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Increasing the recovery of materials from automobile shredder residues through a novel recovery process

Politecnico di Torino

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Introduction

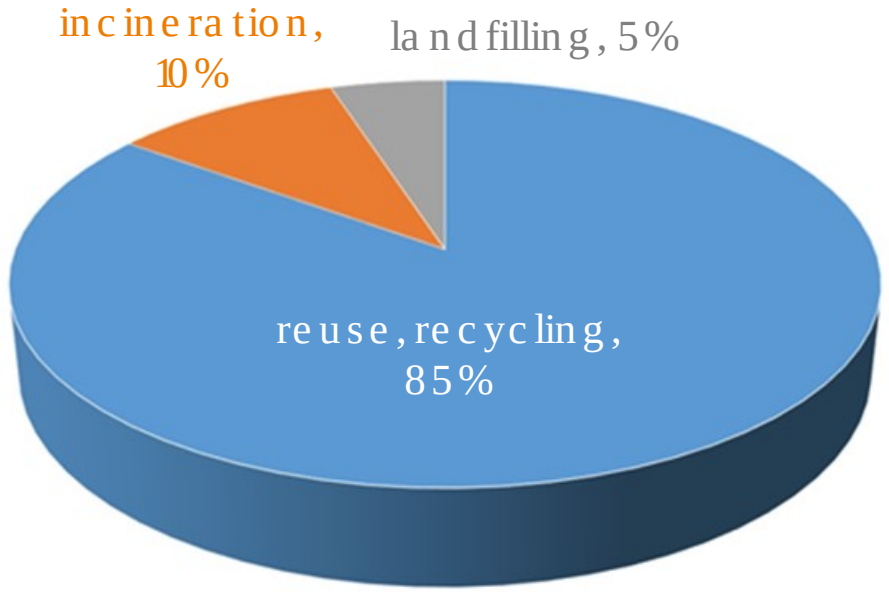
ELV: end of life vehicle

Average vehicle life (EU): 12-15 y

How many ELVs?

EU, 12 M/y

World, > 50 M/y

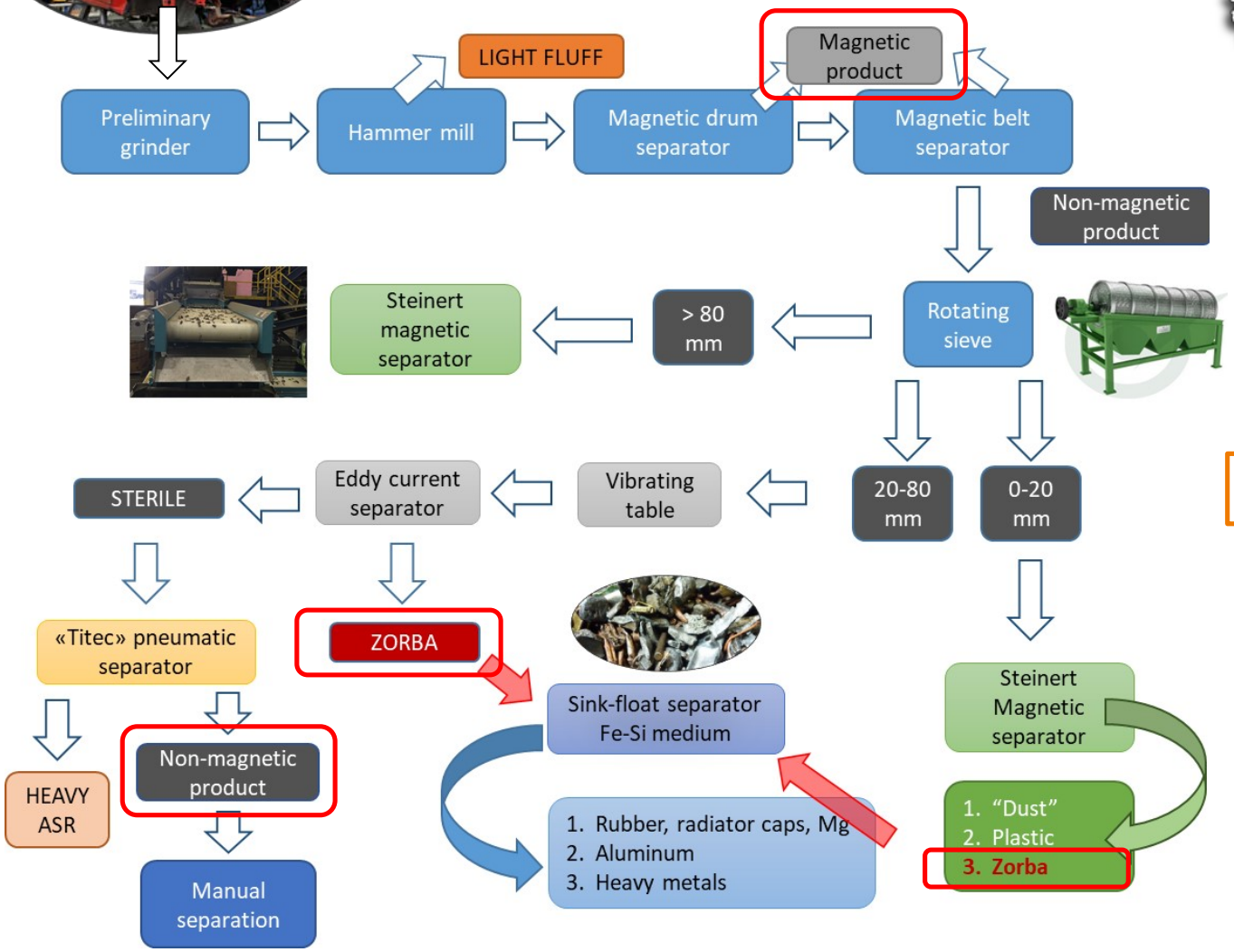


The end-of-life phase of a vehicle is ruled by **EC Directive 2000/53/EC**, recently amended by **EU Directive 2018/849 (Circular Economy Package)**, that aims at making dismantling and recycling of end-of-life vehicles (ELVs) more environmentally friendly.

