IEA Bioenergy

TASK 36

WORKSHOP

"Towards a Sustainable Waste Management"

Rome 17th May 2016

RSE Ricerca Sistema Energetico

ATIA ISWA ITALIA

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OPTIMIZATION OF SFR PRODUCTION AND CHARACTERIZATION

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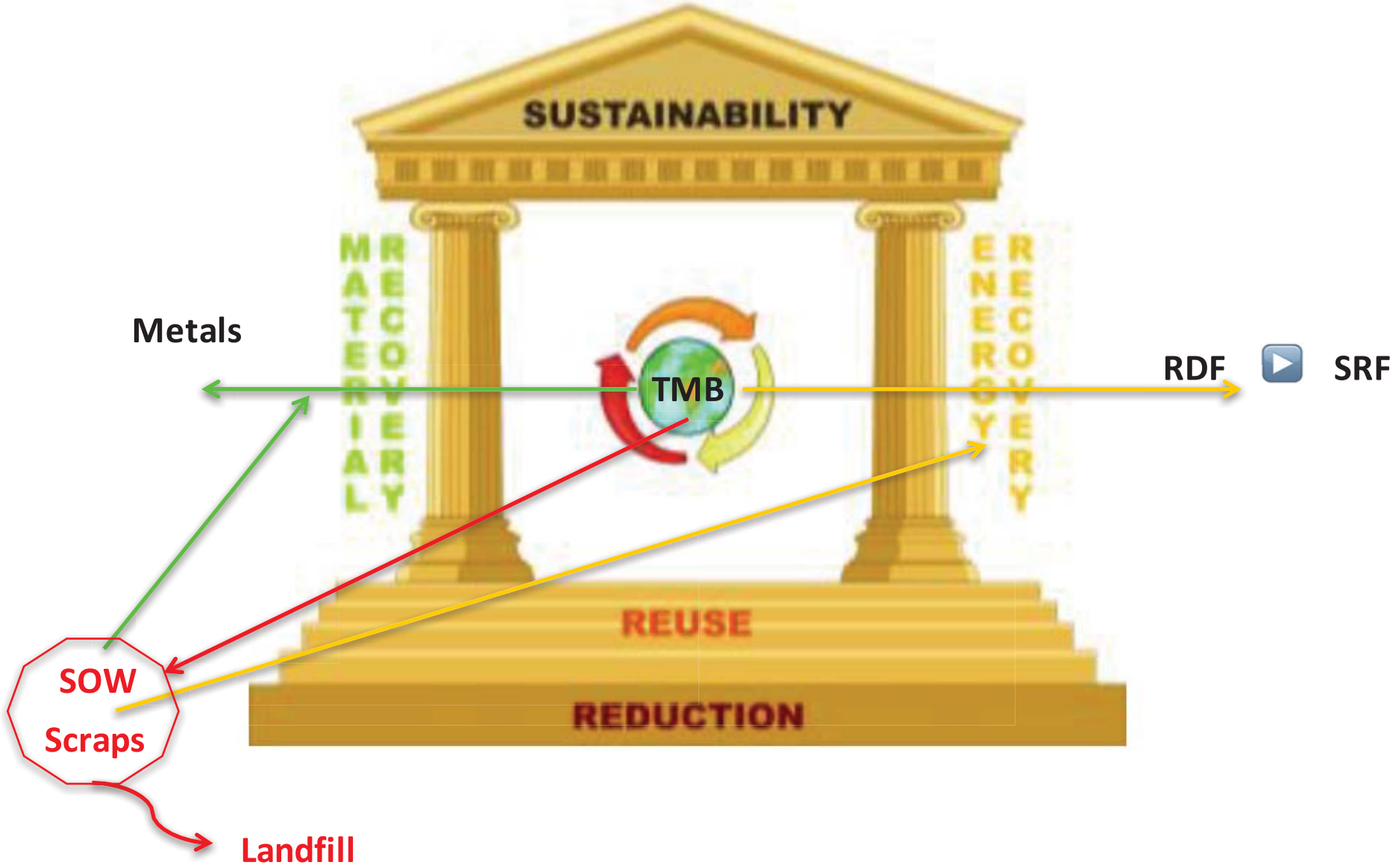
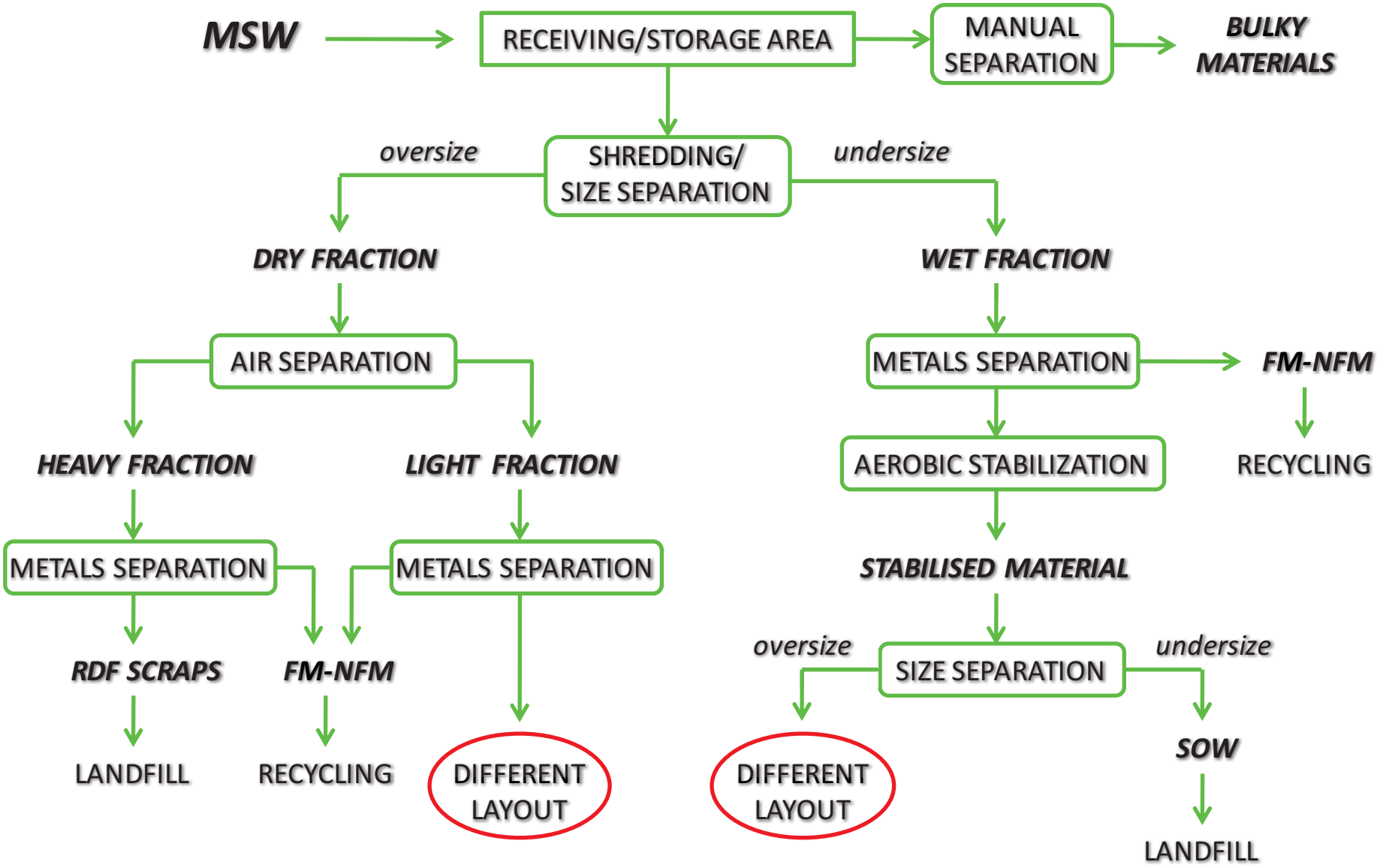
The role of MBT plants in waste management



