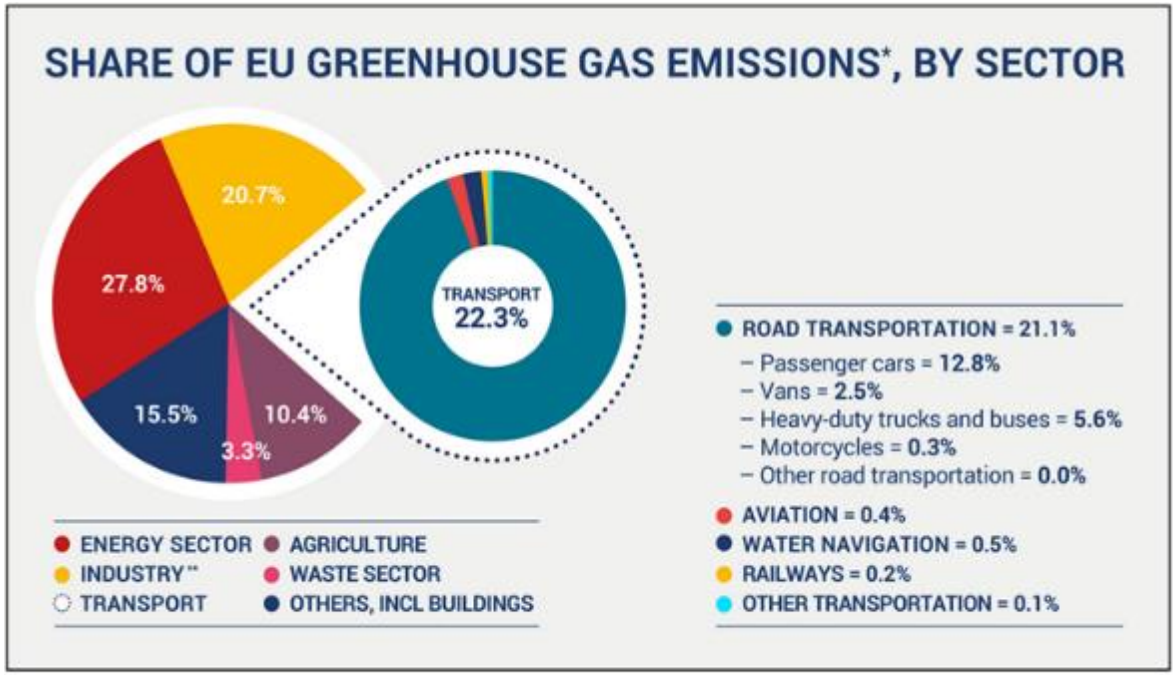
Scrap for Decarbonized Steels

GDR Prométhée

Global Research and Development
6/06/2025 – ISEA Metz
Ph. RUSSO

The iron and steel industry is an important emitter of $C0_2$



* All CO_2 equivalent
** Industry = 'Manufacturing industries and construction' + 'Industrial processes and product use'
Source: European Environment Agency (EEA)

- Globally, 7 to 8 % are due to the Iron & Steel industry
- The emissions of all the other sectors will decrease (electrification of transportation, building insulation, development of renewable energies,…)
- => Emissions from industry and particularly from the steel industry must also decrease if we hope to limit climate change

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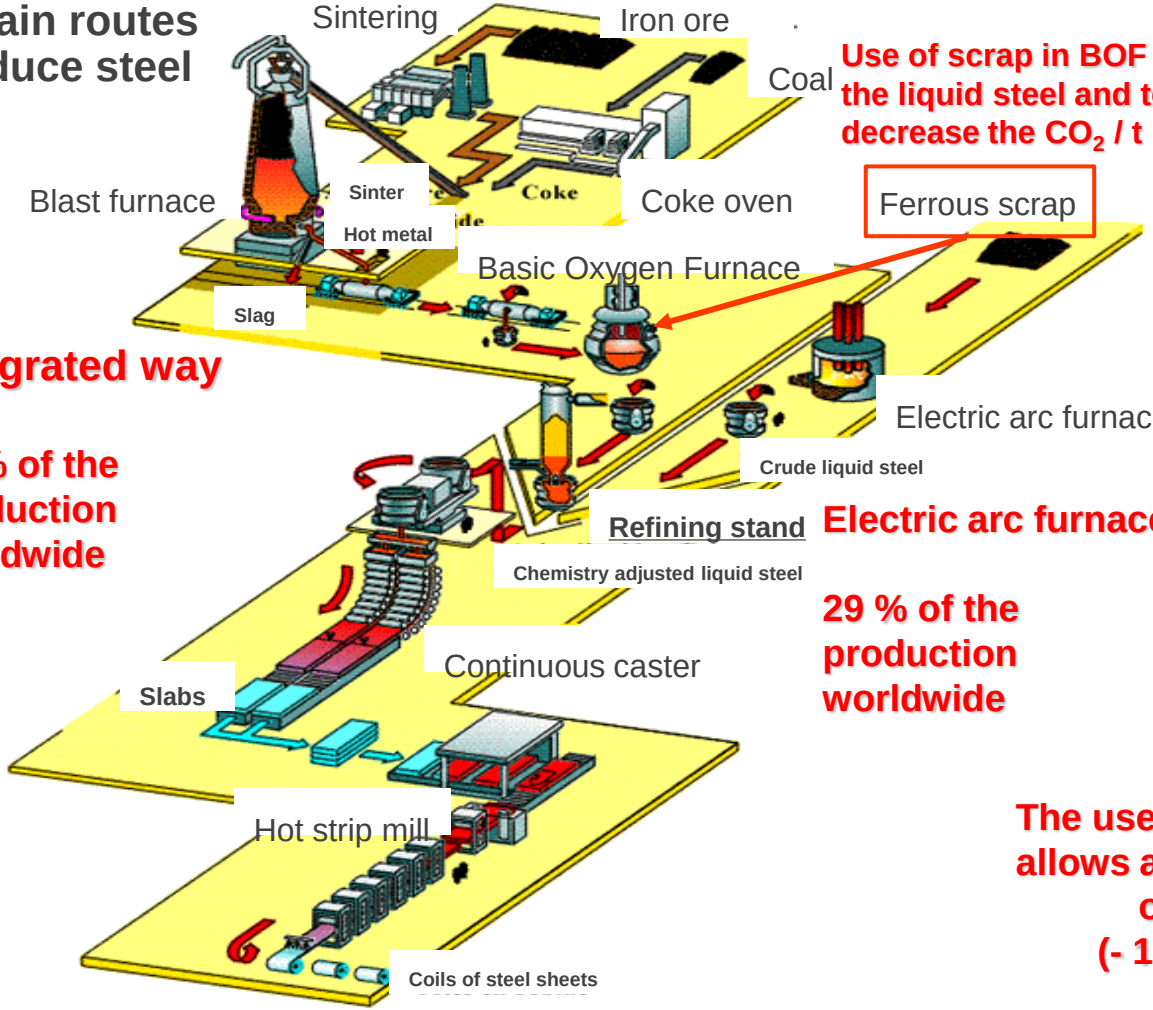
Two main routes to produce steel



