Enhanced circularity of ferrous and non-ferrous fractions present in low quality steel scrap grades by assisting recycling with sensor-based sorting in the steel industry

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Workshop. Implementation of sensors for scrap analysis
02.04.2025 (Online and at ESTEP in Brussels)

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Consortium
CRM (BE) – Coord.
AMMR (FR)
AMBCRC (ES)
AMBD (LU)
AMBe (BE)
AMF (FR)
AM Sestao (ES)
Rolanfer (FR)
Reydesa (ES)
Inatec (ES)
Azterlan (ES)
Tomra Sorting (DE)
KUL (BE)

GA 101058520

Duration
48 months
Starting in June 2022

Total budget = 8029 k€
Maximum Grant = 6295 k€

CRM Contact
JC.Pierret

https://caesarproject.eu/

Title: CirculArity Enhancements by Low quality Scrap Analysis and Refinement

Objectives:

- ✓ to identify new opportunities to use and reuse lower-quality scrap through a better comprehension of the scrap market and the opportunities provided by advanced characterization, sorting and cleaning technologies;
- ✓ to support the production of high-quality steel products in the **EAF** and the increase of scrap rate at the **converter**;
- ✓ to develop and implement an industrial demonstrator of scrap sorting/cleaning based on innovative combination of best available technologies.

This project deals with enhancement of post-consumer scrap and addresses in particular:

- Mapping of scrap market and assessment of grades being exported out of EU;
- Characterization of these scrap grades;
- Optimization of primary treatment (shredding, cleaning, magnetic separation, shearing) and advanced multi-step upgrading;
- Advanced sorting & on-line characterization (XRF, LIBS, vision & hyperspectral techn. + AI);
- Scrap volumen & density measurements technologies;
- Valorisation of residues: non-ferrous metals, carbonaceous material and mineral fraction;
- Industrial validation of quality improvement (BOF, EAF).

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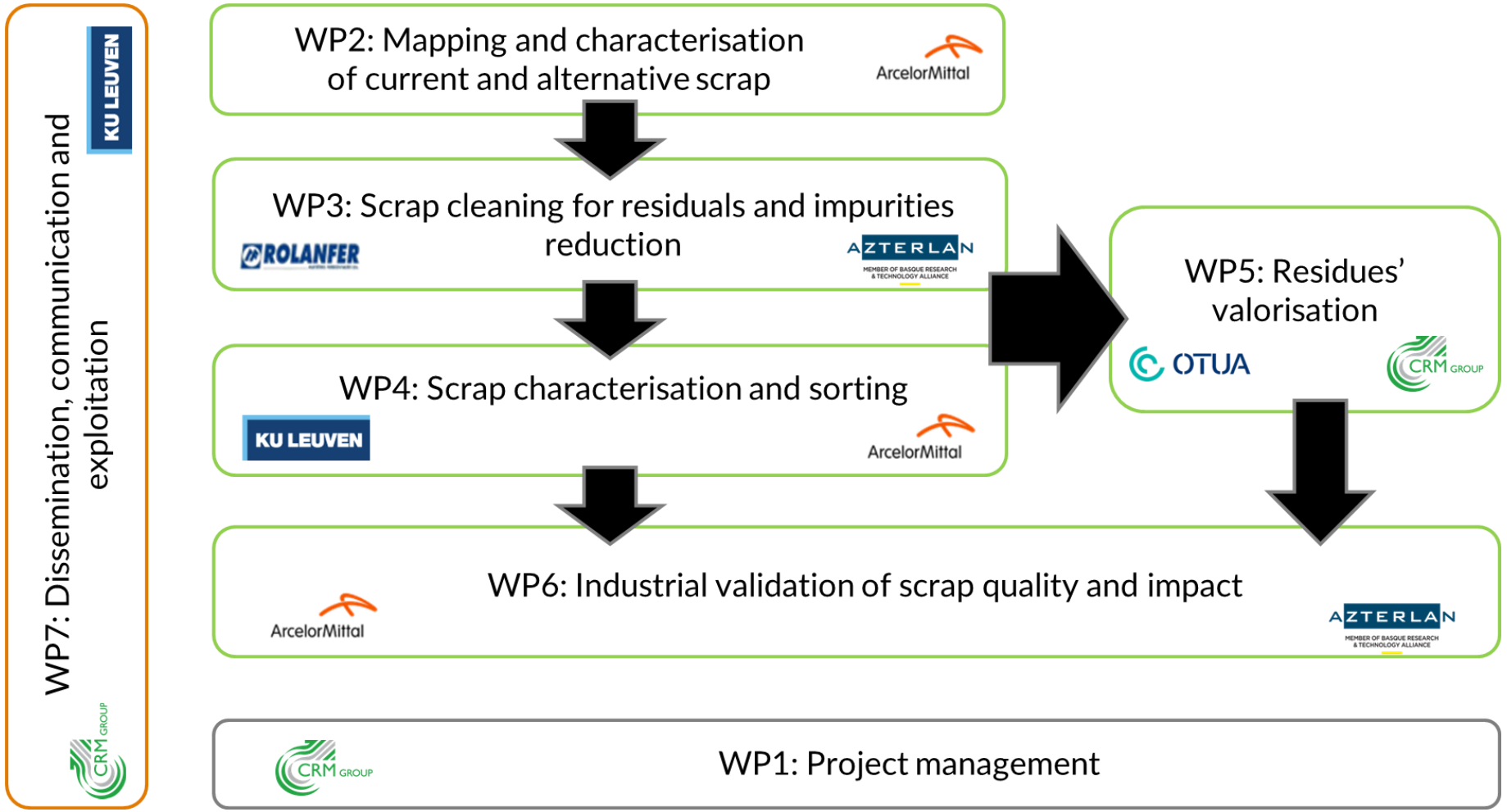

