A circular approach for recovery and recycling of automobile shredder residues (ASRs)

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Introduction

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.

It sets clear targets for reuse, recycling and recovery of the ELVs and their components.

According to this rule, thermal valorization must not exceed 10% b.w. of the weight of an ELV and the amount disposed in a landfill must be of less than 5% b.w.

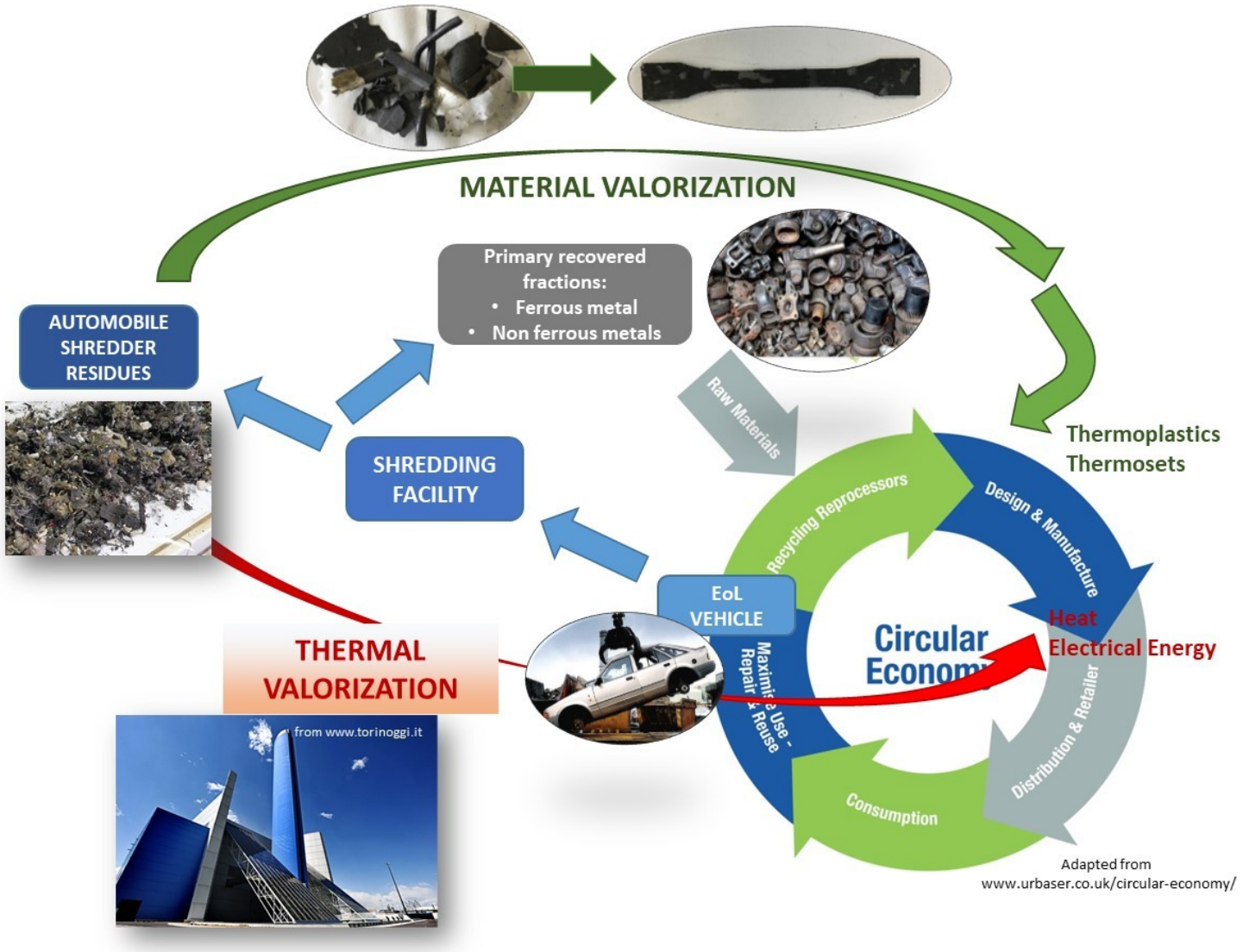
- Collection of ASR samples from an ELV recovery plant located in NW Italy
- Characterization of the waste products for the valorizatio

