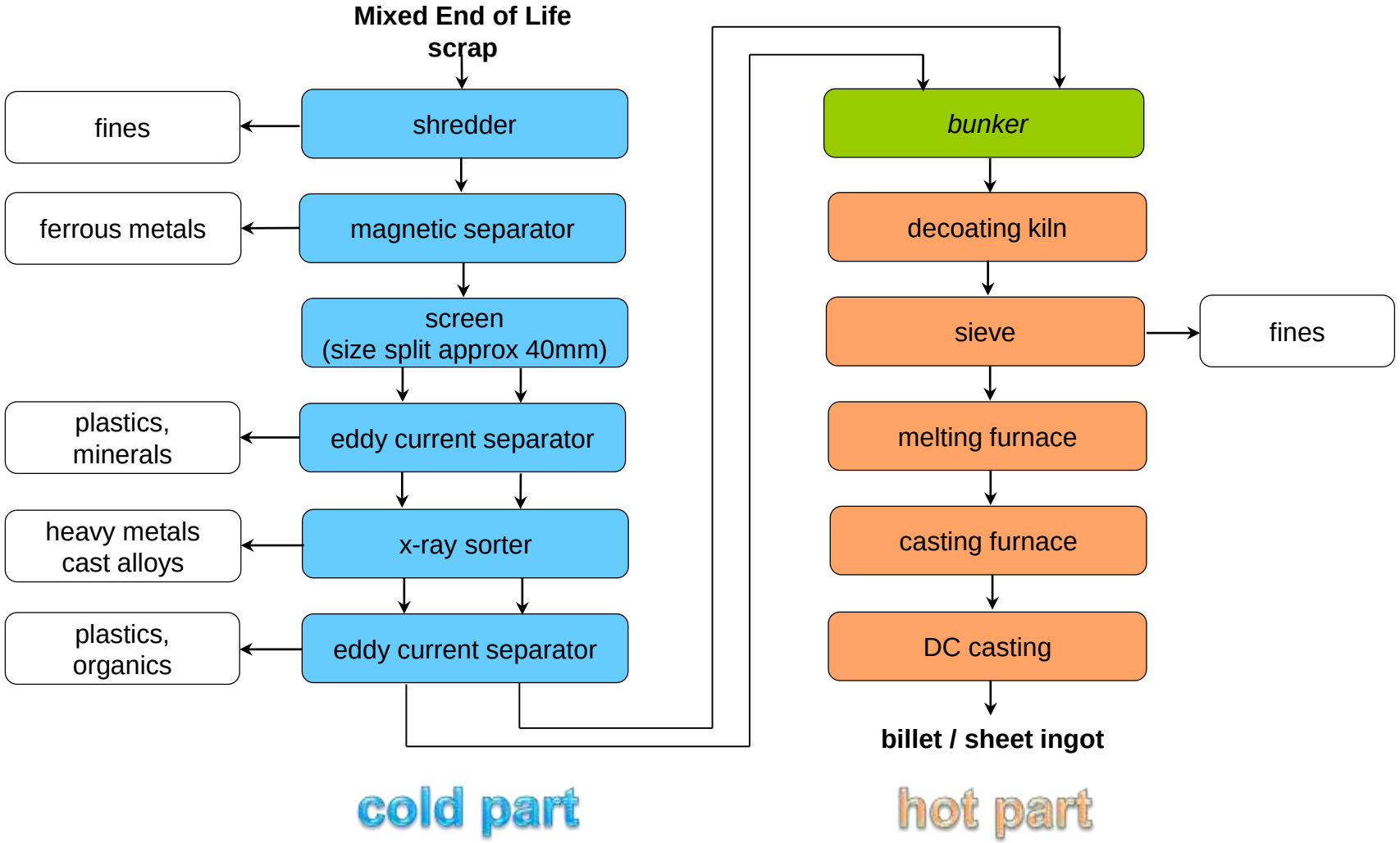
Flow-sheet post-consumed scrap recycling



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Strengthening of recycling position through UBC* recycling line

Establishing strong recycling position

- Fulfilling customer needs and strengthening beverage can market position
- € 45 million investment
- Start of production end 2015
- Contribution towards 2020 carbon neutrality target