Integrated way

71 % of the production worldwide

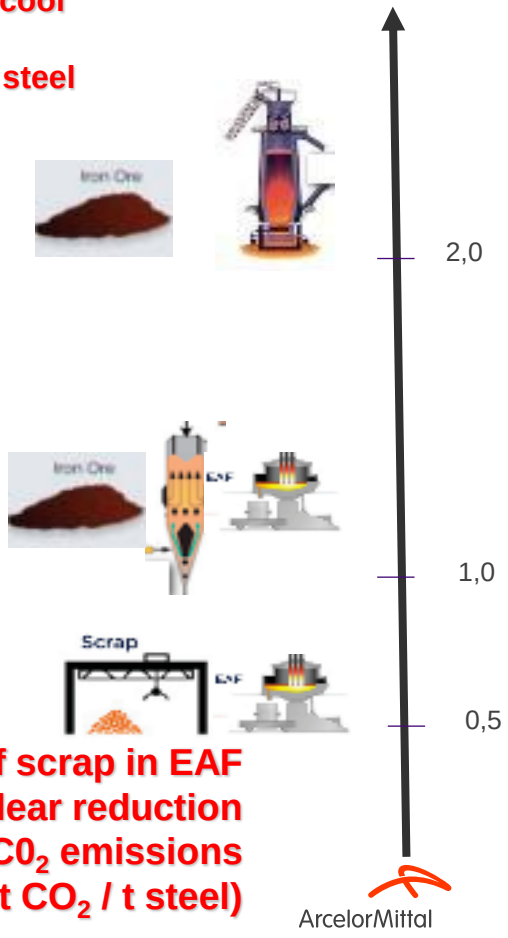
Use of scrap in BOF to cool the liquid steel and to decrease the CO_2 / t liq steel

Electric arc furnace

29 % of the production worldwide

The use of scrap in EAF allows a clear reduction of $C0_2$ emissions (- 1.5 t CO_2 / t steel)

Fe sourcing
CO2 t/t liquid steel



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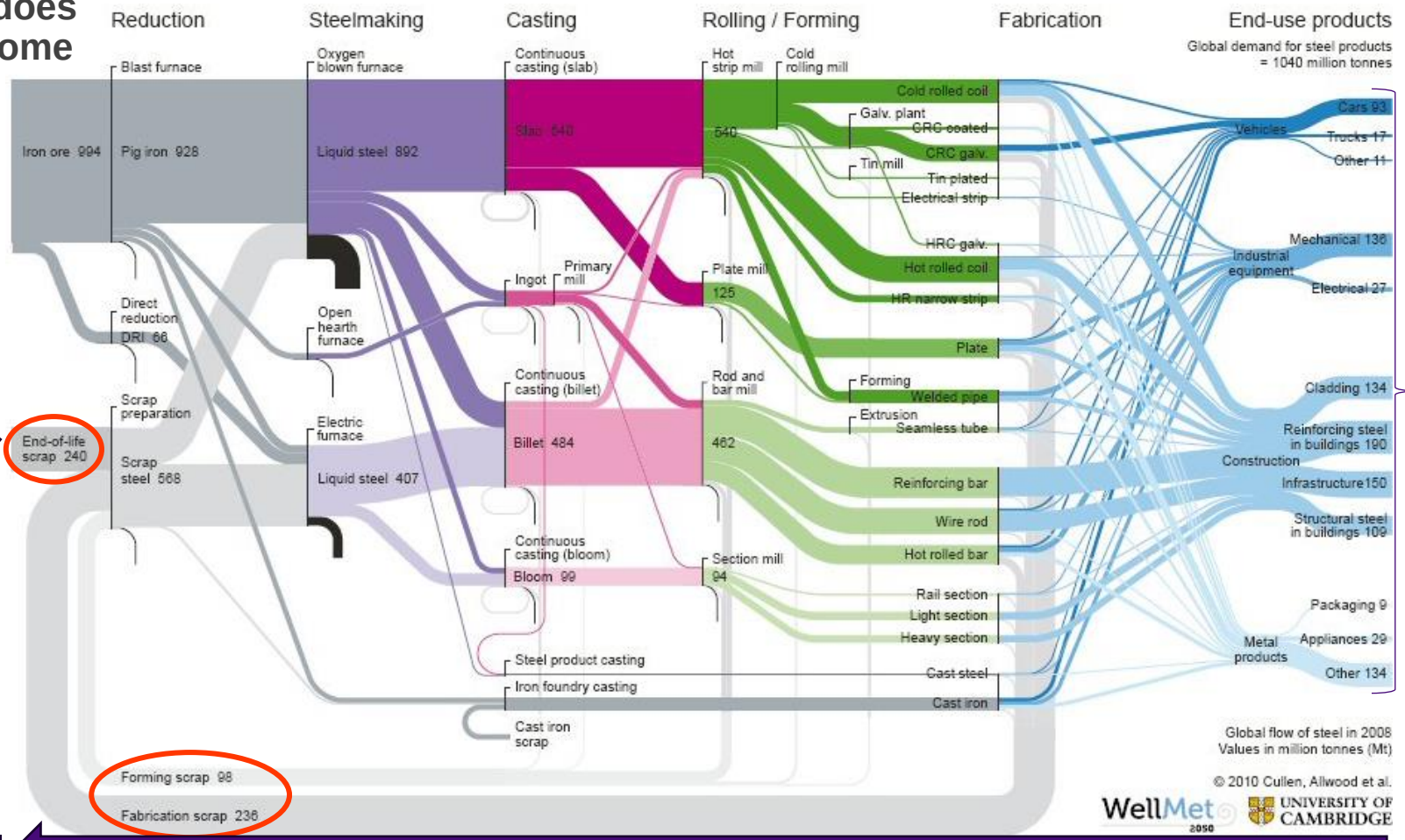
Where does scrap come from?