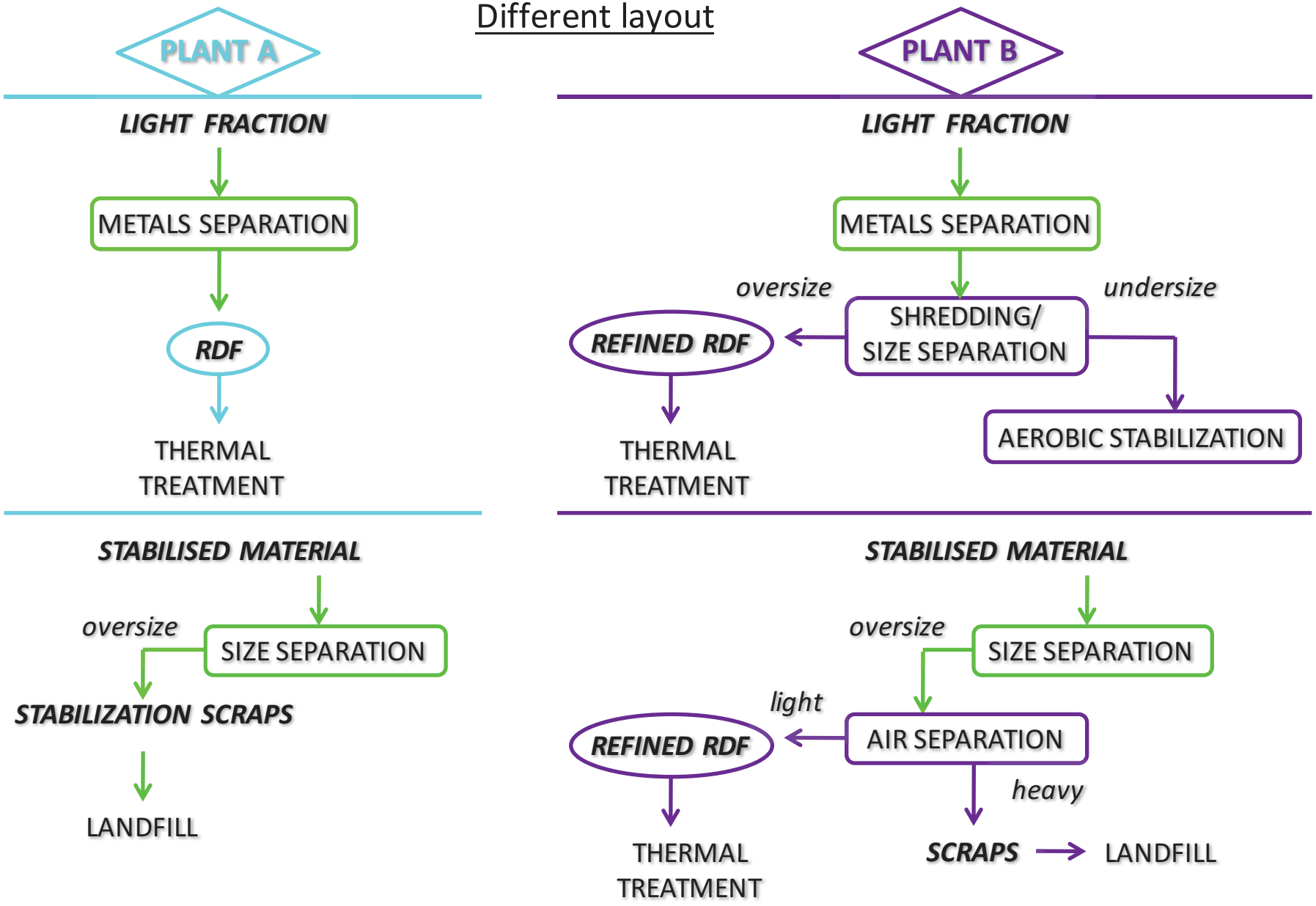
The MBT plants of Rome

Common process units



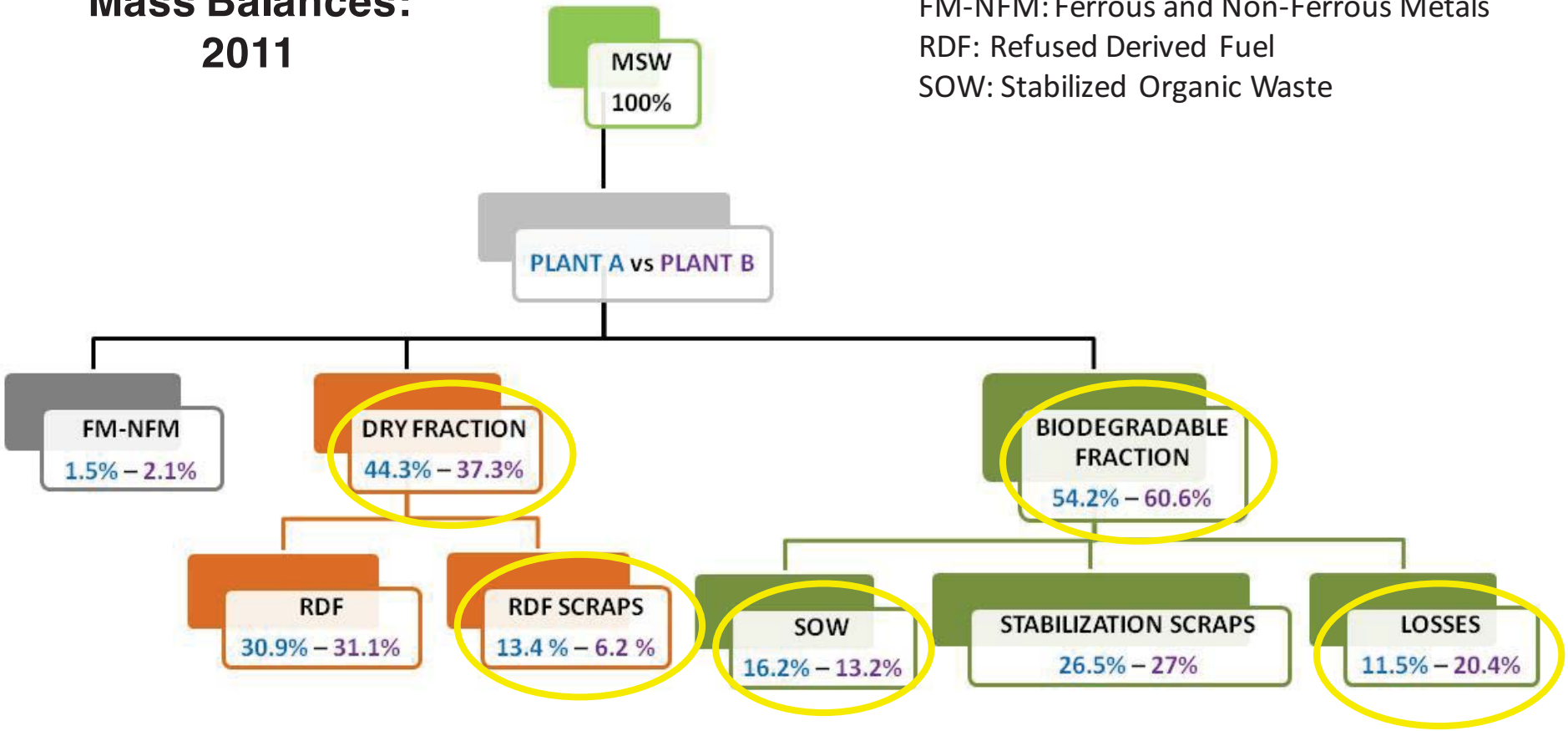
The MBT plants of Rome

Different layout