More than **200,000 tons** of ASRs are landfilled every year in Italy (ISPRA, 2020), thus being Italy one of the EC States non-compliant with the 95% target of recovery and reuse stated by EU-Directives 2000/53/EC and 2018/849/EC.

The ATF and the samples

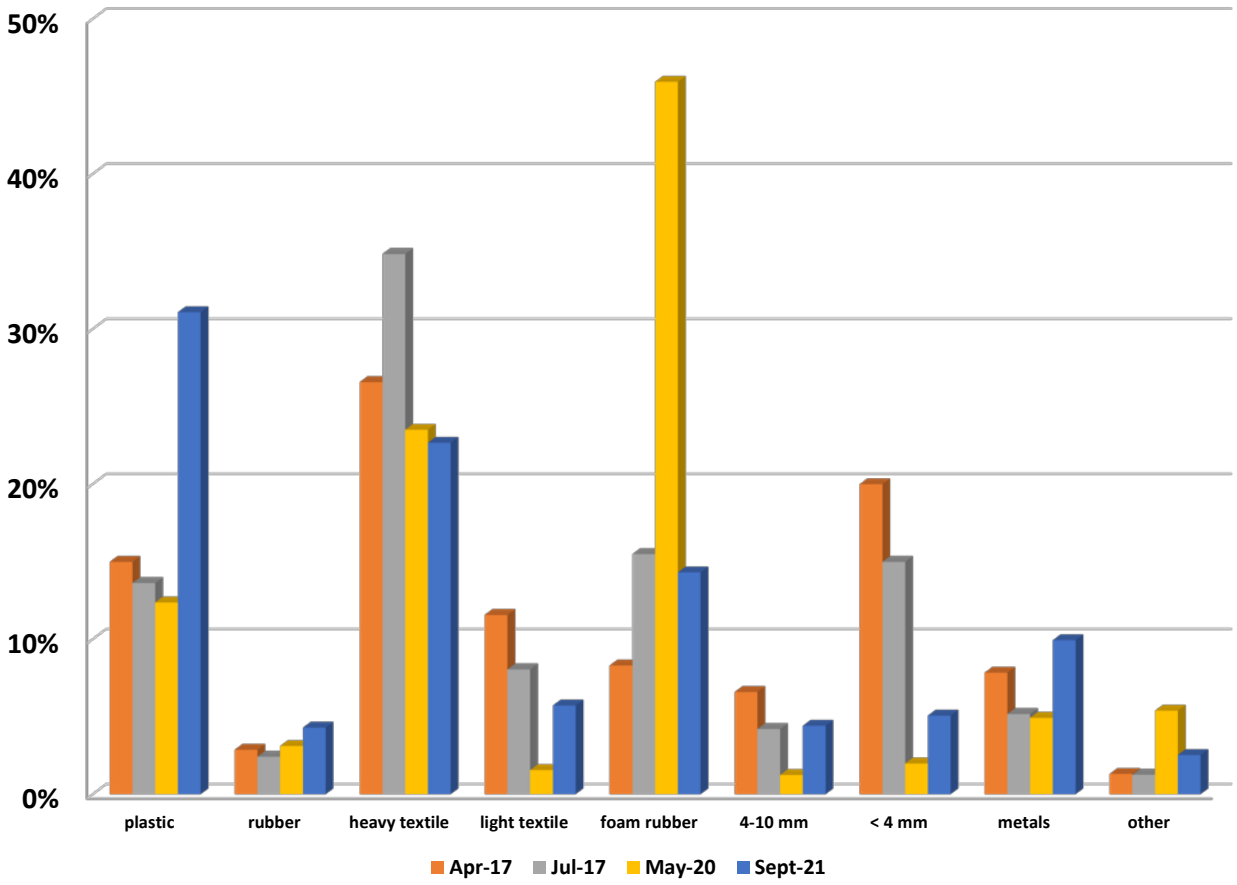
- Air-bags
- Bumpers
- Tires
- Gas tank
- Battery
- Engine
- Catalyzer
- Wheel cup
- Starter



82.1%

Fraction	%
Parts removed before the shredding phase	16.6
Proler	61.2
Zorba (< 20 mm)	0.7
Zorba (20 – 80 mm)	3.1
Non-magnetic product from Titec	0.5
Light fluff	16.3
Heavy fluff	1.1
Dust	0.5