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Where does ferrous scrap consumed in our sites come from?

- In 2024 **ArcelorMittal bought roughly 7 Mt of scrap** for its European sites and this consumption should grow to decarbonize our steels.(Xcarb)
- Two main origins of ferrous scrap
  - **New scrap** (pre-consumer scrap) which are internal scrap or transformation scrap from our customers
  - **Old scrap** (post-consumer scrap) which are ferrous scrap from end of life of capital goods containing ferrous products

Internal scrap which come whether from blast furnaces (beach iron)

Whether from rolling mills: strip ends or edges

Whether from steel mills (electric or converters) :
ladle bottoms, tundish bottoms, steel recovered from slag,…

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Where does ferrous scrap consumed in our sites come from?

- From the transformation of our products by our customers

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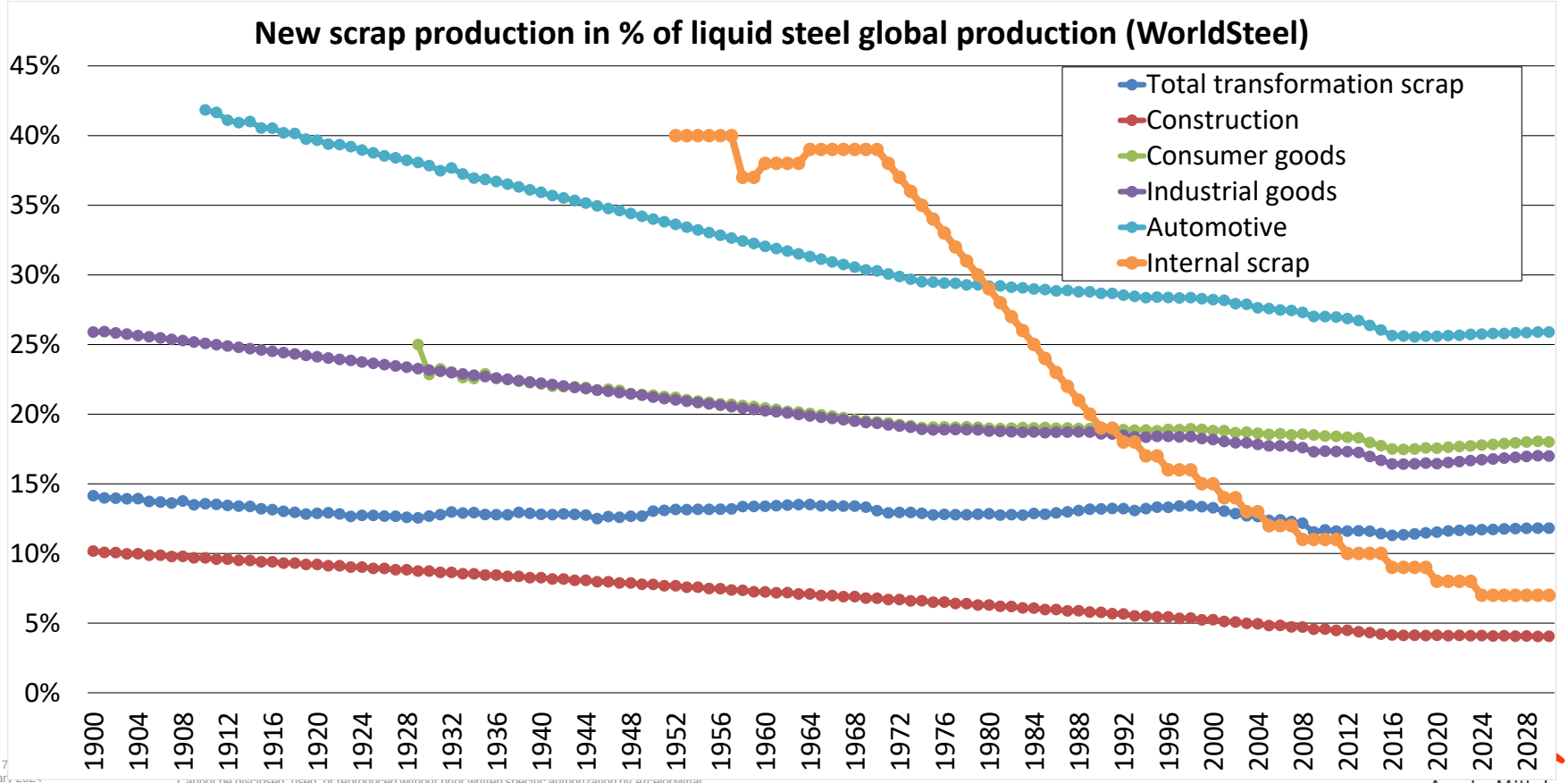
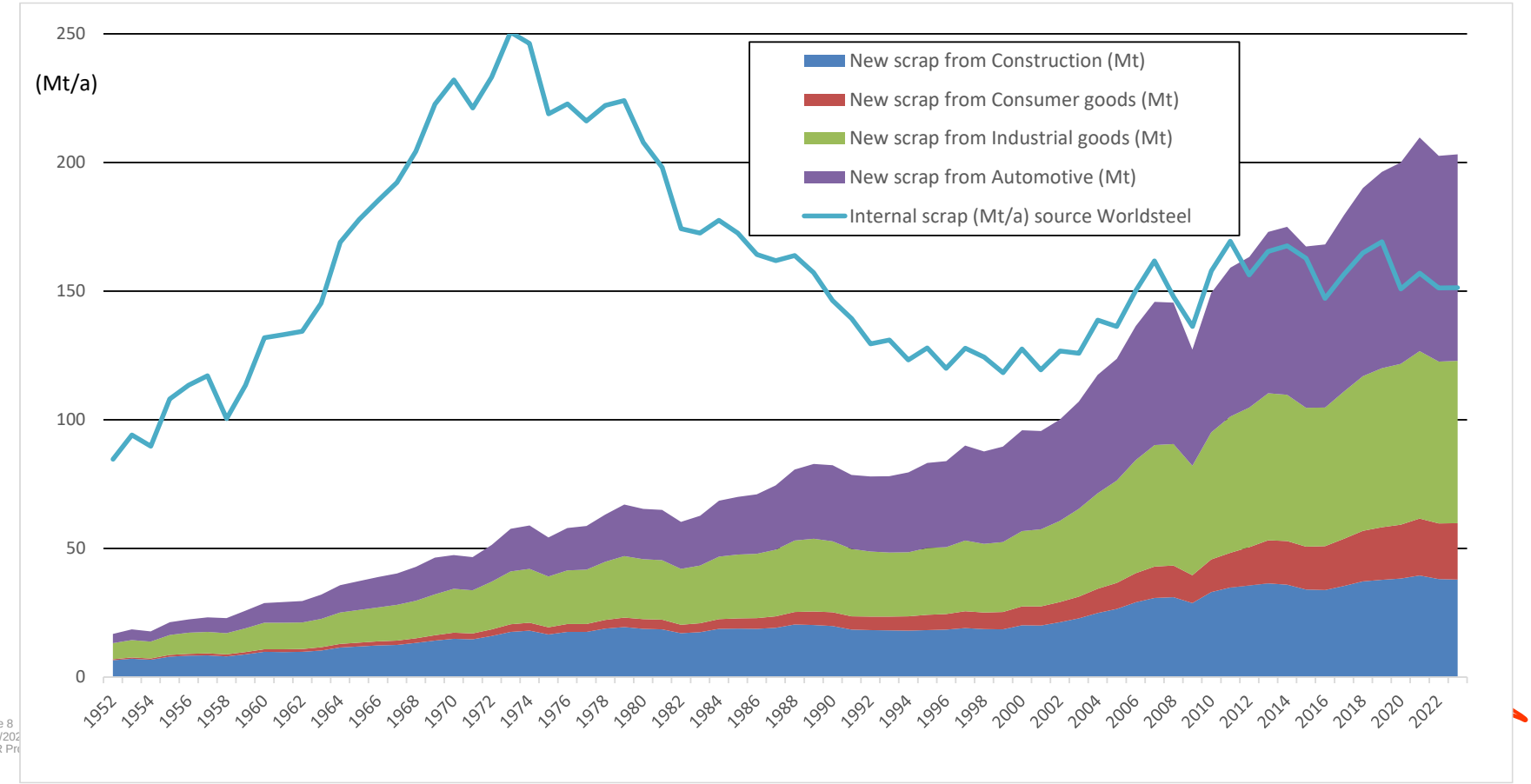
According to Worldsteel, the global steel production yield and the transformation yield are improving with time