* UBC: Used beverage can

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UBC shredder unit

Overview

Shredding the cans for optimal sorting

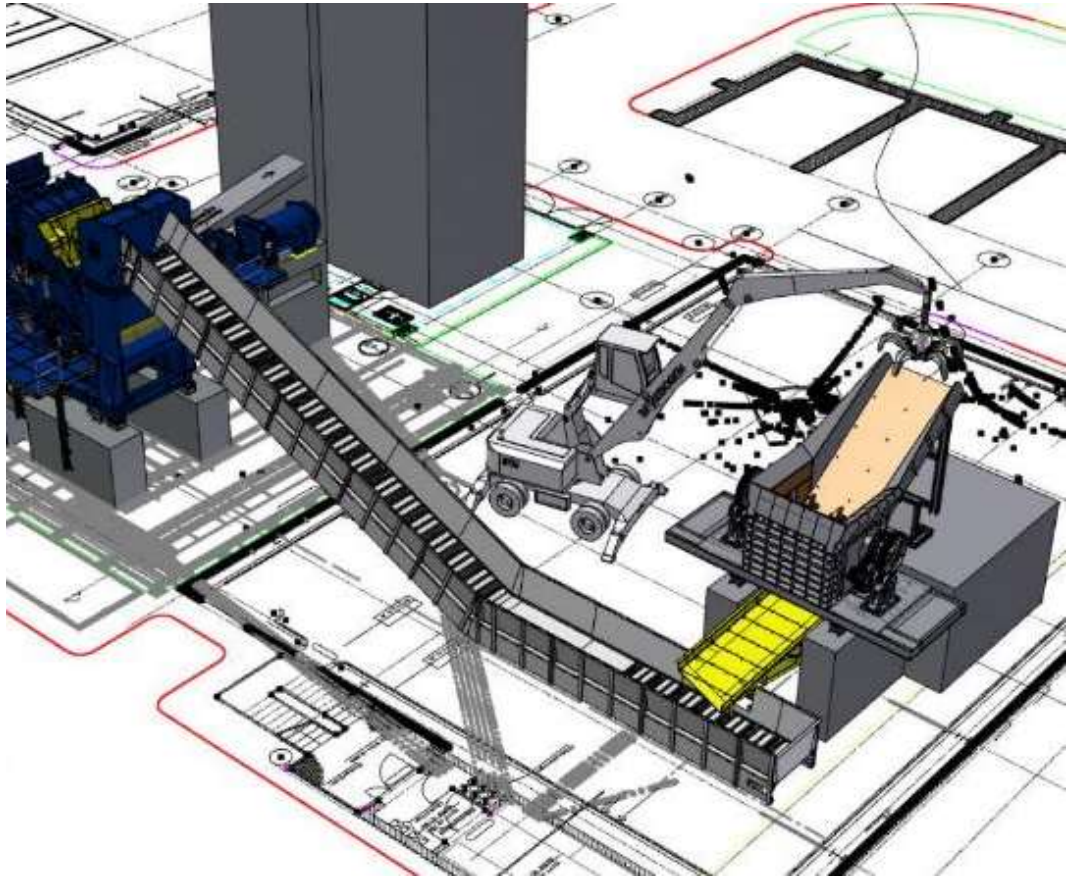
- contamination such as "plastic widgets" in special beer cans must be exposed by the shredding (Guinness / bitter beer)

Shredding the cans for optimal delacquering

- both sides of the aluminium can (inside / outside) must be open
- target grain size: 50mm