Strategies to increase the material recovery from the light ASR fraction



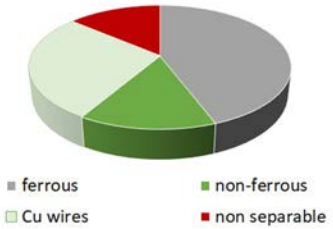
1. Improvement of metal separation

2. Assimilation to a SRF - fuel

1- Improvement of metal separation

light ASR

1 t L-ASR
99.3 kg metals



magnetic separator

ferrous metals

eddy current separator

ferrous and non- metals

magnetic separator

ferrous metals

non ferrous metals

trommel 30 mm

< 30 mm

> 30 mm

granulator

magnetic separator

ferrous metals

zig-zag separator

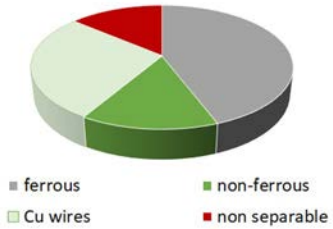
heavy product

light product

1- Improvement of metal separation

light ASR

1 t L-ASR
99.3 kg metals



F – 8.8 kg – 20%

NF – 11.4 kg – 79%
Cu – 14.0 kg – 51%

magnetic separator

ferrous metals

F – 27.3 kg – 62%

ferrous metals

non ferrous metals

heavy product

NF – 2.8 kg – 20%
Cu – 13.5 kg – 49%

eddy current separator

ferrous and non- metals

magnetic separator

zig-zag separator

light product

trommel 30 mm

> 30 mm

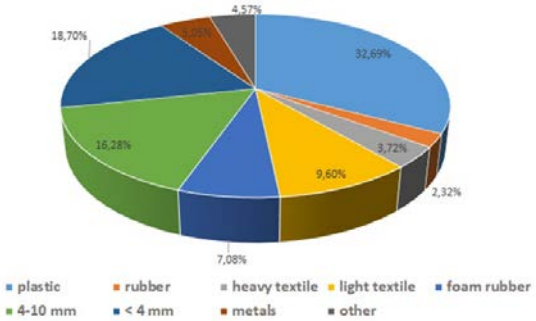
granulator

magnetic separator

ferrous metals

F – 7.9 kg – 18%

< 30 mm



Dismantling and separation: 82.1%

Enhanced metal recovery: **+ 14%**

Total: **83.5%**

2- Assimilation to a SRF- fuel

Light ASR: approx. 15% of the ELV weight

Destination (2018)

- 87%: landfill
- 12%: material recovery
- 1%: energy recovery

MATTM Circolare 29/03/2018

- SRF- fuel

Compliance with the requirements of DM 14/02/2013, n. 22

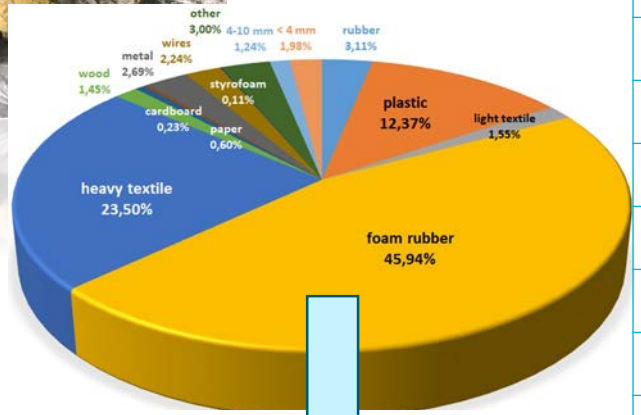
Caratteristiche di classificazione							
Caratteristica	Misura statistica	Unità di misura	Valori limite per classe				
			1	2	3	4	5
PCI	media	MJ/kg t.q.	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3
Cl	media	% s.s.	≤ 0,2	≤ 0,6	≤ 1,0	≤ 1,5	≤ 3
Hg	mediana	mg/MJ t.q.	≤ 0,02	≤ 0,03	≤ 0,08	≤ 0,15	≤ 0,50
	80° percentile	mg/MJ t.q.	≤ 0,04	≤ 0,06	≤ 0,16	≤ 0,30	≤ 1,00

- Decree 14/02/2013, n. 22 - Regulation governing the cessation of the waste status of certain types of solid recovered fuels (SRFs)

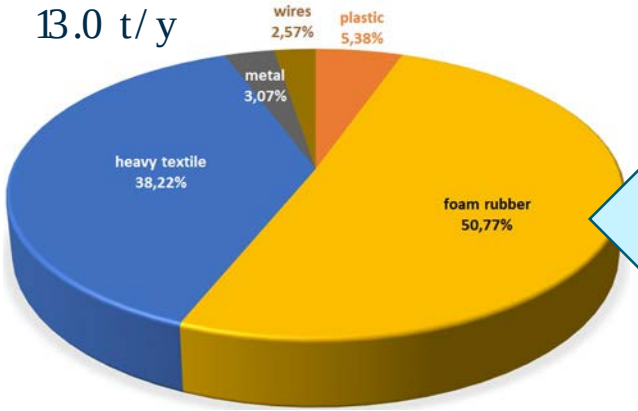
Caratteristiche di specificazione			
Parametro	Misura statistica	Unità di misura	Valore Limite
Parametri fisici			
Ceneri	media	% s.s	--- *(vedasi nota 1)*
Umidità	media	% t.q.	--- *(vedasi nota 1)*
Parametri chimici			
Antimonio (Sb)	mediana	mg/kg s.s.	50
Arsenico (As)	mediana	mg/kg s.s.	5
Cadmio (Cd)	mediana	mg/kg s.s.	4
Cromo (Cr)	mediana	mg/kg s.s.	100
Cobalto (Co)	mediana	mg/kg s.s.	18
Manganese (Mn)	mediana	mg/kg s.s.	250
Nichel (Ni)	mediana	mg/kg s.s.	30
Piombo (Pb)	mediana	mg/kg s.s.	240
Rame (Cu)	mediana	mg/kg s.s.	500
Tallio (Tl)	mediana	mg/kg s.s.	5
Vanadio (V)	mediana	mg/kg s.s.	10
Σ metalli [Sb,As,Cr, Cu,Co, Pb,Mn,Ni,V]	mediana	mg/kg s.s.	--