materia l

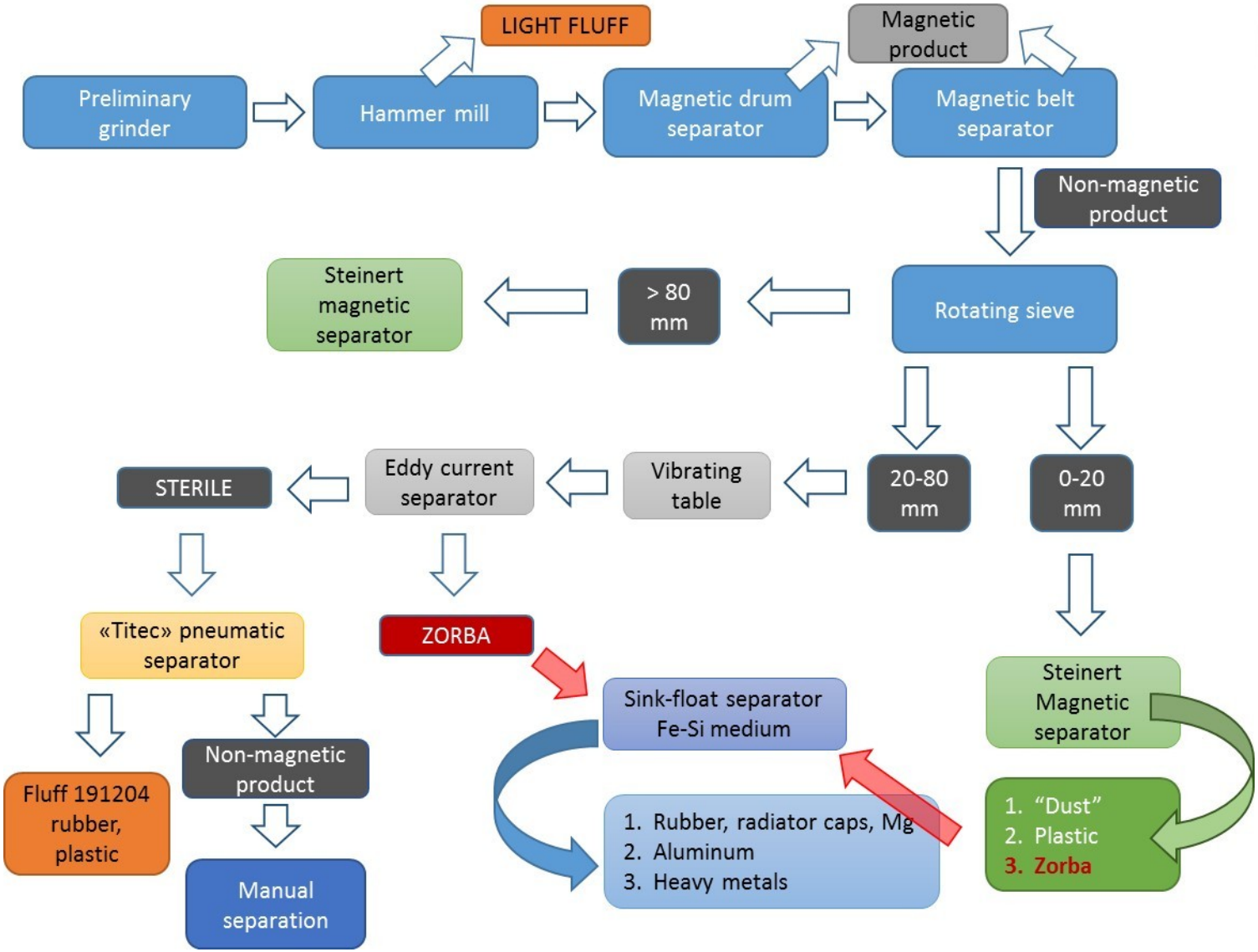
heat

A focus on plastics

Aim of the work



The plant and the samples

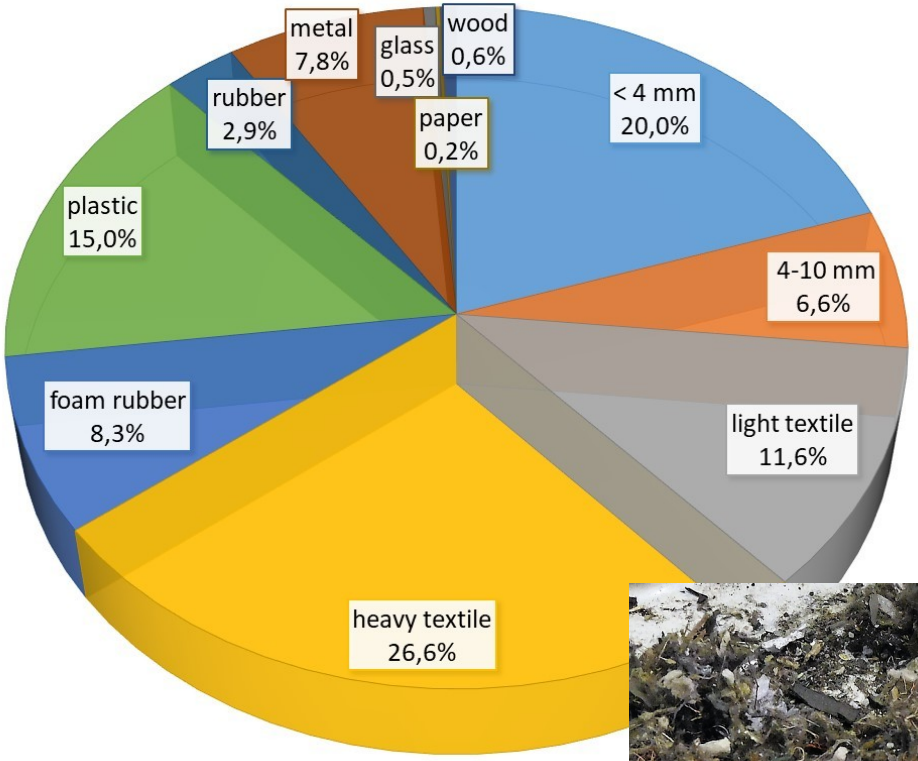


Sampled waste products:

- **Light fluff** CER 191004
- **Heavy fluff from "Titec" separato** CER 191204

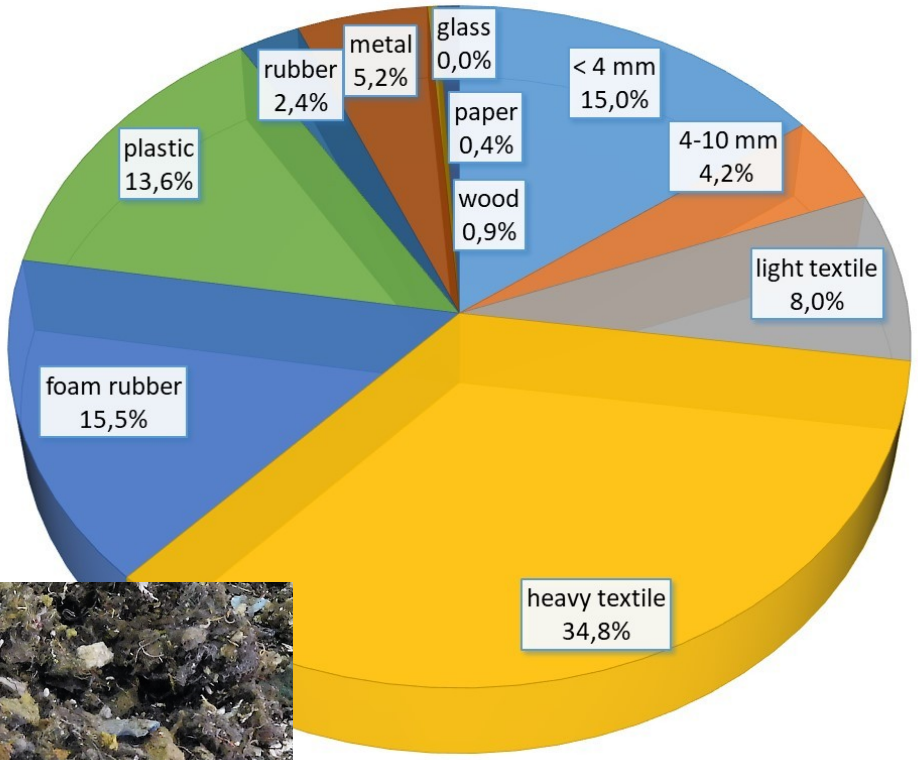
Sample Characterization (1/2)

Product composition analysis of the light fluff sample (CER 191004)