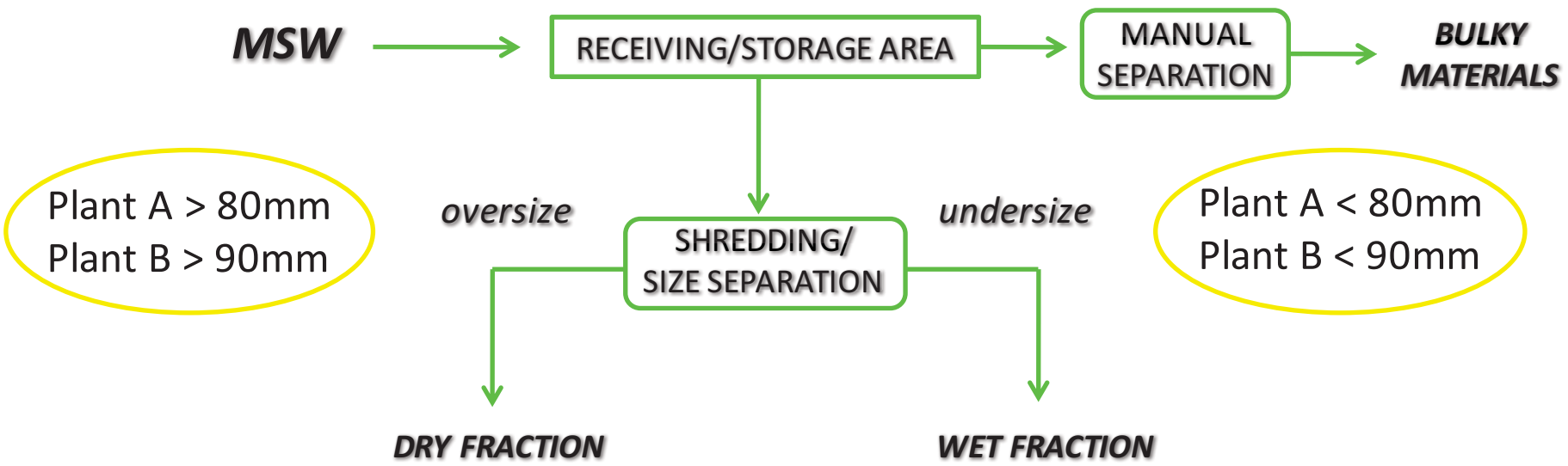
Mass Balances: 2011

MSW: Municipal Solid Waste
FM-NFM: Ferrous and Non-Ferrous Metals
RDF: Refused Derived Fuel