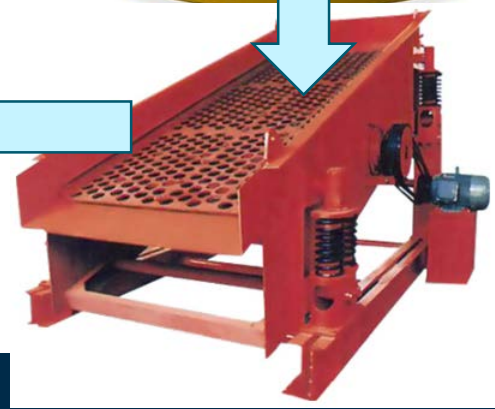
2- Assimilation to a SRF- fuel

28.4 t/y



45.8%
13.0 t/y



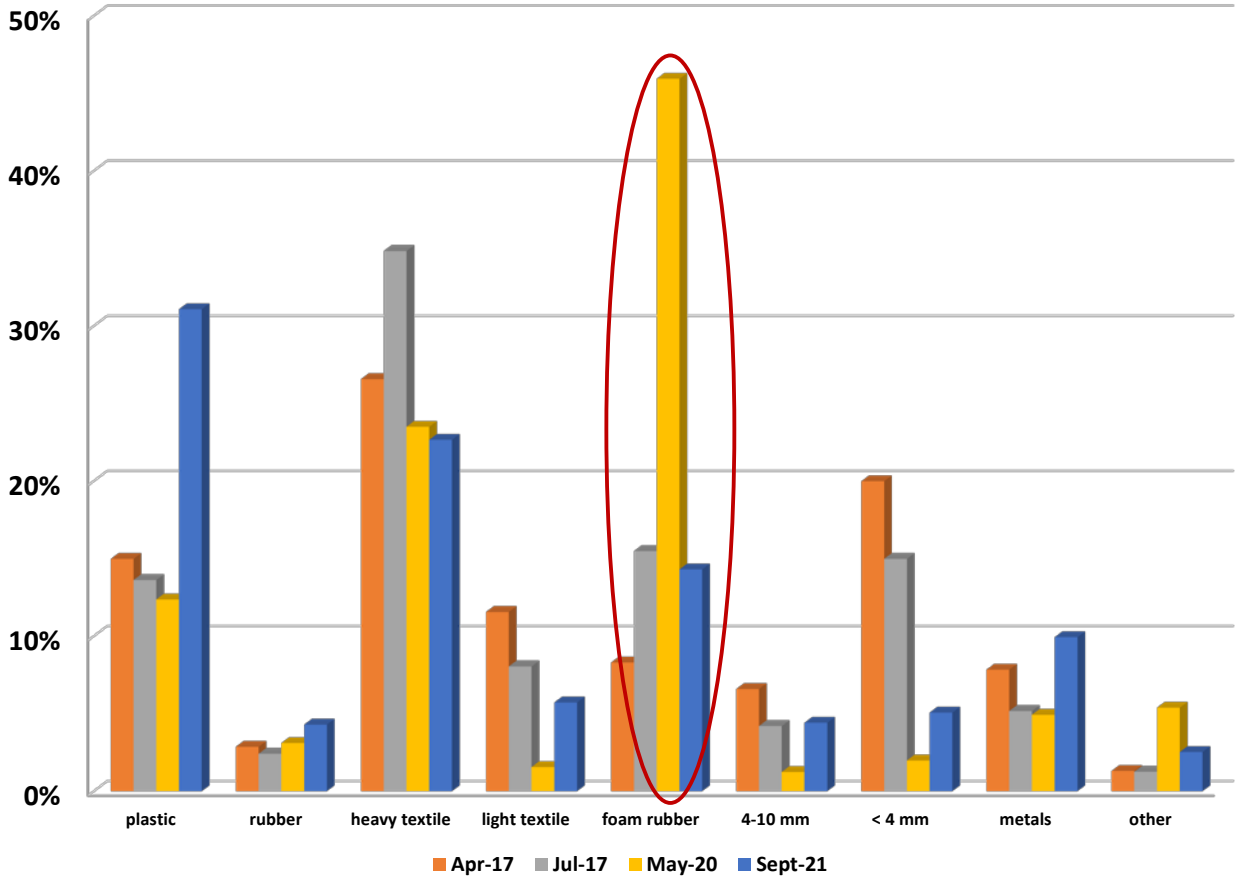


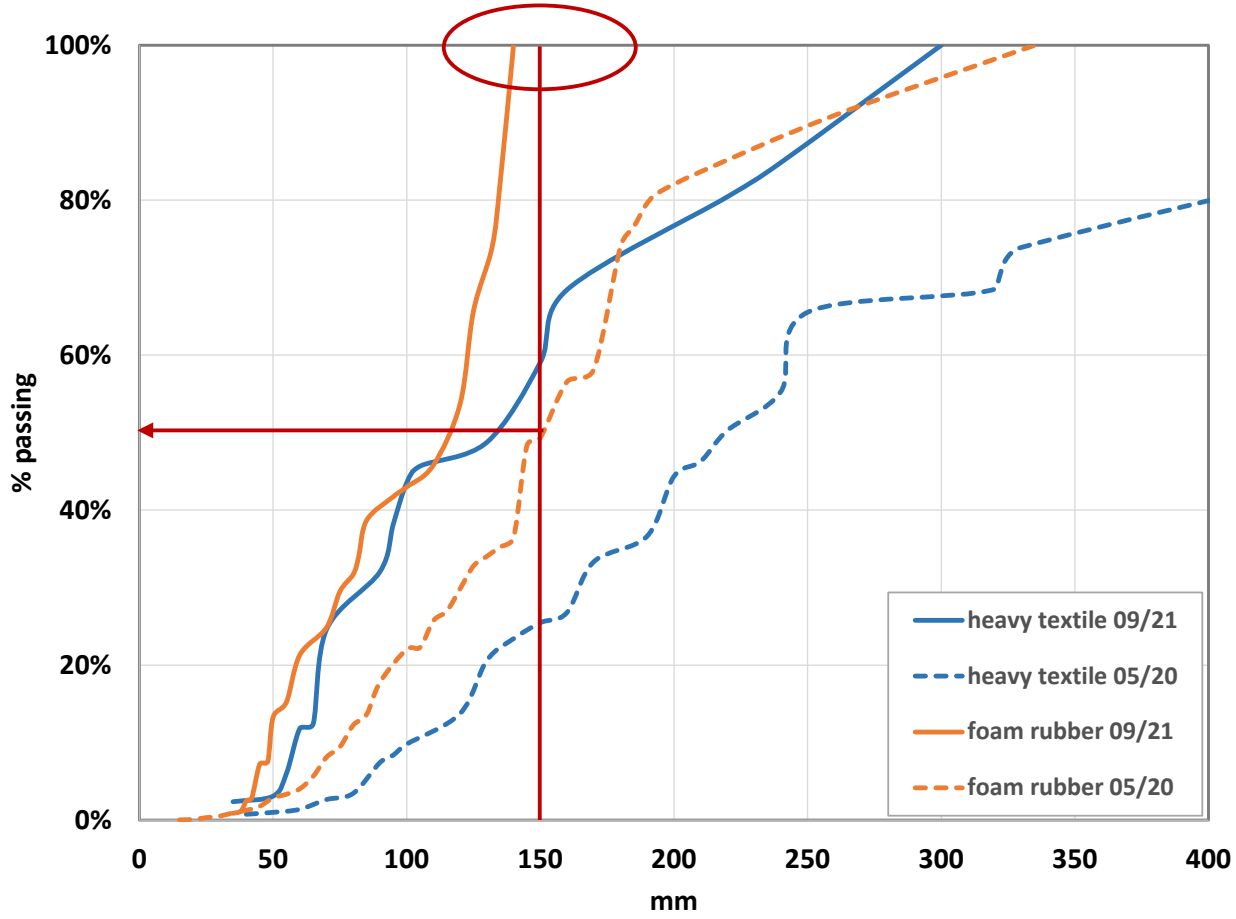
150 mm

Sample May 2020 – Characterization results

Parameter	Heavy textile >150 mm	Foam rubber >150 mm	Plastic	Threshold values 22/2013
ashes (%)	9.19 ± 0.31	5.14 ± 0.29	4.80 ± 1.11	
Cd (mg/kg)	1.40 ± 0.17	1.75 ± 0.18	0.715 ± 0.556	4
Cr (mg/kg)	51.3 ± 2.6	33.3 ± 0.6	22.4 ± 15.4	100
Cu (mg/kg)	259 ± 30	270 ± 10	11.8 ± 4.9	500
Pb (mg/kg)	24.7 ± 6.0	29.8 ± 6.2	< 3	240
Fe (mg/kg)	5668 ± 180	2549 ± 112	810 ± 197	-
Mn (mg/kg)	93.9 ± 4.3	58.6 ± 0.8	12.7 ± 5.4	250
Zn (mg/kg)	1974 ± 39	908 ± 15	134 ± 28	-
Ni (mg/kg)	43.1 ± 6.8	36.5 ± 2.0	7.22 ± 3.40	30
Co (mg/kg)	6.76 ± 0.60	3.54 ± 1.64	8.27 ± 14.3	18
HHV (MJ/kg)	22.64 ± 0.51	28.04 ± 0.60	~ 20	