April 2017

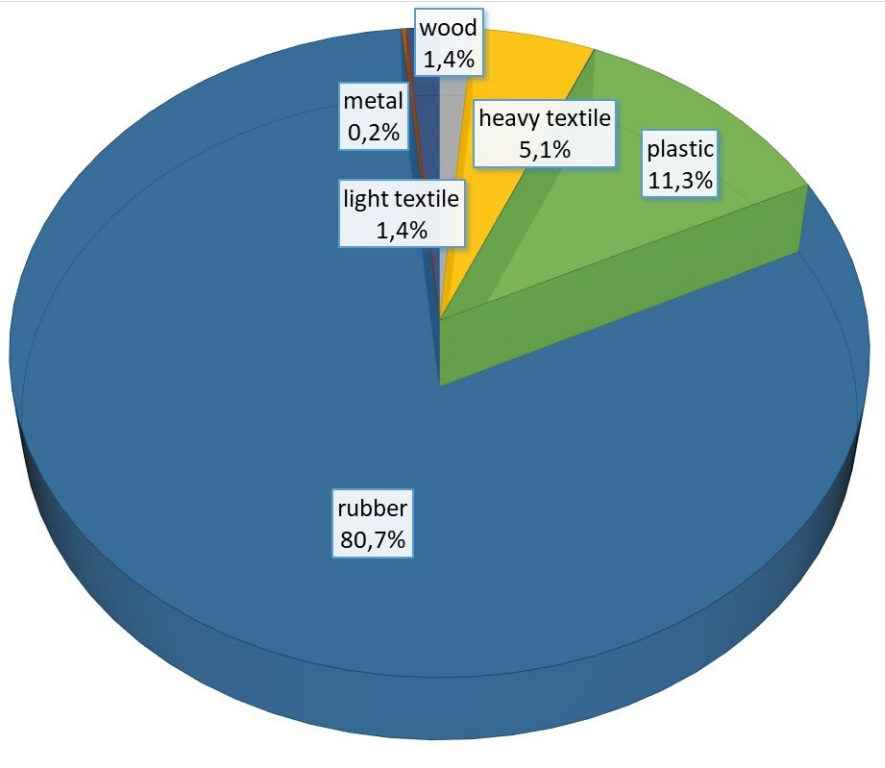
Starting sample



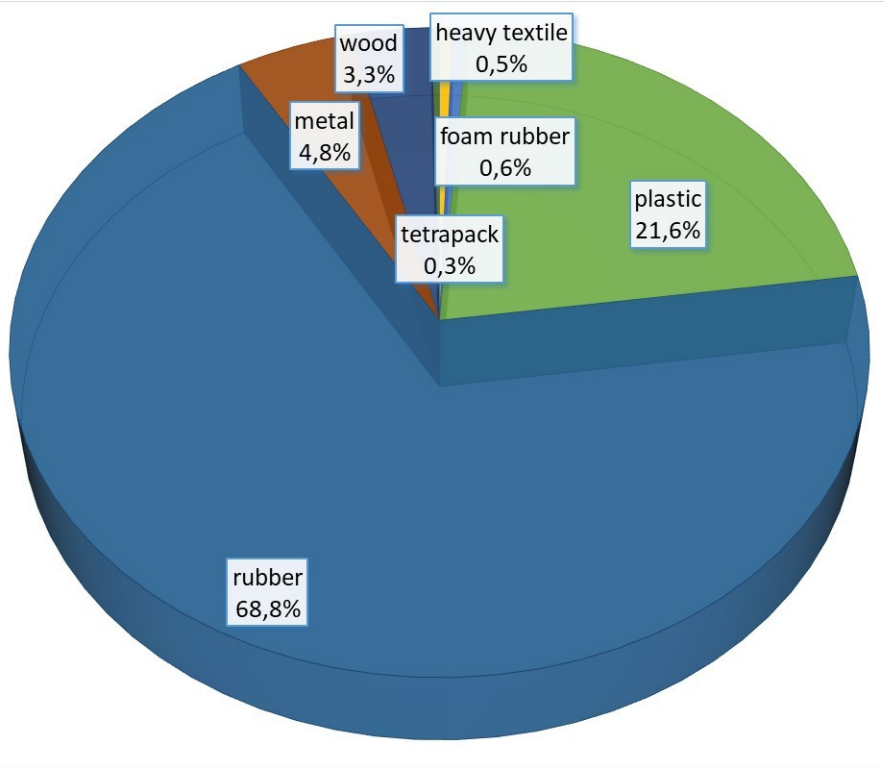
July 2017

Sample Characterization (2/2)

Product composition analysis of the heavy fluff sample (CER 191204)