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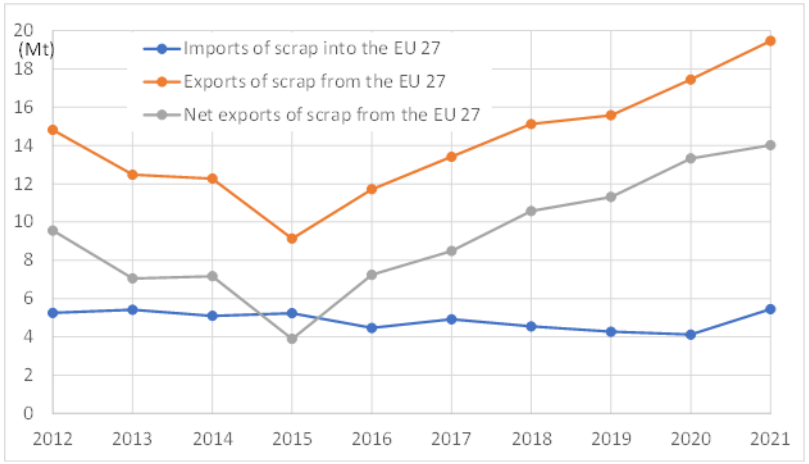
Mapping & characterization of current and alternative scrap