2- Assimilation to a SRF- fuel

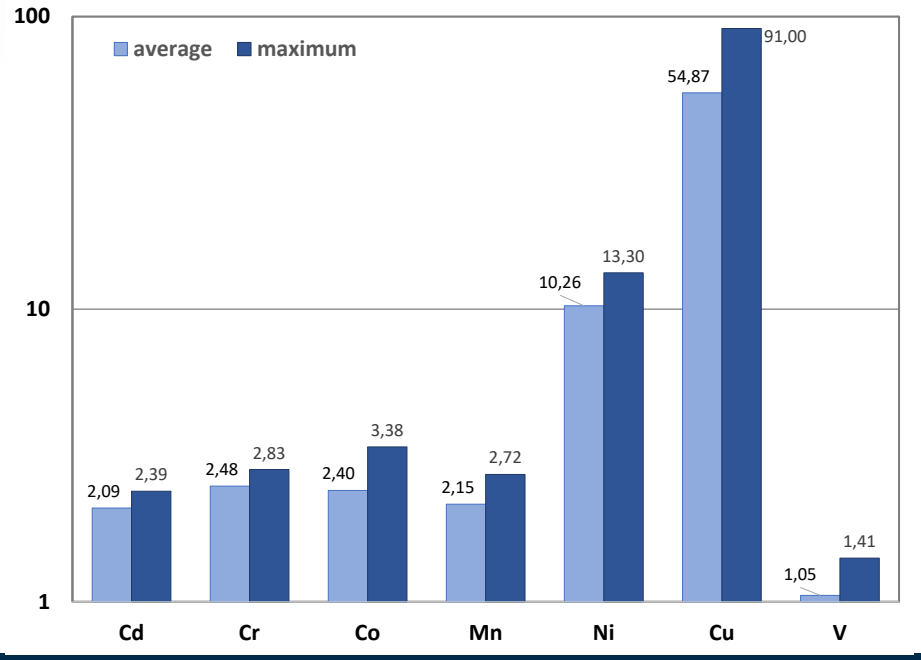




2- Assimilation to a SRF- fuel

CORE

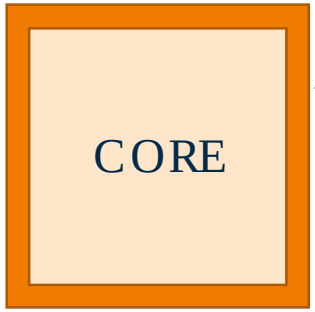
SHELL (3 mm)