Technical challenge

- scrap composition
- shape and density of scrap bales and packages



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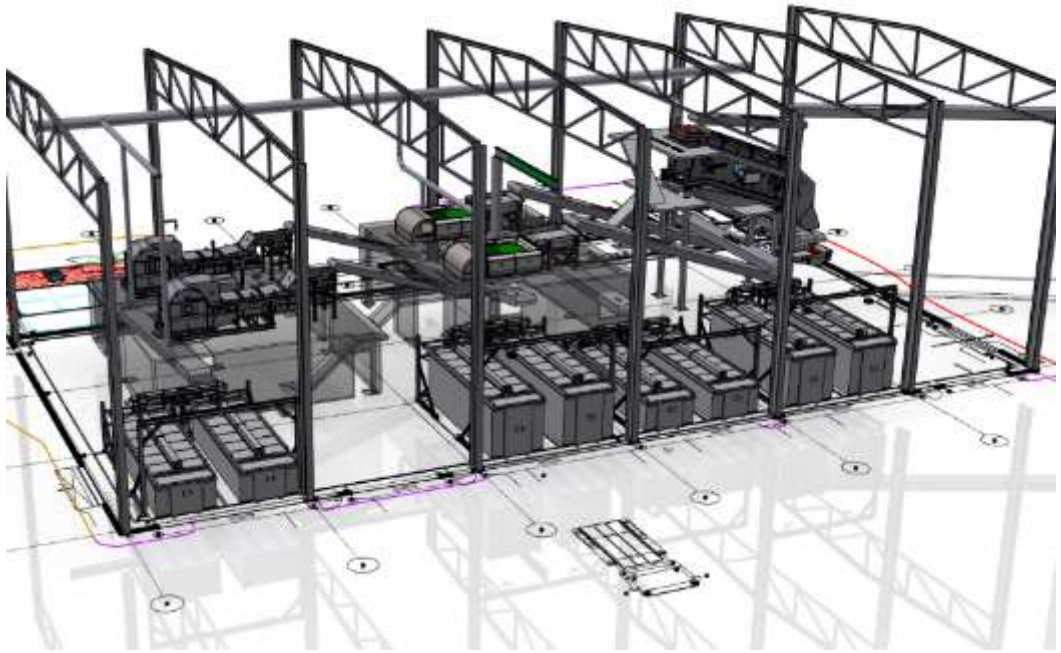
Bale braker and hammer mill

Sorting line, furnace and delaquering



Acquisition of WMR Recycling GmbH

Superior patented shredding & sorting technology

Two-stage scrap processing

Step 1:

- Scrap shear
- Hammer mill
- Magnetic & eddie-current-sorting, sieving
- Particle size 150 – 250 mm

Step 2:

- 2 parallel cutting mills
- X-ray transmission sorting
- eddie-current-sorting, sieving
- Particle size 30 – 80 mm

Throughput (extrusion & sheet scrap)

- 12 t/h input
- Particle weight 15 – 40 g
- Sorting of 1,000 particles per second

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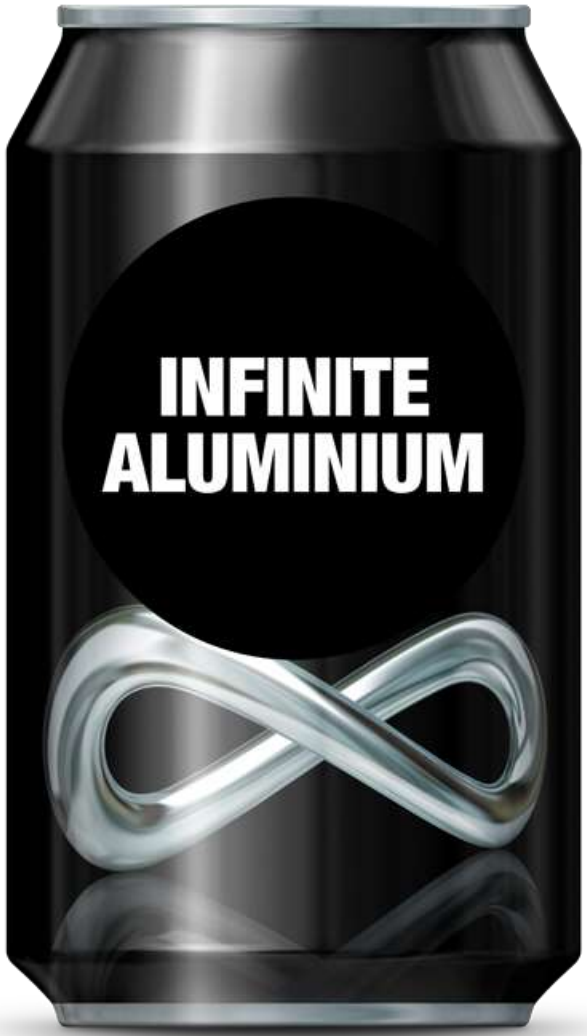

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