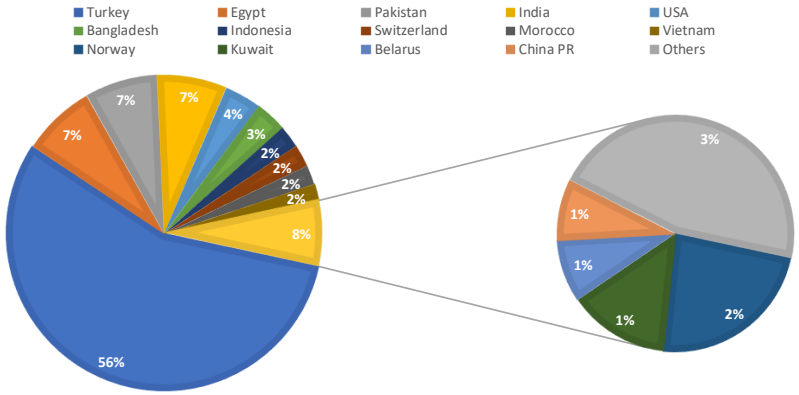


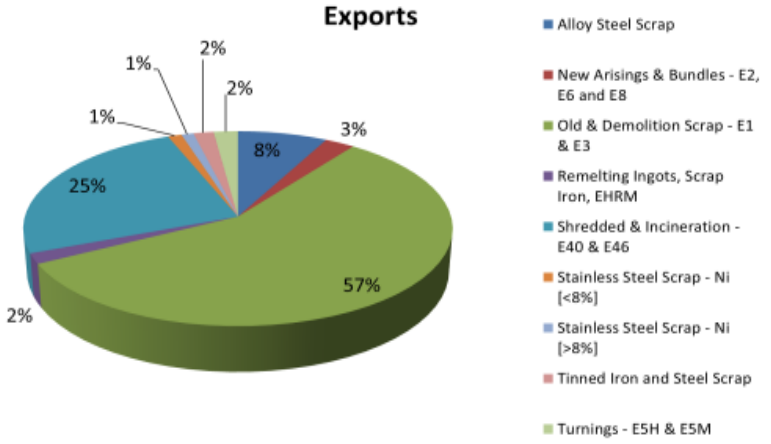
Scrap production > consumption
→ Europe is exporting scrap

Scrap imports in Europe remains at low level → EU 27 is net exporter

Phenomenon is increasing with time

Ferrous scrap is by far the first waste exported from the EU27





2021 (almost same ranking as in 2018):

- Turkey imported 2/3 of ferrous scrap leaving Europe

~20Mt scrap could be used in EU industry without import but:

<10% exported scrap is new scrap

>90% is post-consumer scrap of rather poor quality (major grades exported: E1 & E3)

➔ To be able to use such scrap grades to produce steel sheets, need to find technical solutions to **upgrade** them.

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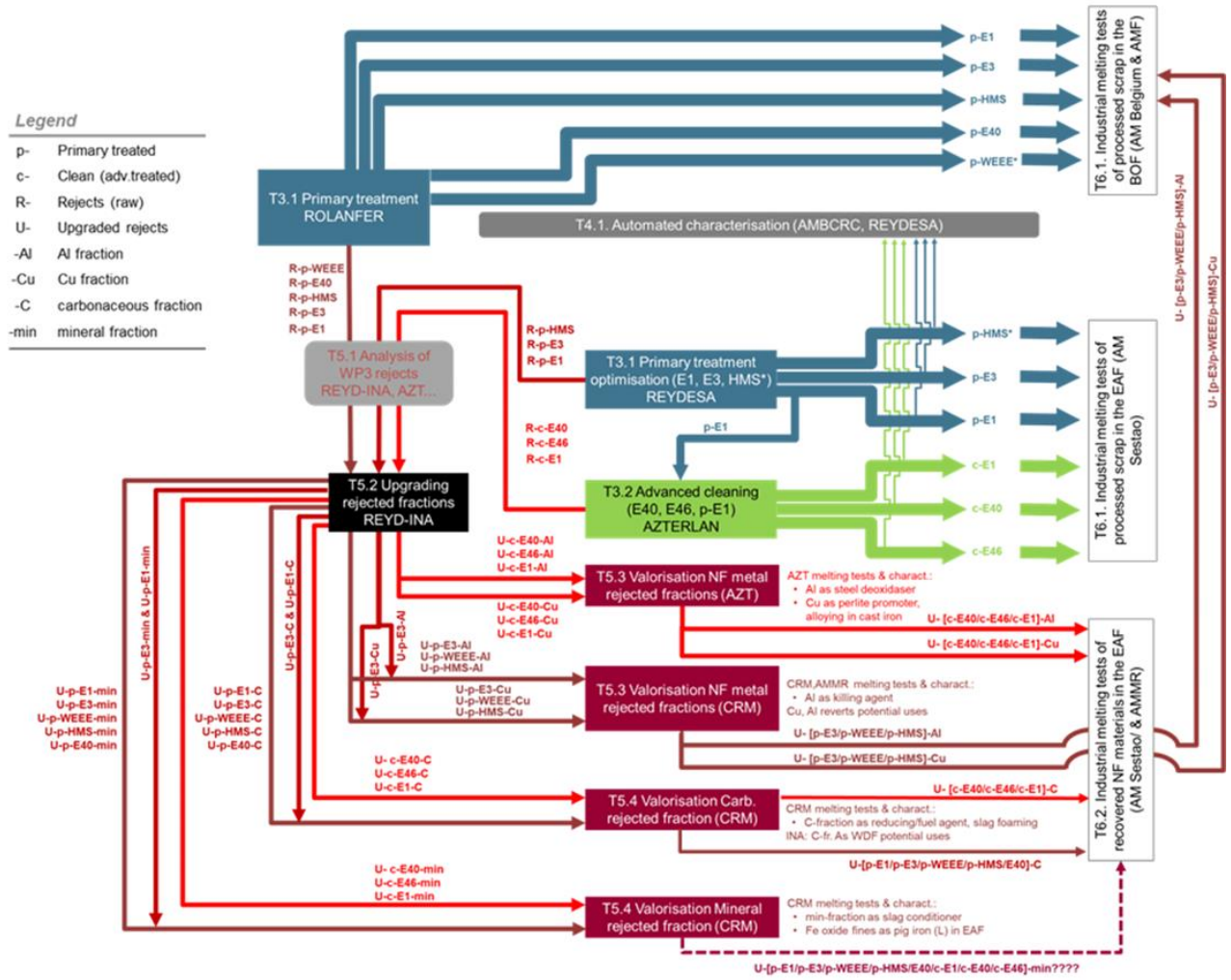
CAESAR ambition: upgrade ferrous scrap & valorise cleaning residues