Nevertheless, due to the increase of the global steel production, the quantity of new scrap produced by our clients is increasing and the quantity of scrap produced internally is rather stable for the last 35 years, according to Worldsteel



Where does ferrous scrap consumed in our sites come from?
From the scrap collectors: in Europe, pyramidal structure
(source BIR & EFR)

- 7 companies provide 40% of the ferrous scrap consumed in Europe.
- 45.000 dealer's scrap yards in Europe:

- Small size companies are selling to larger ones
- The steel industry is generally only buying to larger ones.

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Ferrous scrap preparation: torch cutting

- Necessary to avoid long pieces which could not enter the furnace and to increase the bulk density of the scrap
- Treatment cost: 45 to 55 €/t (according to “Recyclage Récupération”)

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Ferrous scrap preparation:

Compressing shear

- **reduces the size of the scrap pieces, increases the bulk density and can allow downstream sorting**
- **Various types :**
  - **Fixed or movable**
  - **With pre-compression or without but slopes…**

Treatment cost: 25 to 35 €/t, according to the shear type and the goods processed (according to “Recyclage Récupération”)

The quality of the sheared scrap is very variable depending on the goods sheared, the shear type used, the cutting length and the sorting tools downstream if any.

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Ferrous scrap preparation

The Shredder

Shredding cost: around 80 €/t including

- Investment/depreciation
- Working costs
- Landfilling of the shredder residues

(according to “Recyclage Récupération”)

Post-consumer ferrous scrap consumption worldwide

- Until 2017, the BIR (Bureau International du Recyclage) published the quantities of post-consumer scrap consumed yearly by steelmakers and cast-iron but this publication stopped due to uncertainties of the data coming from Asia.
- To verify the BIR data and to estimate the obsolete scrap consumption worldwide after 2017 we developed a model based on Worldsteel data and personal assumptions about lifespan averages of the products containing steel and about collection rates.
- The main iron losses of the construction domain is due to oxidation while usage and the non-recovery of foundation's steel the sheet piles, and part of rebars…

2017	Lifespan (assumpt.)	Production reference year (assumpt.)	Crude Steel production of the refence year (Worldsteel)	Global yield loss rate for crude & finished steel production of the reference year (Worldsteel)	Domains share of the reference year (Worldsteel)	Prompt scrap per domain at the reference year (Worldsteel)	Steel used per domain in the reference year (Worldsteel)	Collection rates in 2017 (assumpt.)	Obsolete scrap in 2017 per domain origin
Major domains of steel use	years		Mt	%	%	%	Mt	%	Mt
Vehicles	20	1997	799	16	19	28	91,8	95	87,2
Industrial equipments	35	1982	646	27	24	19	91,7	97	88,9
Construction	45	1972	630	37	60	7	221,5	75	166,1
Packaging Appliances Others	20	1997	799	16	5	19	27,2	90	24,5
Cast iron goods	35	1982	54	*10*		*10*	43,4	97	42,1
Total or average	35	1982					475,5	86	408,8

- Results induced by this model: Estimation of the average rate of steel recycling at the global level (86% in 2017 and 93% globally with new scrap) and average lifespan of consumer goods containing iron (35 years)