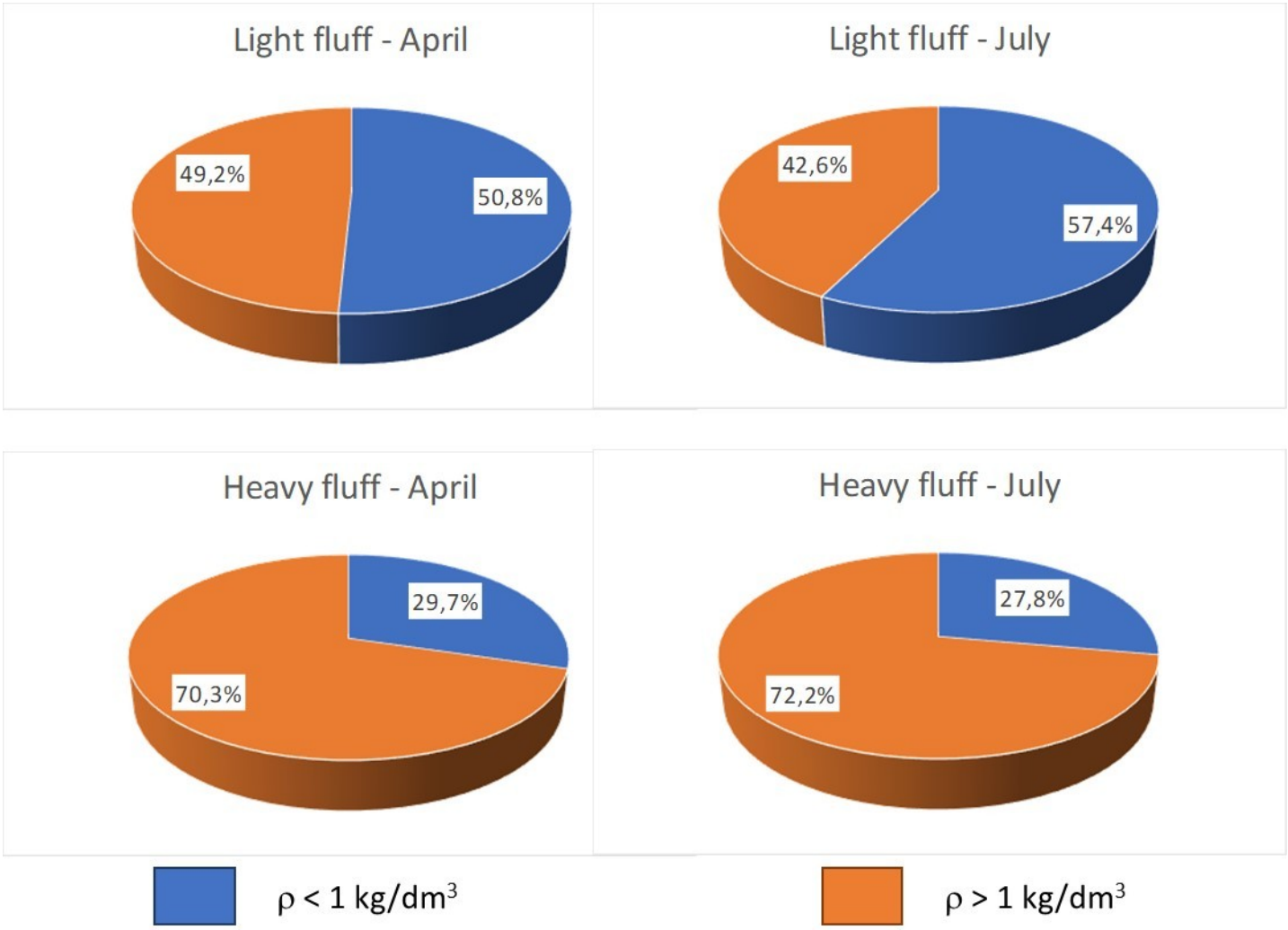
April 2017



July 2017

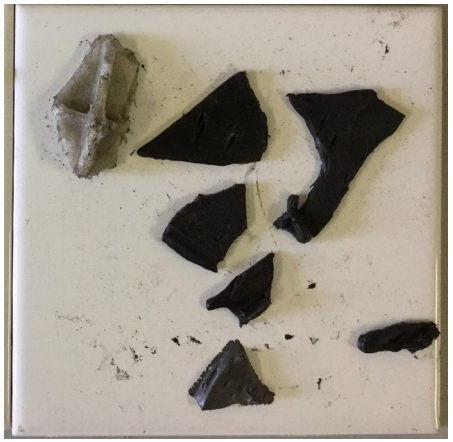
Scenario 1 – Material Recovery

Densimetric analysis

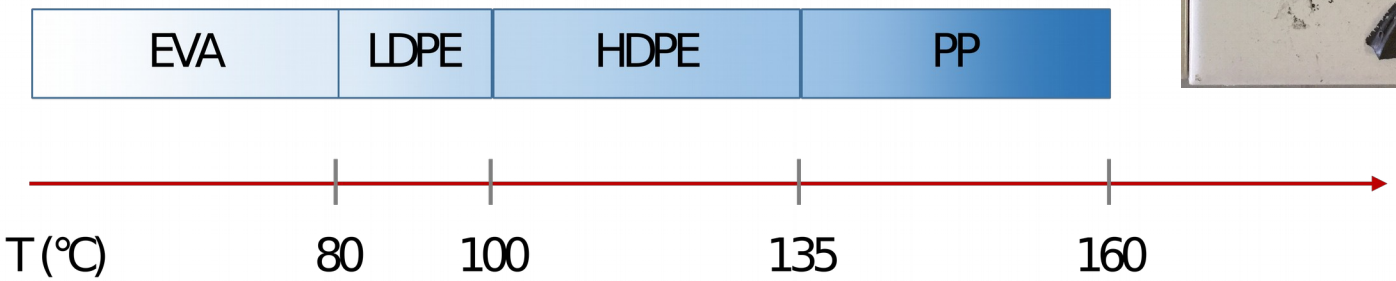


Scenario 1 – Material Recovery

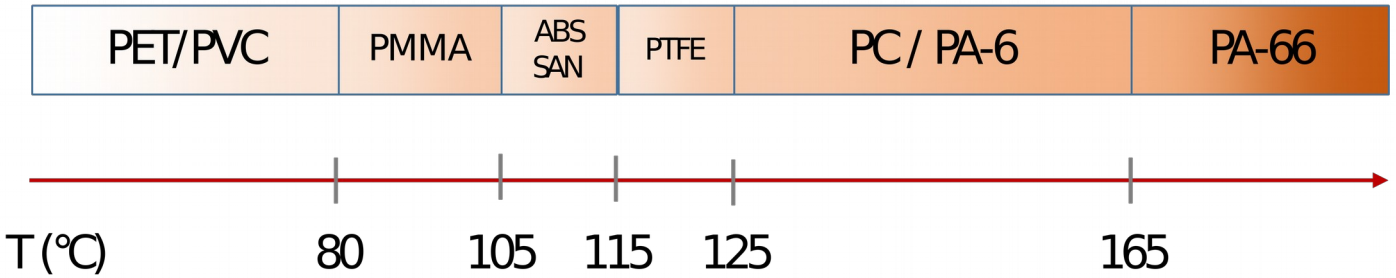
Softening test - ASTM D 1525 rule (Vicat softening temperature)