Project aims

- ✓ to improve sorting of purely FE scrap
- ✓ to valorize all the treatment by-products:
  - Non-ferrous metals
  - Carbon bearer materials (plastics, wood…)
  - Mineral fraction

Work on the optimization of separation and purification steps

- ➢ **Sensor-based sorting**



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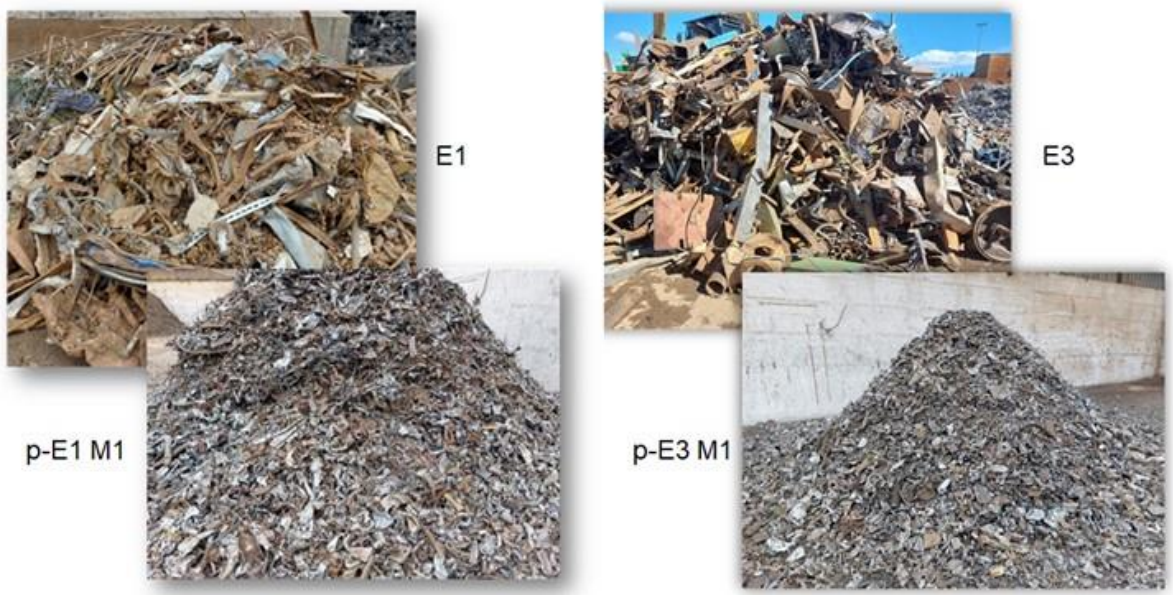
Selection and combination of BATs in multi-step processes for material upgrading (= cleaning, size control, density increasing) in recyclers plants: optimization of treatment sequence and machines settings specific to scrap grade characteristics.