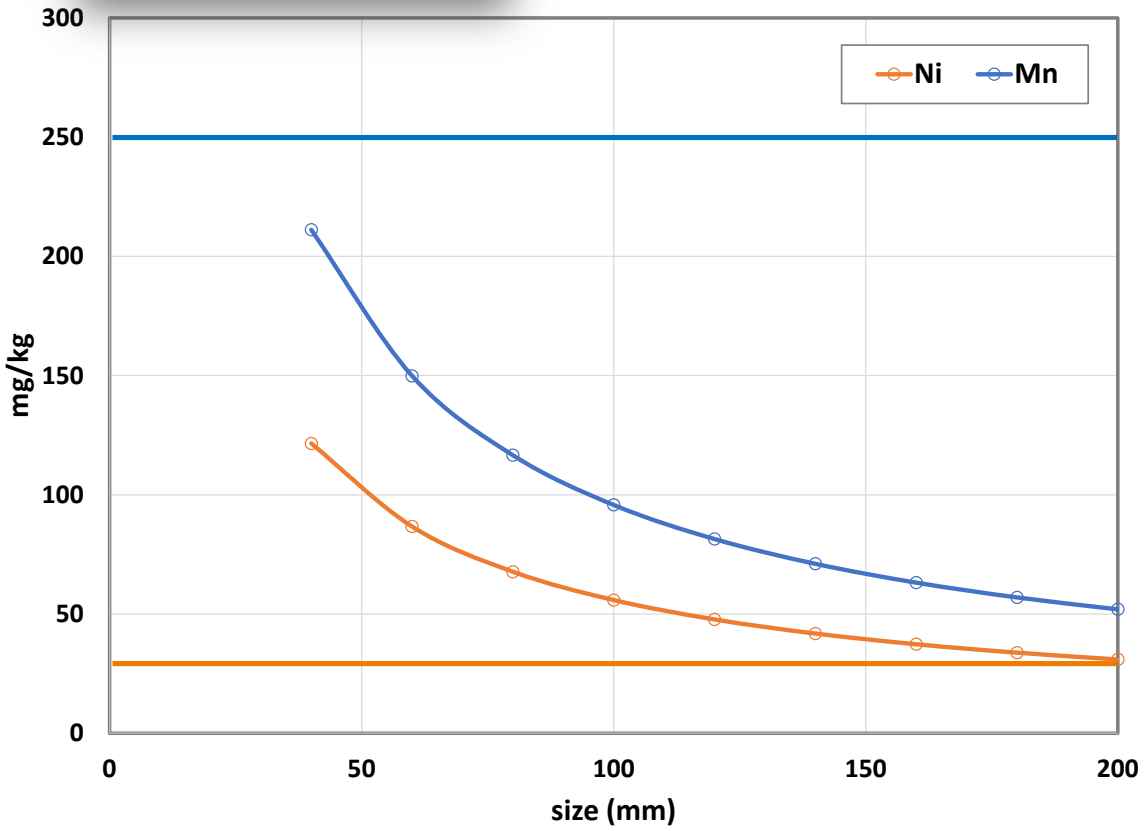


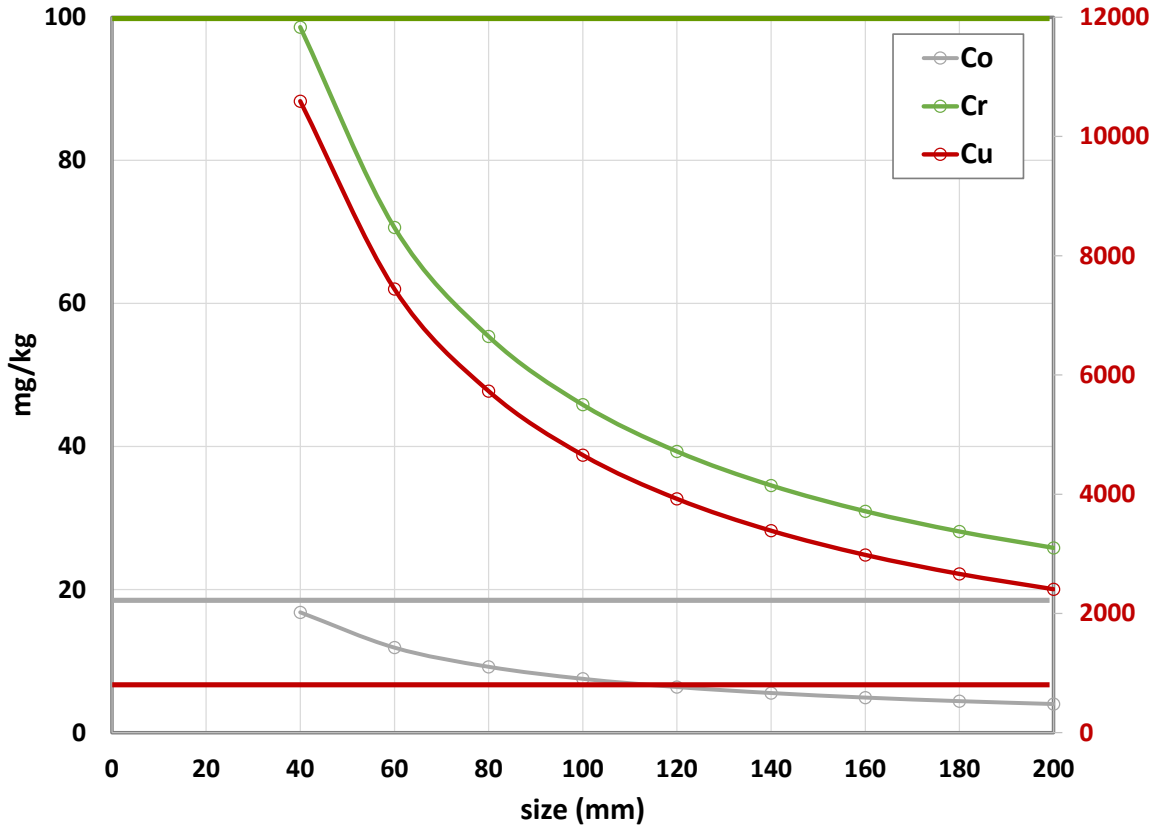
Sample September 2021– Characterization results

Parameter	Foam rubber "core"	Foam rubber "shell"	Foam rubber >150 mm 2020	Threshold values 22/2013
ceneri (%)	0.72 ± 0.12	16.6 ± 1.1	5.14 ± 0.29	
Sb (mg/kg)	4.09 ± 1.75	28.8 ± 5.2	n.a.	50
Cd (mg/kg)	0.833 ± 0.174	8.36 ± 1.18	1.75 ± 0.18	4
Cr (mg/kg)	4.53 ± 1.25	248 ± 35	33.3 ± 0.6	100
Co (mg/kg)	< 0.25	43.2 ± 17.7	3.54 ± 1.64	18
Mn (mg/kg)	5.45 ± 1.93	538 ± 143	58.6 ± 0.8	250
Ni (mg/kg)	4.45 ± 0.55	308 ± 91	36.5 ± 2.0	30
Pb (mg/kg)	6.38 ± 2.67	153 ± 28	29.8 ± 6.2	240
Cu (mg/kg)	10.1 ± 3.4	$(2.74 \pm 1.81) \cdot 10^4$	270 ± 10	500
V (mg/kg)	< 0.25	10.5 ± 3.6	n.a.	10

2- Assimilation to a SRF- fuel







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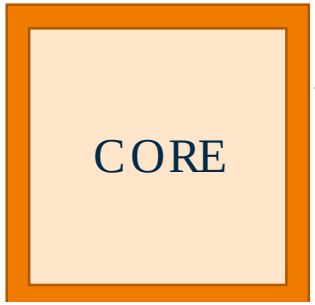