SOW: Stabilized Organic Waste

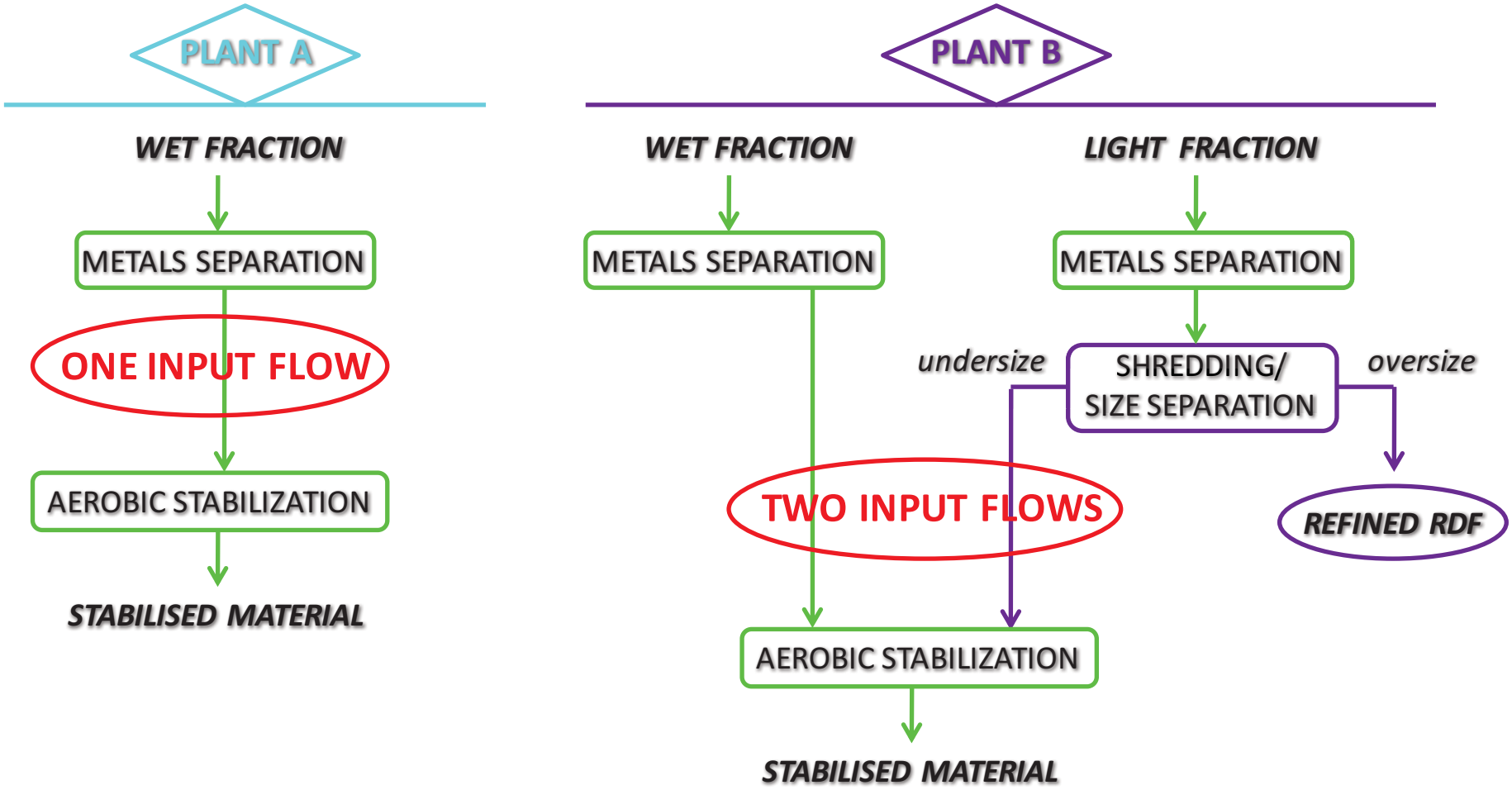


The differences in the mass balances are mainly due to the different configurations of the two plants.