Scrap grades investigated:

- ✓ Bulky scrap grades **E3, E1 (HMS)**
- ✓ Heterogeneous scrap grade **WEEE**
- ✓ Fragmentised scrap grades **E40**, **E46**
- ✓ Others: **ELV, E61** (packaging bundles)



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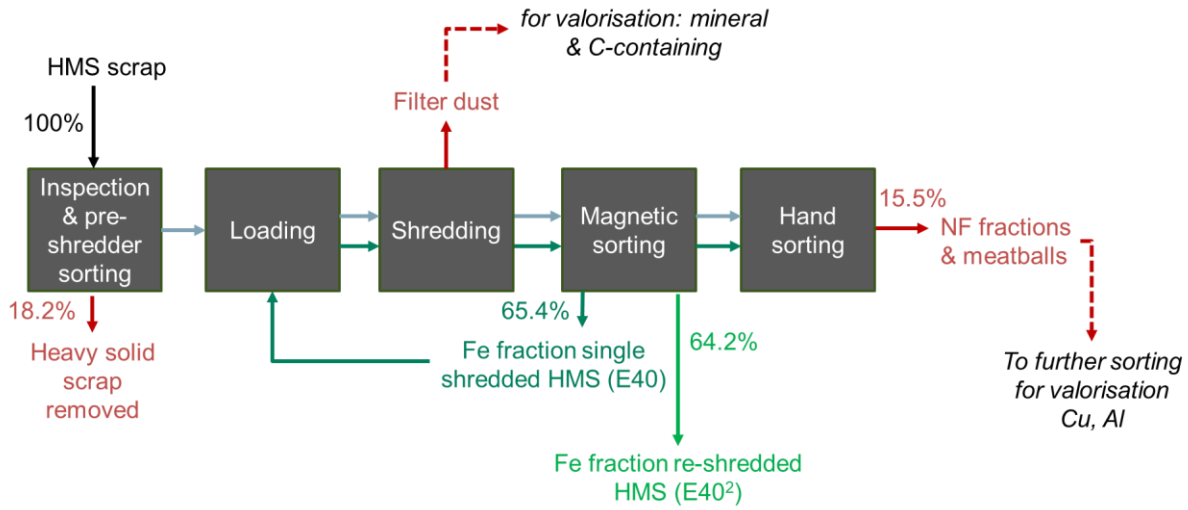
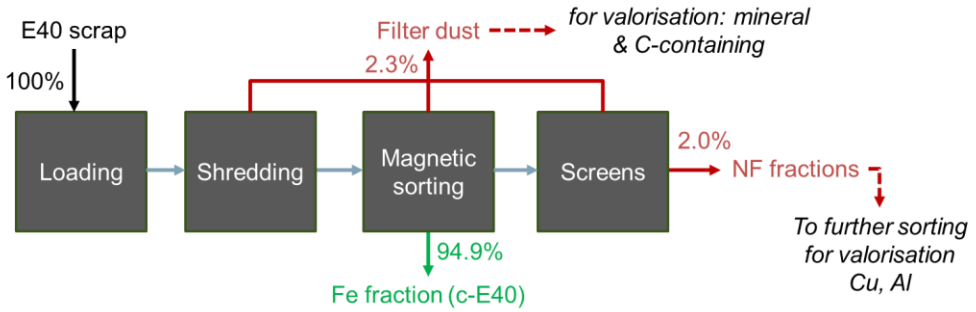
Primary treatment and sensor-based sorting. Case study: HMS – E40





	E40	c-E40 M1
bulk density, kg/m³	554.34	1369.35
scrap: non-adhering steriles, wt%	0.31	0.18
scrap: complex FE scrap with attached steriles, wt%	50.84	0.95
Cu content of scrap, wt%	0.453	0.135