Light Plastic

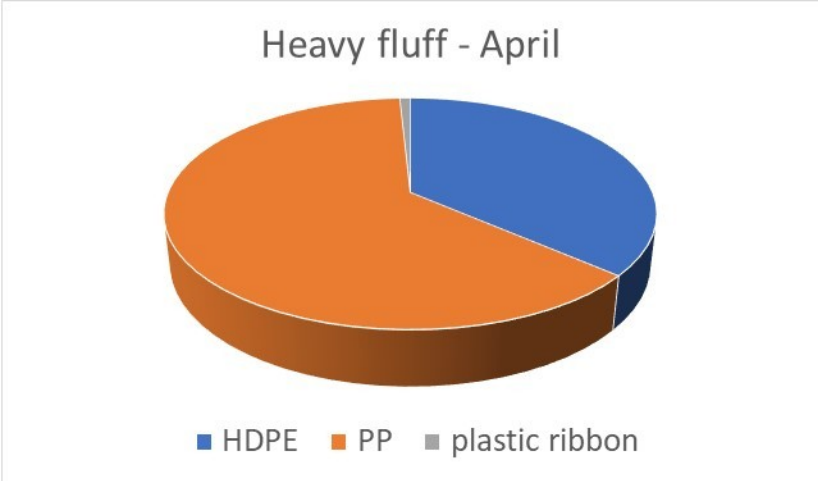


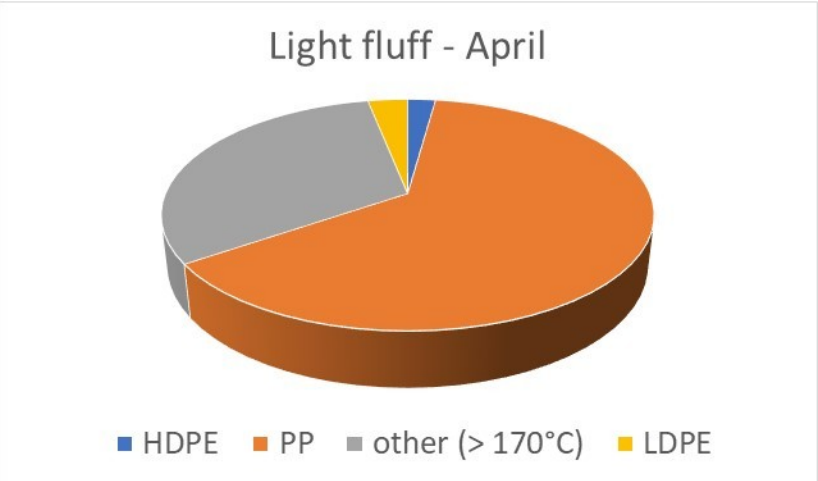
Heavy Plastic

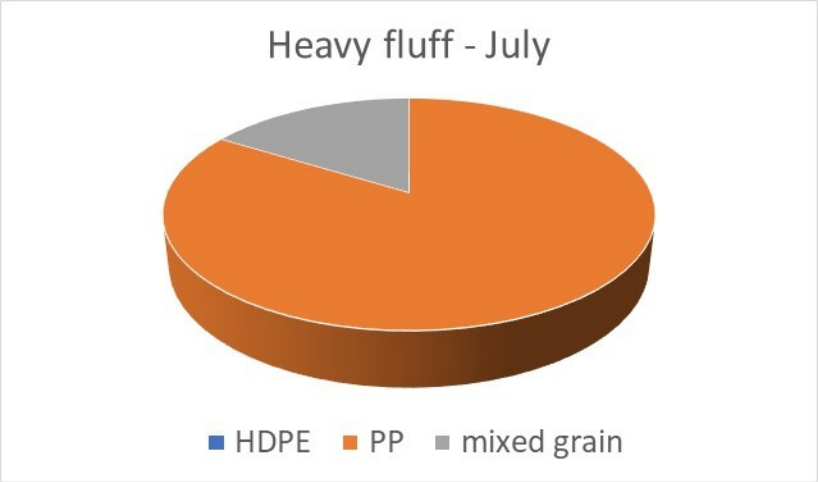


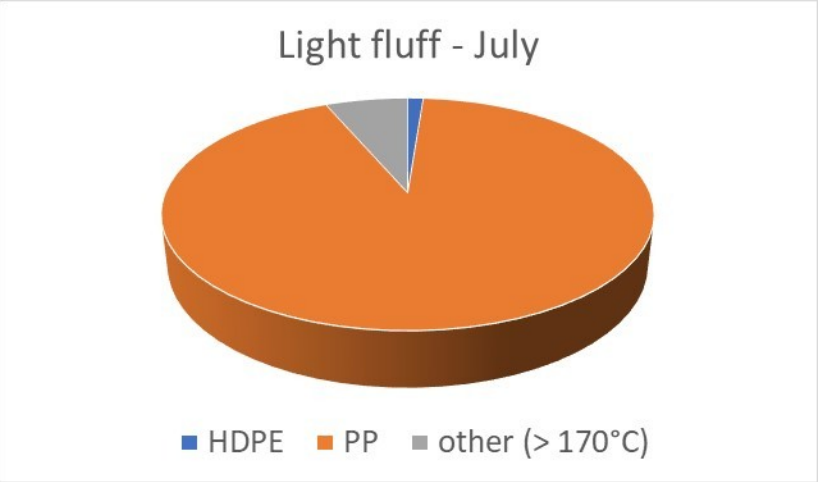
Scenario 1 – Material Recovery

Softening test – light plastic ($\rho < 1$ kg/dm^3)