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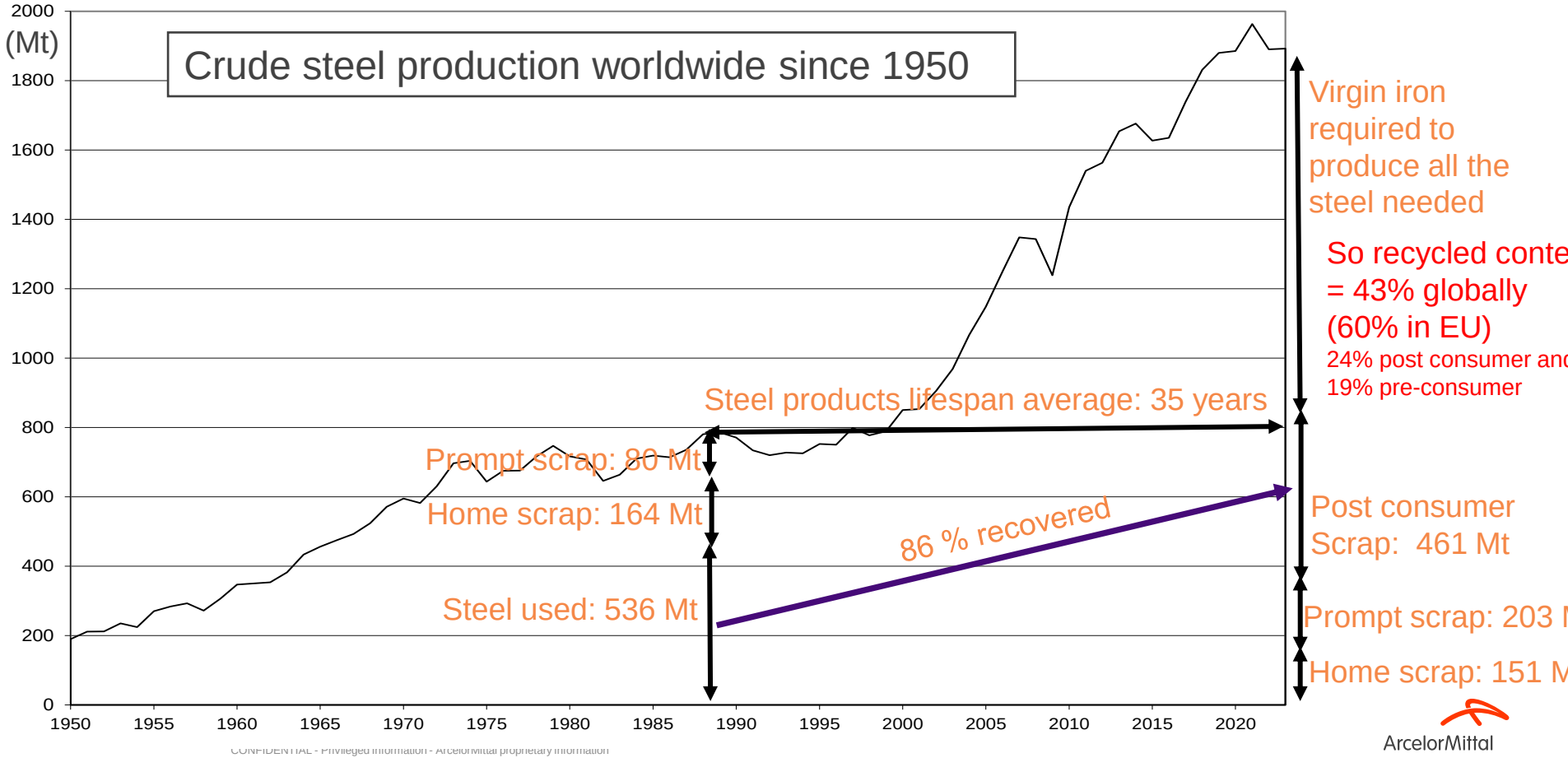
But we will continue to use some virgin iron because although steel is the most recycled material (93% Worldwide) there is a lack of scrap



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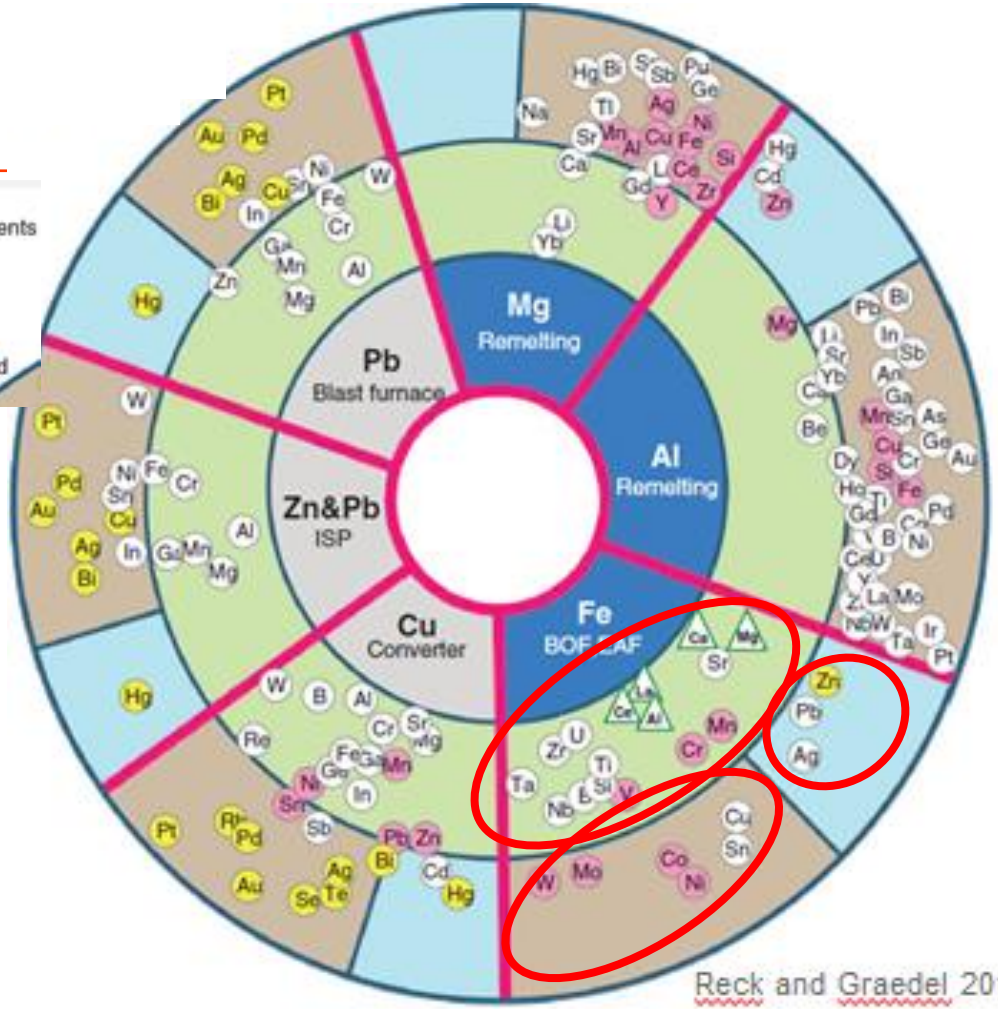
And we need “clean” scrap

Recoverable element (as pure metal) Alloying element Deoxidation agents

To metal phase
Elements that have distributed among the metal phase as a solid or liquid metal

To slag phase
Elements that have distributed among the slag phase as oxide

To gas phase
Elements that have evaporated and distributed among the gas phase



When we melt ferrous scrap, other elements than iron are going

- In fumes (environnemental impact)
- In slag (process impact)
- Or remain in liquid steel (metallurgical impact)