HMS statistics: Fe 84.5% & Cu 0.38-0.43%

	p-HMS (E40)	c-HMS (E40²)
Bulk density of scrap, t/m³	1.3	1.4
Cu content of scrap, wt%	0.144	0.136
Σ(Cr,Ni,Mo) content of scrap, wt%	0.228	0.234
Upgrading efficiency	**Single shredding**	
increased content of iron in scrap	**+10.16%**	
Relative rise in bulk density	**+225%**	
Relative drop in residual Cu content in scrap	**from -55.3% to -66.5%**	
Cleaning efficiency	**Re-shredding**	
increased content of iron in scrap	**+0.72%**	
Relative rise in bulk density	**+7.8%**	
relative drop in residual Cu content in scrap	**-5.5%**	

TOMRA sorting tests to reduce the copper content of the typical E40 shredded steel scrap

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Evaluating XRT and RGB Technologies to cut Copper and Boost Steel Quality

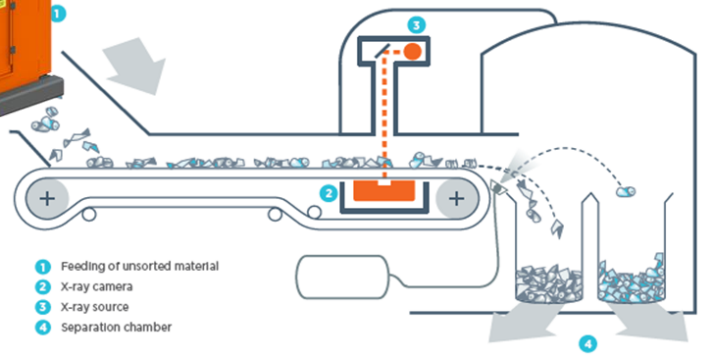
Initial Working task:

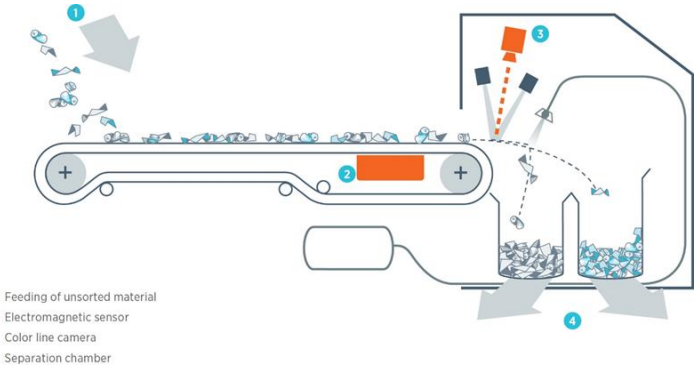
Evaluation of readily available sensor-based sorting technology to reduce copper content of E40 shredded steel scrap

Utilization of initially two different sensor technologies and sorting machines to establish ‘status quo’:

X-TRACT™ - X-Ray transmission technology differentiating material based on (atomic) density; combined with shape detection.

COMBISENSE™ - RGB (color) detection technology; combined with shape detection.





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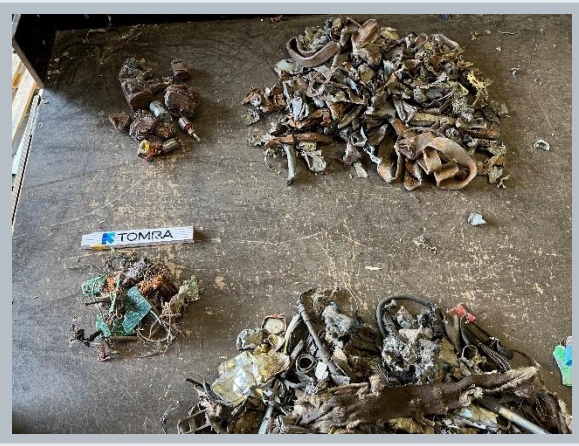
Initial sorting results achieved with X-TRACT™ on 31.5-120 mm

- Heavy pieces removed by their density
  - High recovery on copper and meatballs
  - Main impurities in steel: steel wires and cast iron

28.9 t/h

DROP (72.2 wt.-%)		
EJECT (27.8 wt.-%)		

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Video of X-TRACT™ - Output Streams

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X-TRACT™ sorting tests showed promising separation results