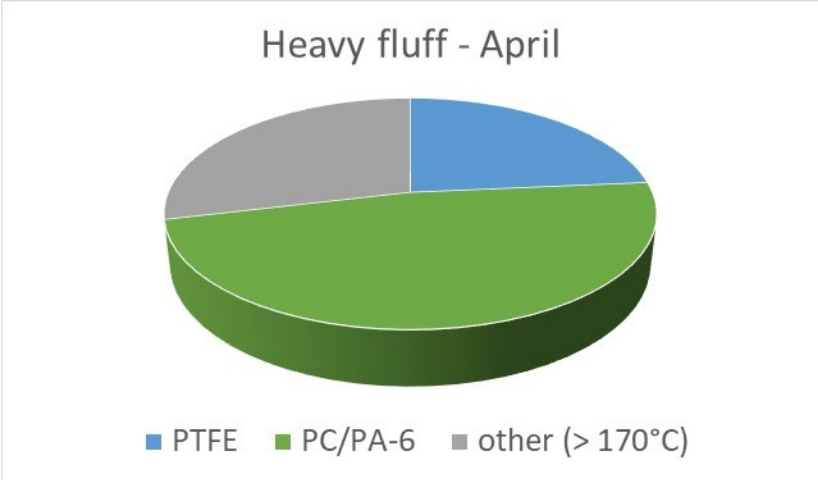


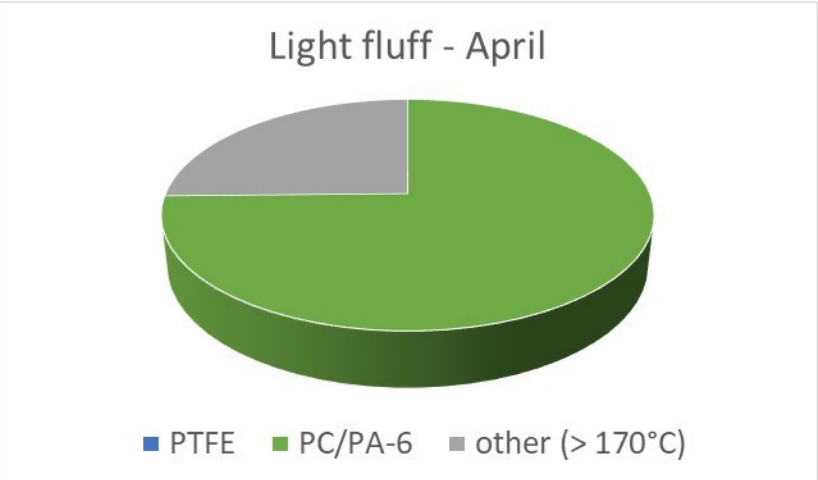


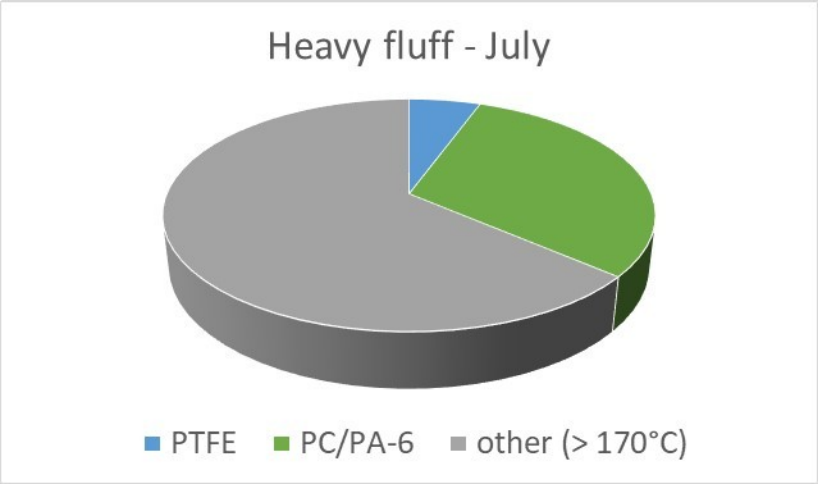


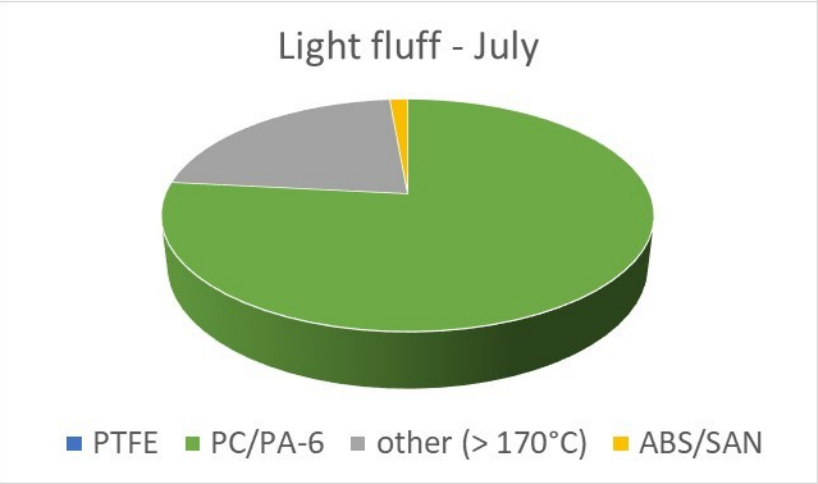
Scenario 1 – Material Recovery

Softening test – heavy plastic ($\rho > 1$ kg/dm^3)



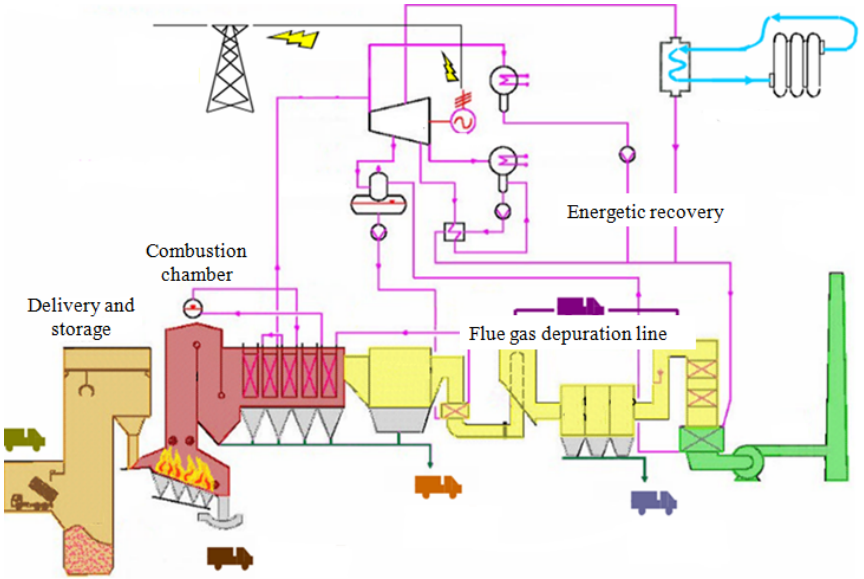






Scenario 2 – Thermal Recovery

- Thermal Valorization in TRM plant - Turin



Treated MSW	421,000 t/y	Electrical yield	30%
LHV	11,000 kJ/kg	Electrical power	62 MWe
Thermal Power	206 MW	Bottom ash	20% b.w.(*)
Saved Conventional Fuel	32,300 TOE	Fly ash	2% b.w.(*)

(*) of the MSW input

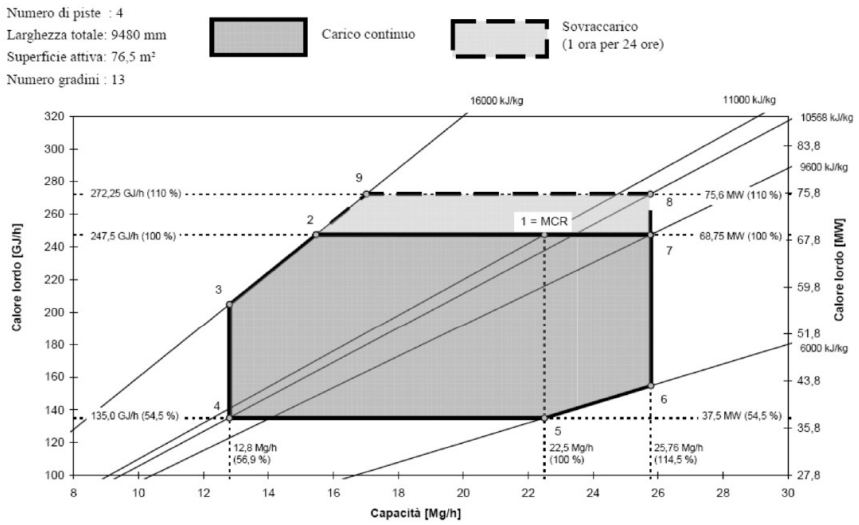
Scenario 2 – Thermal Recovery

- Thermal Valorization in TRM plant - Turin

According to Decree 133/2014 («Decreto sblocca Italia»), the plant can work at the maximum of its potentiality

Yearly amount of waste treated in the Turin Incineration Plant (TRM)