Reck and Graedel 2012

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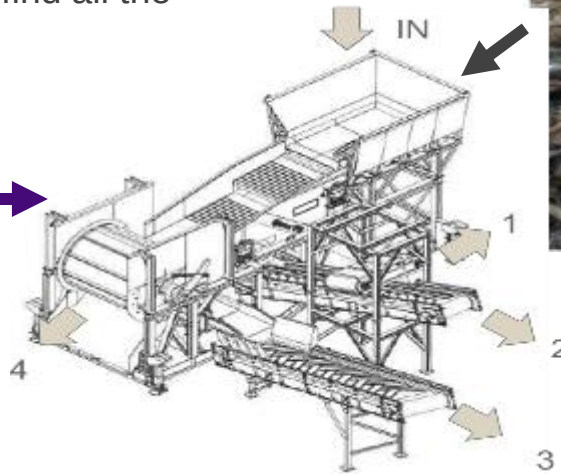
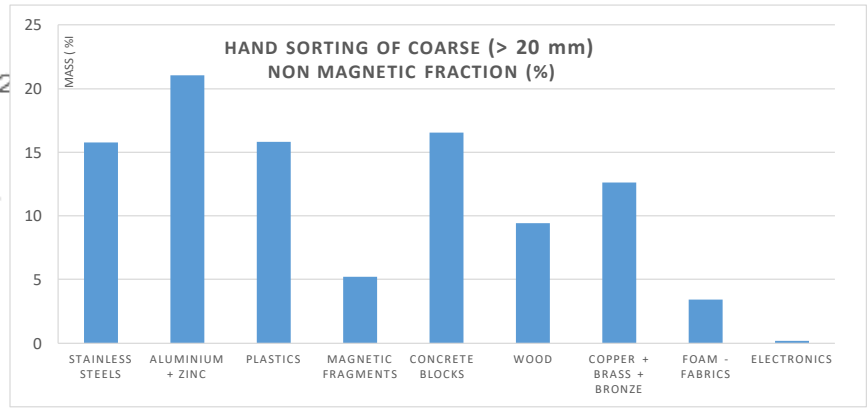
How to get clean scrap?

- Select suppliers capable to deliver the high quality scrap required
- But presently we cannot find all the good quality we need so

ArcelorMittal invested in Cleaning Machines to remove the non-magnetic materials from low quality scrap such as post consumer sheared scrap





A lot of nonferrous metals in the nonmagnetic fraction, but also plastics, concrete and wood

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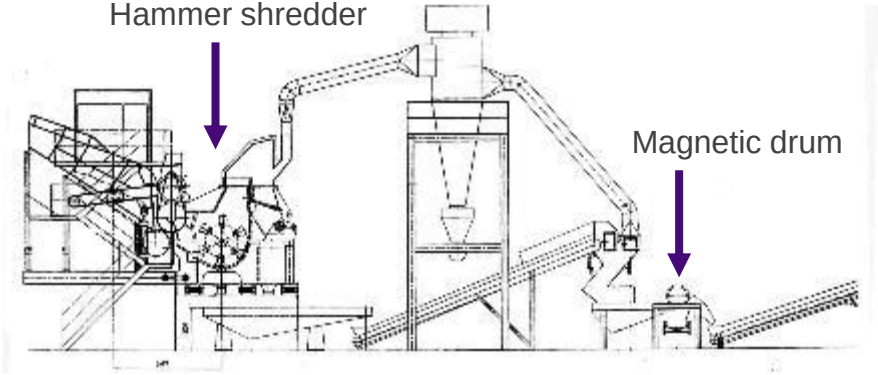
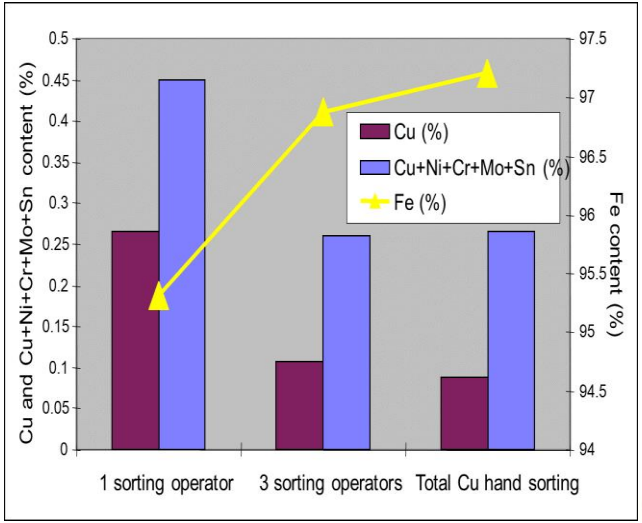
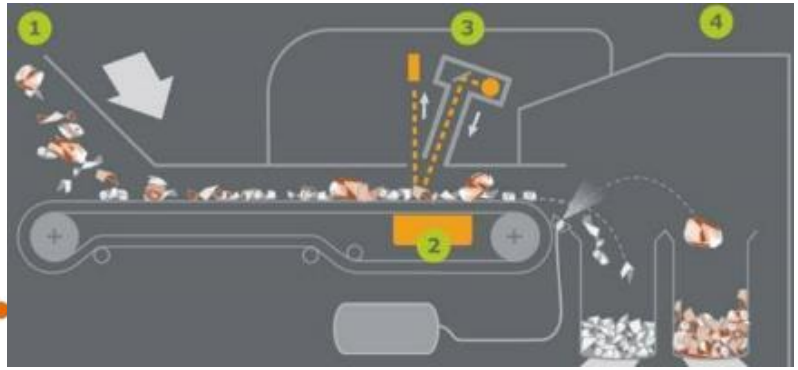
Shredding and sorting to decrease sterile & Cu content in ELV scrap

- Shred goods to obtain small size fragments that improves bulk density and liberates the different materials that can be sorted with a magnet
- For mix fragments: hand picking and sorting tools







1 feeding
2 Electromagnetic detector
3 X ray source and detectors
4 ejection area by air blowing