Throughput: 28.9 t/h

31.5-120 mm 276 kg	Copper reduced fraction		Copper rich fraction	
Total	**197.4 kg**	**71.5 wt%**	**78.6 kg**	**28.5 wt%**
Steel Sheets 200.1 kg	84%		16%	
Mechanical Parts 67.4 kg	41%		59%	
Fragments with Copper 6.6 kg	18%		82%	
Sterile 1.43 kg	33%		67%	
Non-Ferrous Metals 0.5 kg	8%		92%	

Throughput: 12.9 t/h

8-31.5 mm 112 kg	Copper reduced fraction		Copper rich fraction	
Total	**32.3 kg**	**71.2 wt%**	**79.7 kg**	**28.8 wt%**
Steel Sheets 33 kg	80%		20%	
Mechanical Parts 76.4 kg	8%		92%	
Fragments with Copper 1.7 kg	10%		90%	
Sterile 0.9 kg	16%		84%	

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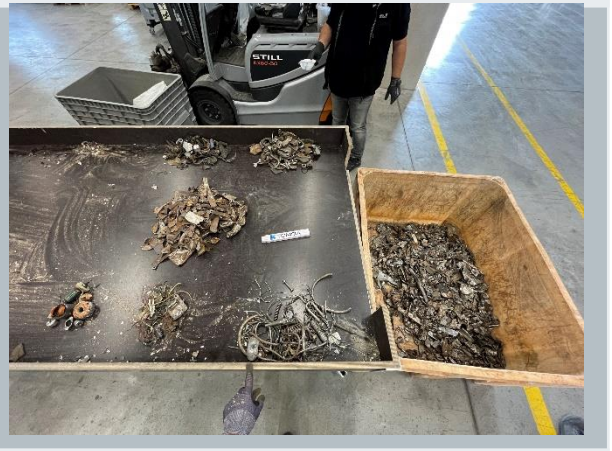
Initial sorting results achieved with COMBISENSE™ on 31.5-120 mm

- Copper removal by colour
  - High losses of steel due to corrosion
  - Higher recovery of meatballs due to shape recognition
  - Rods and wires were well recovered

17.0 t/h

DROP (41.5 wt%)		
EJECT (58.5 wt%)		

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COMBISENSE™ sorting tests showed promising separation results

Throughput: 17 t/h

31.5-120 mm 150 kg	Copper reduced fraction		Copper rich fraction	
Total	**89.3 kg**	**59.4 wt%**	**61.1 kg**	**40.6 wt%**
Steel Sheets 108.7 kg	67.3%		32.7%	
Mechanical Parts 32.2 kg	47.6%		52.4%	
Fragments with Copper 9.18 kg	5.6%		94.4%	
Steriles 0.25 kg	100%		0%	

Throughput: 10.3 t/h

8-31.5 mm 90.6 kg	Copper reduced fraction		Copper rich fraction	
Total	**48.7 kg**	**54 wt%**	**41.8 kg**	**46 wt%**
Steel Sheets 37.3 kg	73.4%		26.6%	
Mechanical Parts 50.4 kg	27.3%		72.7%	
Fragments with Copper 2.2 kg	15.5%		84.5%	
Steriles 0.7 kg	47.0%		53.0%	

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Melting Tests performed by ArcelorMittal Maizières Research SA:

300 kg Induction Furnace

	X-TRACT™		COMBISENSE™	
	31.5-120 mm	8-31.5 mm	31.5-120 mm	8-31.5 mm
Initial (Input) Copper Content, total sample	**0.63%**	**0.73%**	**1.02%**	**0.97%**
Copper reduced Fraction	0.24%	0.30%	0.23%	0.51%
Copper rich fraction	1.57%	0.91%	2.20%	1.38%

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Conclusions:

- X-TRACT™ and COMBISENSE™ sorting technology can detect and remove copper bearing materials reliably
- Grain Size is important and screening of input material is required.
- Required Cu-content of below 0.25% is possible at a high, reliable t/h base for coarser grain size material.
- Significant Cu-reduction can be achieved reliably even on small size material; but with a reduction in t/h and also in achievable copper content in the finished scrap product

Outlook

- Within the project, further evaluation of XRT and RGB technology will follow
- There is a need reduce copper content in scrap below currently achieved values; there for further detection technologies from TOMRA's portfolio and currently under development will be investigated and tested.

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Thanks for your attention

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