Year	2014	2015	2016	Average
Treated wastes (t)	420,500	472,756	450,500	447,900



LHV (MJ/kg)	Amount (t)	Residual amount (t)
11.0	~ 580,000	132,000
11.5	~ 560,000	112,000
12.0	~ 530,000	82,000
12.5	~ 510,000	62,000
13.0	~ 490,000	42,000

Scenario 2 – Thermal Recovery

- Thermal Valorization in TRM plant - Turin

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

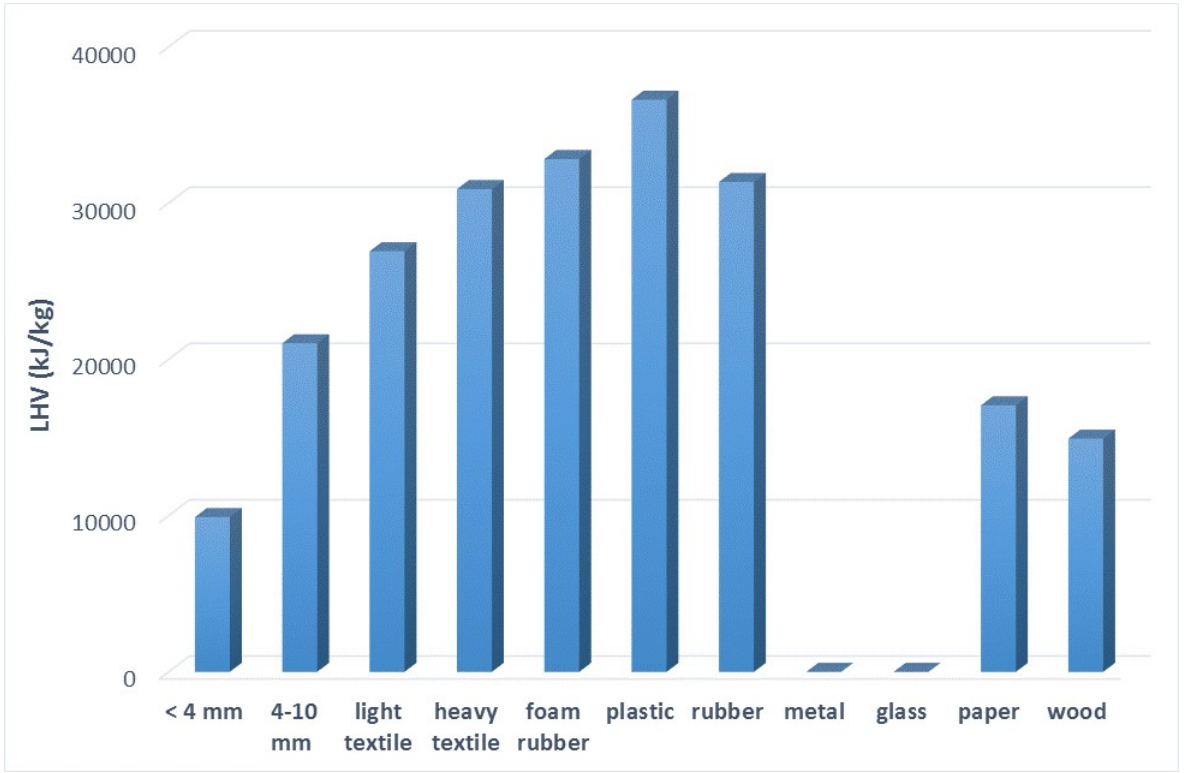
Caratteristiche di classificazione							
Caratteristica	Misura statistica	Unità di misura	Valori limite per classe				
			1	2	3	4	5
PCI	media	MJ/kg t.q.	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3
Cl	media	% s.s.	≤ 0,2	≤ 0,6	≤ 1,0	≤ 1,5	≤ 3
Hg	mediana	mg/MJ t.q.	≤ 0,02	≤ 0,03	≤ 0,08	≤ 0,15	≤ 0,50
	80° percentile	mg/MJ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

LHV: commercial parameter
Cl: process parameter
Hg: environmental parameter

Scenario 2 – Thermal Recovery

- Heating Value determination

Weighted average starting from the LHV data determined for each fraction with a Mahler calorimeter



Scenario 2 – Thermal Recovery

- Heating Value determination

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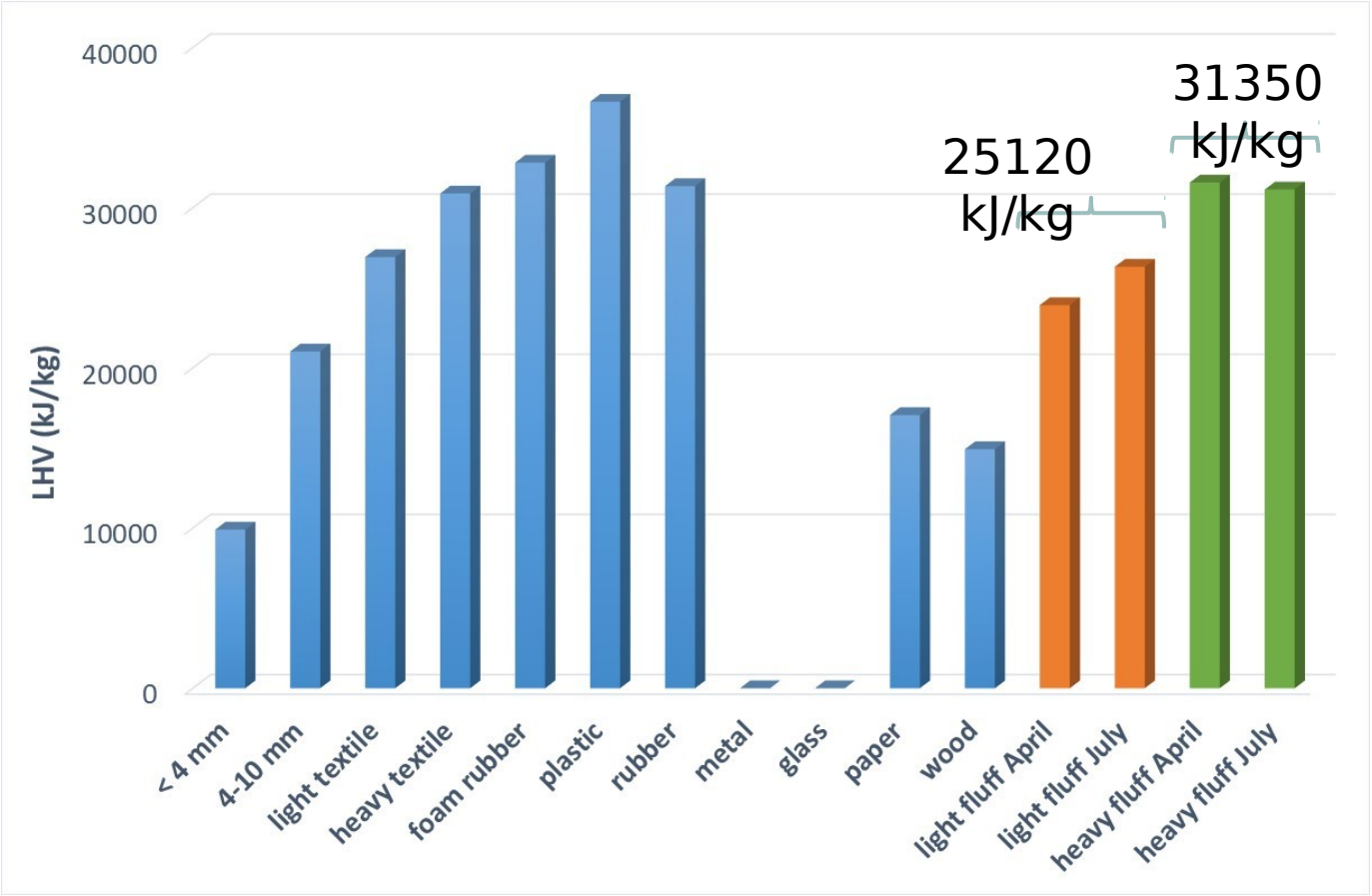