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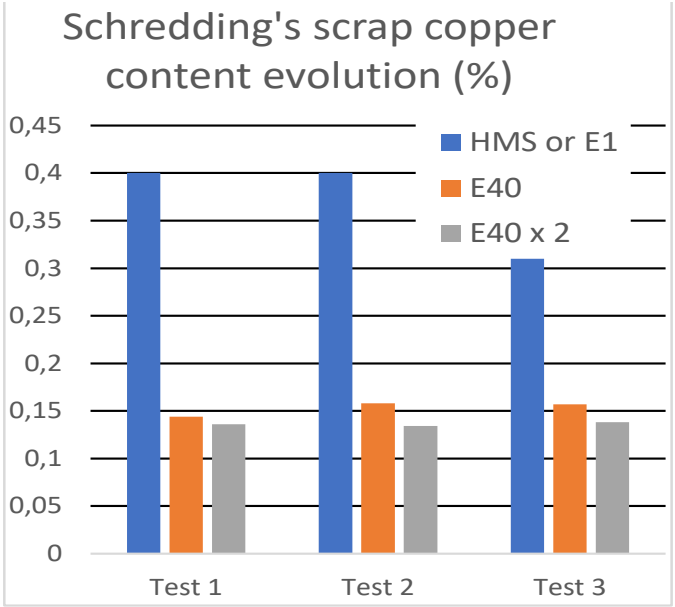
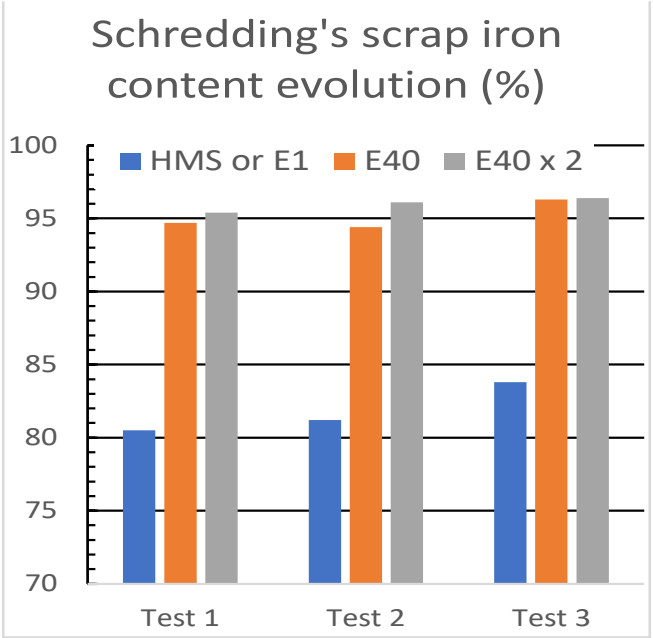
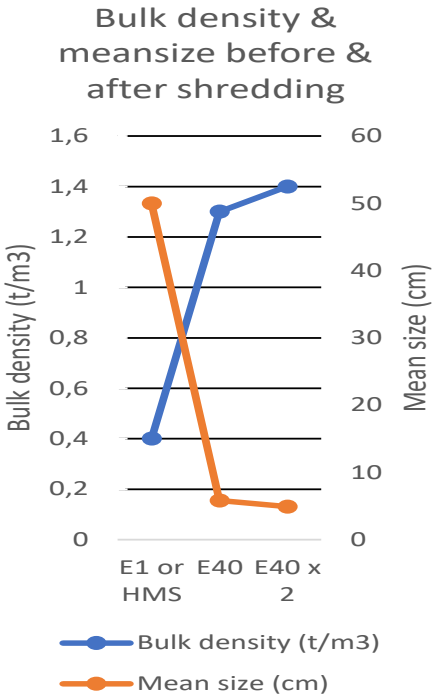
Shredding and double shredding (E40 x 2) trials have been done on low quality scrap (HMS or E1) in the framework of a European project (CAESAR)

- Three trial campaigns were performed with scrap grades HMS or E1 from Benelux (Test 1), Germany (Test 2) and South of France (Test 3) to measure the quality improvement
- After a single shredding, the scrap obtained (E40) had a lower Cu content, a higher iron content and bulk density than the initial scrap grades (HMS or E1), but double shredding did not bring a significant improvement







Funded by the European Union Grant N°: 101058520
CAESAR

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Shredded scrap quality improvement

Funded by the European Union

CAESAR

- Impact of the pre-sorting of material before shredding
  - Avoid mixing different types of goods before shredding to obtain batches of high-quality shredded scrap and batches of low quality shredded scrap with very complex goods that cannot produce good E40 with a simple shredding (WEEE).

HHA	Fe	Mn	C	H	S	P	Si	Al	Ni	Cr	Cu	Mo	Sn
Washing	94,2	0,34	0,87	0,05	0,04	0,08	0,45	0,17	0,09	1,28	0,34	0,012	0,007
Fridges	96,3	0,28	1,16	0,18	0,02	0,02	0,16	0,01	0,04	0,06	0,20	0,004	0,006
Cookers	97,2	0,28	0,41	0,07	0,02	0,03	0,15	0,04	0,10	0,30	0,24	0,005	0,006

	Fe	C	Mn	P	S	**Al**	**Ni**	**Cr**	**Cu**	**Ti**	Mo	**Sn**	**Zn**	**CaO**	MgO	SiO2
WEEE chain shredder	**83.00**	0.475	**0.406**	0.040	**0.065**	**3.670**	**0.214**	**0.587**	**1.332**	**0.115**	0.014	**0.040**	**0.097**	**0.477**	**0.856**	0.818
WEEE pre-shredder and granulator	**90.93**	0.459	**0.732**	0.031	0.040	**0.449**	**0.232**	**0.617**	**0.771**	0.028	0.009	**0.060**	**0.075**	0.184	0.366	0.888

  - Remove parts containing a lot of copper or other detrimental elements before shredding which is also called: ”end of life goods pre-dismantling”

%	**Fe**	**Cu**	Cr	Ni	P	**S**	Mn	Mo	Al	SiO2	CaO	TiO2
Entire ELVs shredded	**94.18**	**0.333**	0.200	0.066	0.019	**0.021**	0.443	0.009	0.513	0.721	0.193	0.07
Pre-dismantled ELVs	**93.42**	**0.159**	0.042	0.042	0.023	**0.059**	0.094	0.004	0.055	0.762	0.964	0.144
Pre-dismantled ELVs shredded	**94.59**	**0.109**	0.206	0.034	0.020	**0.017**	0.444	0.007	0.101	0.585	0.110	0.047