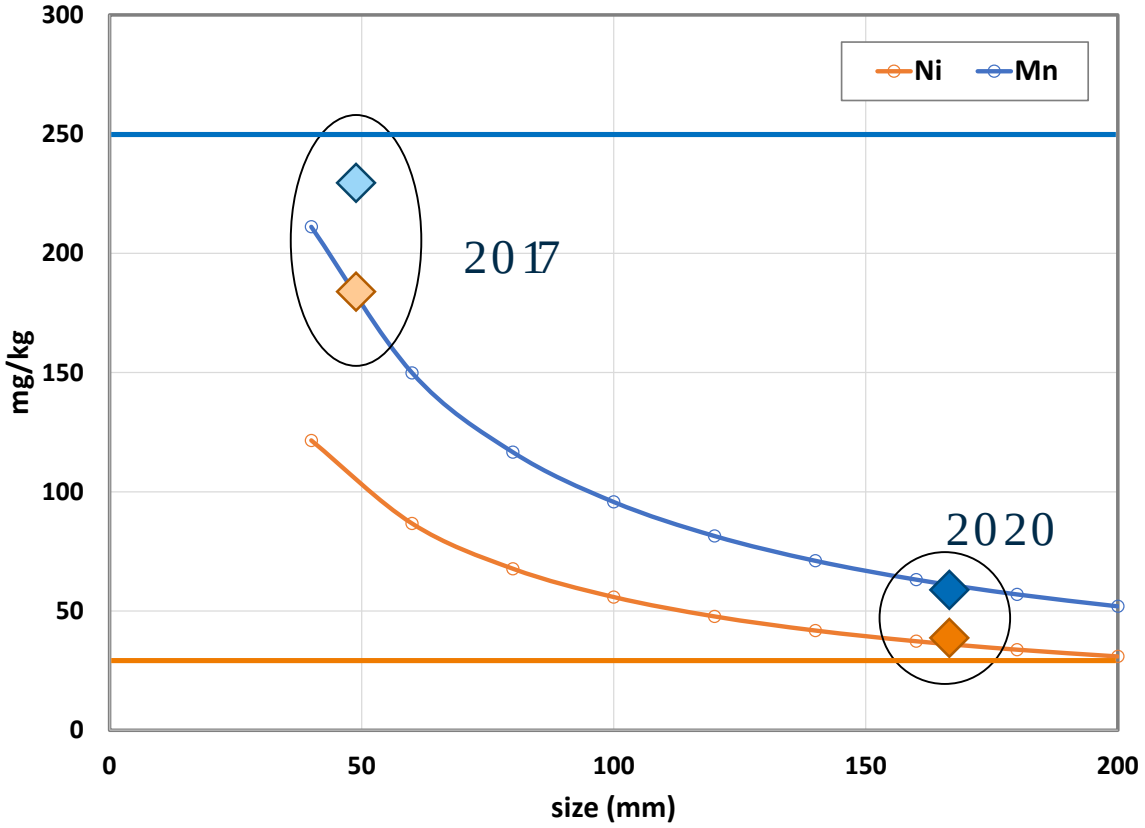

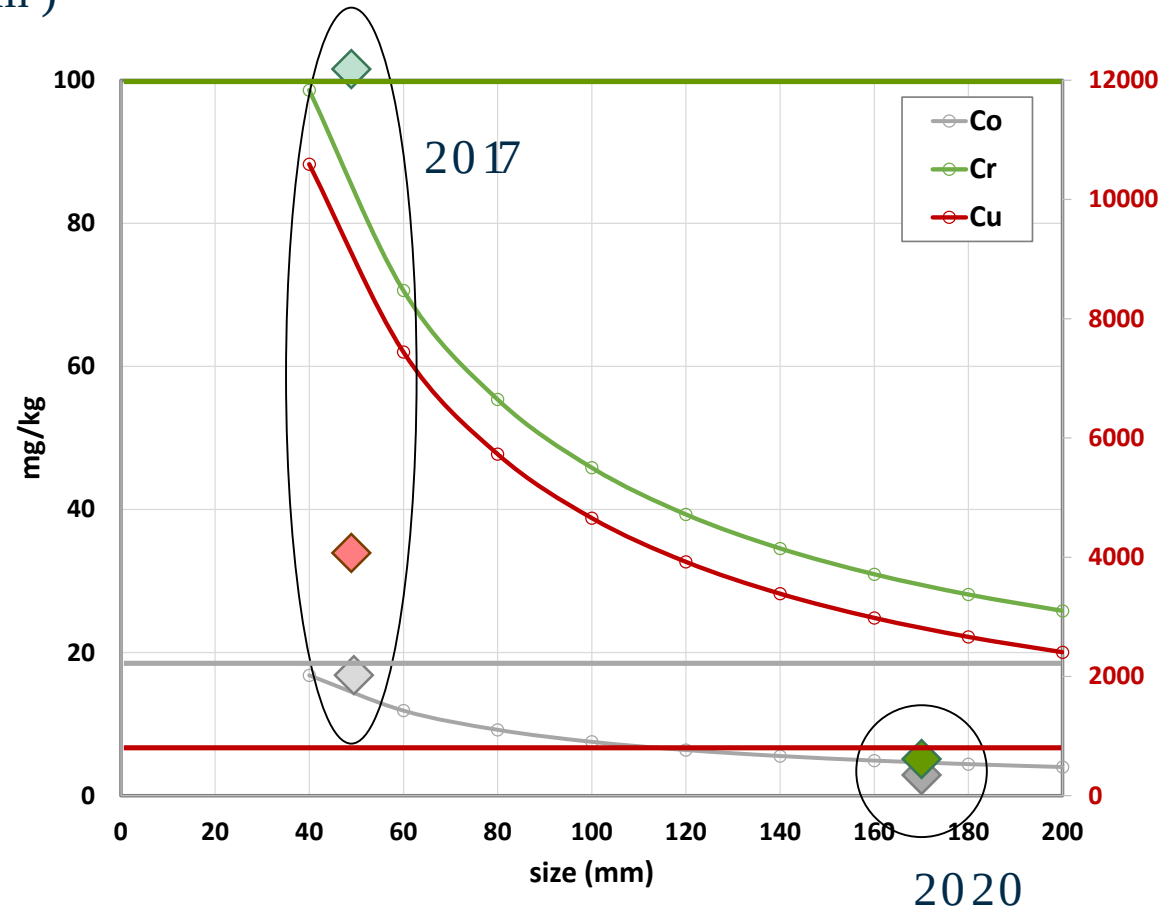

Conclusions

- ✓ Accurate operations of dismantling and post-shredding separation are compulsory in order to comply with the requirements of EC Directive 2000/53/EC, recently amended by EU Directive 2018/849 (Circular Economy Package); the target value for material recovery (85%) can be approached;
- ✓ A dedicate mechanical post-treatment of the light fraction of ASRs can increase the performance in material recovery by at maximum 1% - 1.5% (from approx. 82% to 83.5%);
- ✓ The Italian legislation permits the assimilation of (certain fractions) the ASRs to a SRF-fuel, provided the compliance with parameters fixed by DM 14/02/2013, n. 22;
- ✓ Full compliance for porous / impregnable fractions (i.e. heavy textile, foam rubber) seems to be difficult, especially for what concern the content of copper and nickel;
- ✓ Plastic fraction, whether properly separated, can be assimilated to a SRF-fuel, with a consequent material recovery in the order of 2-3%.

This study was funded by Regione Piemonte through POR FESR 2014/20 RECIPLAST Project.

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Thanks for your kind attention!

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