Scenario 2 – Thermal Recovery

- Chlorine and Sulfur determination

Mixed-plastic granules (d <4 mm)

↓

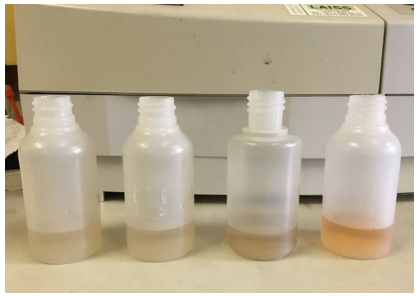
Dissolution in microwave oven
100 mg – 5 ml HNO_3 – 1 ml H_2O_2

↓

Chloride determination with the Volhard method ($Fe(SCN)^{2+}$)

↓

Chloride under the detection limit!
< 25 mg/kg ($2.5 \cdot 10^{-3}$ %)



Mixed-plastic granules (d <4 mm)

↓

Dissolution in microwave oven
100 mg – 5 ml HNO_3 – 1 ml H_2O_2

↓

Sulfate determination with turbidimetric method ($BaSO_4$)

↓

Sulfate under the detection limit!
< 250 mg/kg ($25 \cdot 10^{-3}$ %)

Scenario 2 – Thermal Recovery

- Chlorine in emissions after combust

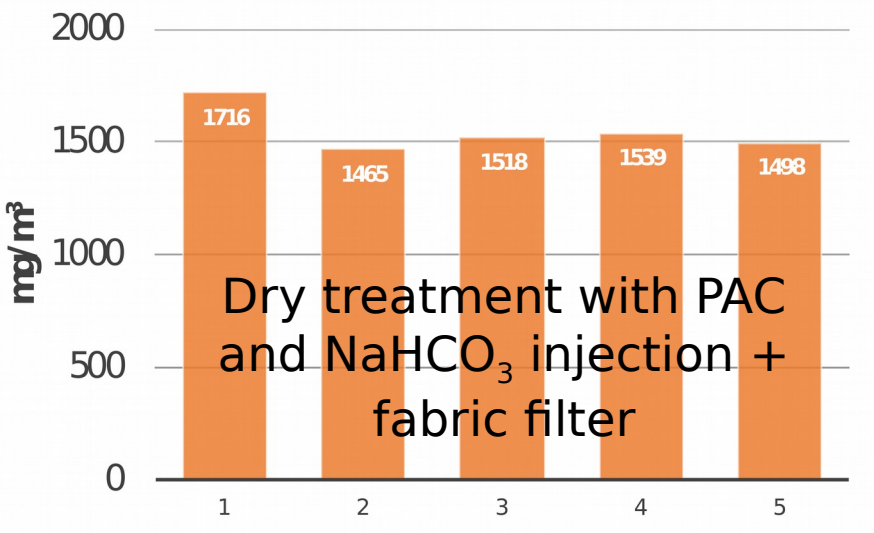
Recall: 11 MJ/kg → RP = 132,000 t

Table 6
Elemental composition and characteristics of ASR from Italian shredder plants (data are expressed as wt% of dry substances).

from Cossu et al., 2014

Parameters	Patierno et al. (1998)	Maurino (2000)	Galvagno et al. (2001)	APAT (2002)	Mirabile et al. (2002)	Zolezzi et al. (2004)	Viganò et al. (2010)	Ruffino et al. (2014)	Mancini et al. (2010)	Morselli et al. (2010)	Santini et al. (2011)
Ash					36.2	27.3			44.7	28.2	35.8
C	17.5	40	37.2	48.11	44.5	47	40	46	36.3		
H	2.1	5	4.8	6.07	5.3	5.8	5	5.89	4.67		
N	0.5	1	–	–	4.5	1.2	2	1.68	–		
O	17.4		1.5	–	6.9	19.5	2.5		–		
S	0.25	0.95	0.4	0.3	0.2	0.3	0.3	0.4	0.28	6	0.23
Cl	0.05	3.5	2	–	0.5		1.25		0.94		0.95
F	–		–	–	–	–	0.75		0.017	<0.05	

Average chlorine content: 1.31 wt% of dry subs



Five scenarios

1. Residual MSW after separate collection
2. Residual MSW + 45,000 t/y ASR
3. Residual MSW + 45,000 t/y ASR (Cl, 1.31%)
4. Residual MSW + 45,000 t/y ASR (Cl, +15%)
5. Residual MSW + 45,000 t/y ASR

Conclusions

Material Valorizatio

- Thermoplastics
- Thermosets

Light Fluff
13-15% b.w.

ρ < 1 kg/dm³
50%
PP

ρ > 1 kg/dm³
50%
PC or PA-6

Heavy Fluff
10-20% b.w.

ρ < 1 kg/dm³
30%
PP

ρ > 1 kg/dm³
70%
PC or PA-6
Unknown!
(resin?)

Conclusions

Thermal Valorization

- Benefit of a residual capacity of TRM plant
- Assessment of the cessation of the waste status of certain types of solid recovered fuels (SRFs) - 14/02/2013, n. 22

Residual capacity of TRM plant

42-132•10^3 t/y

depending on LHV

Decree 14/02/2013. n. 22

Caratteristiche di classificazione							
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Thanks for your kind attention!

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photo B. Ruffino, 2018

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