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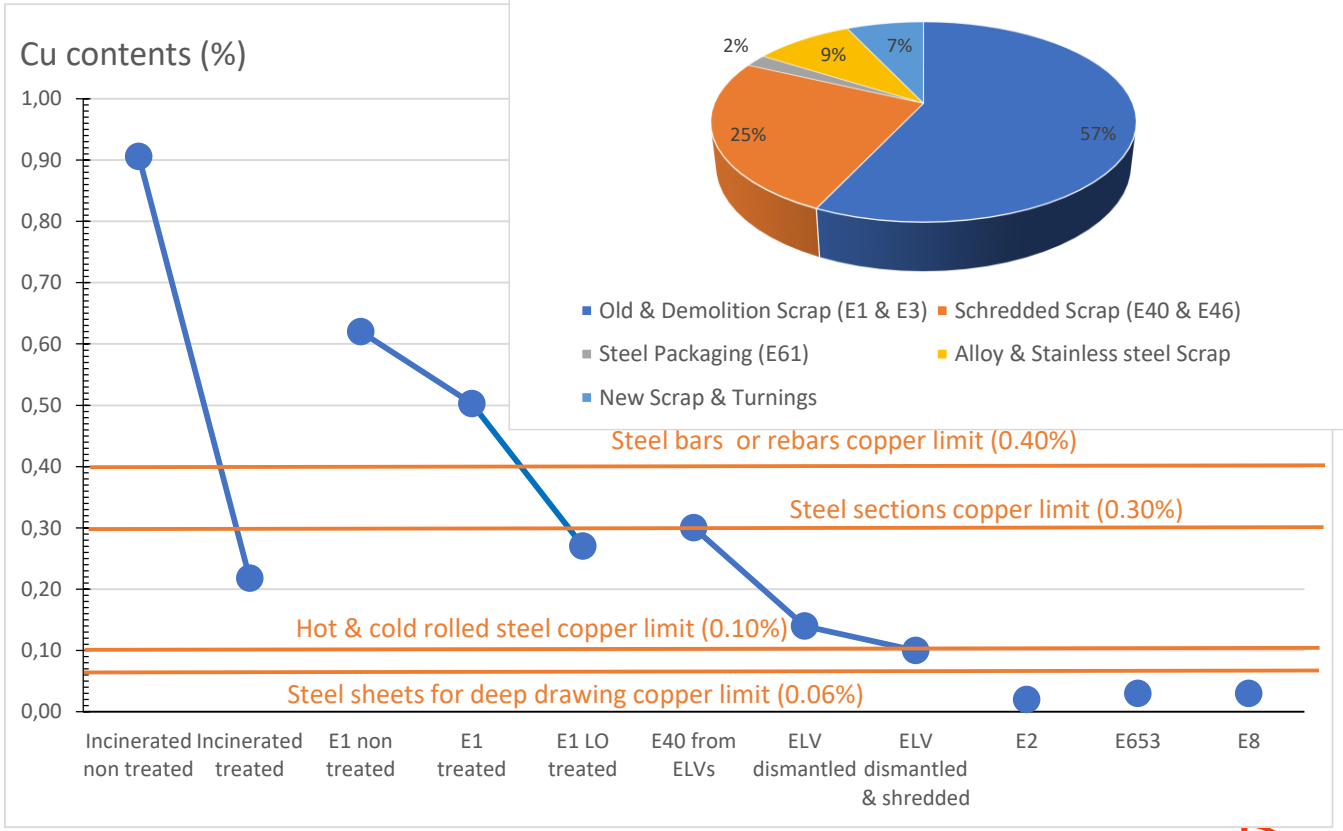
AM Europe will use more scrap but with quality limitations

Exported scrap grades outside EU are mainly of low quality so they must be treated to be used in steel sheet production for vehicles for example

- Treatments will not be enough to get 100% recycled content in steel sheet production for vehicles.
- Only new scrap (E2, E653 & E8) can be used, or we need to dilute post-consumer scrap with new scrap or DRI



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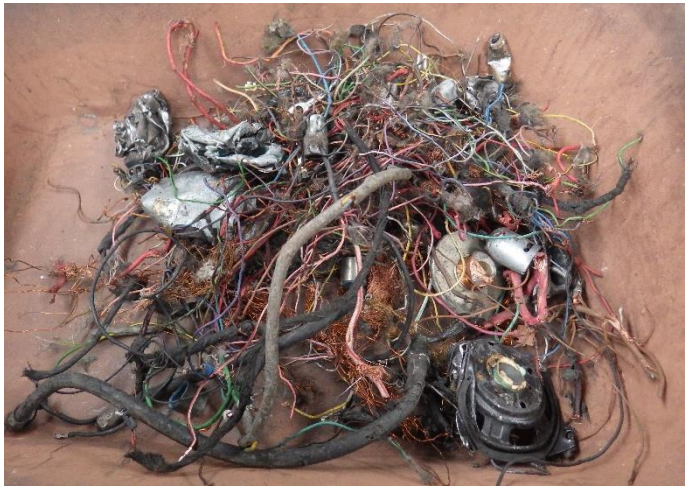
Ecodesign can also help to decrease Cu in shredded scrap

- Copper content of goods is increasing with time (for example in vehicles roughly 2% today and only 1% 30 years ago).
- Manufacturers can help reaching low copper content in obsolete goods shredded scrap by decreasing the use of copper, bronze and brass in vehicles.
- One first step can be to replace Cu wires used for electricity purpose by Al wires.
- Electrical engines from electrical vehicles represent a lesser stake because they are removed from ELVs before shredding



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Conclusions

- The iron and steel industry must decrease its $C0_2$ emissions.
- One solution to reach this aim is to use more scrap in the steel production, especially in Europe from where 20 Mt are exported yearly. This evolution will come in two steps:
  - Saturation of current tools (mainly the converter)
  - Gradual replacement of blast furnaces and converters by electric arc furnaces.
- The ferrous scrap market will be challenged by **growing demand** for high quality scrap as steelmaking technologies evolve to respond to the decarbonization needs.
- **Circularity** of steel can be further enhanced:
  - Adoption of **best available technologies** by scrap dealers and/or steel makers to remove Cu contaminants from ferrous scrap.
  - Design should plan for the **pre-dismantling** of all Cu-containing parts that cannot be later removed in the shredding and sorting processes. Moreover, electrical wiring solutions that **substitute** Cu with Al can prevent the problem at source.

Thank you for your attention!

- Internet sites:
- ArcelorMittal : http://www.arcelormittal.com/
- ArcelorMittal Packaging : http://www.arcelorpackagingintl.com/
- FFA : http://www.acier.org/
- Worldsteel : http://www.worldsteel.org/
- BIR : http://www.bir.org/industry/ferrous-metals/

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