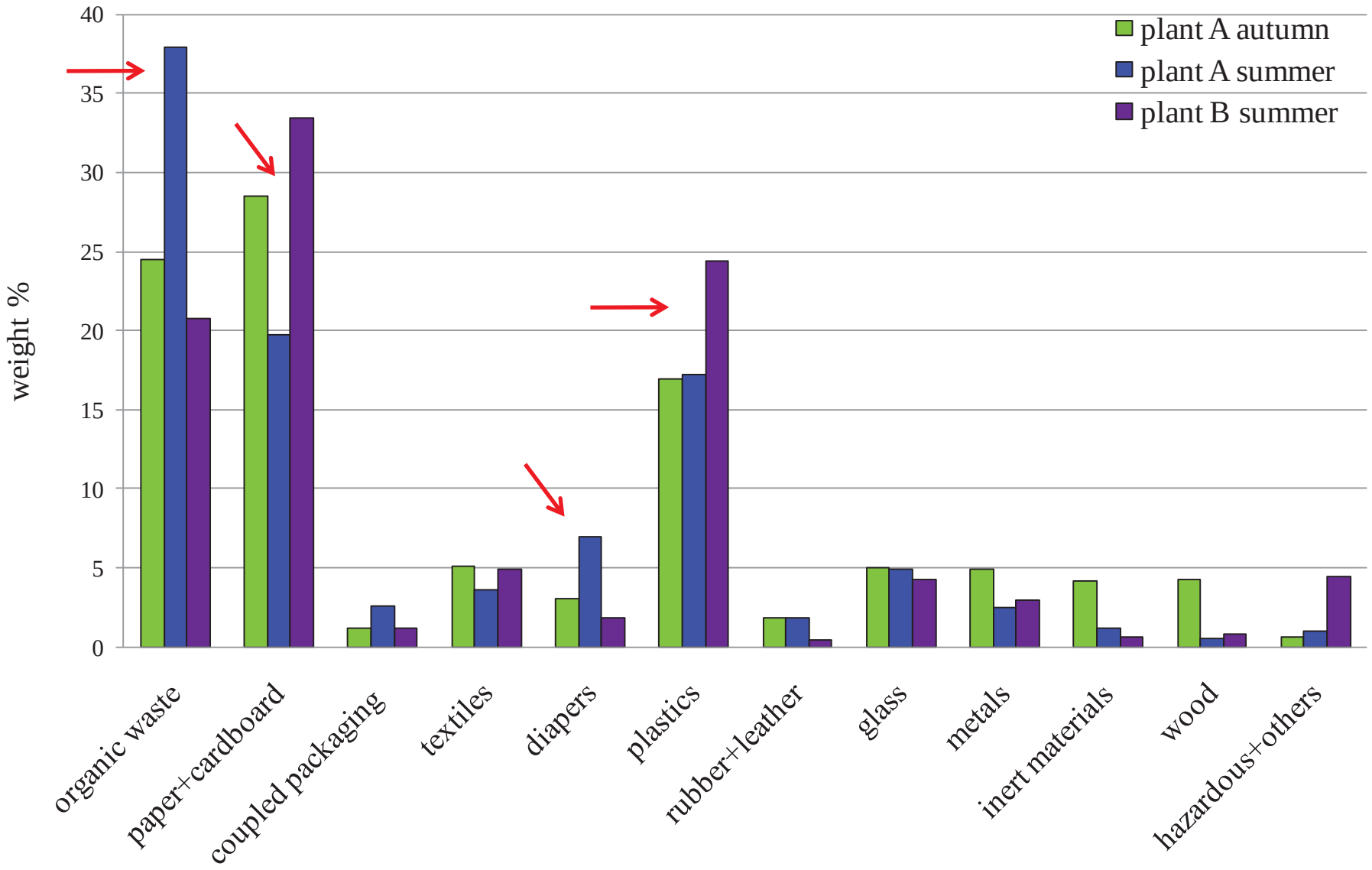
The MBT plants of Rome



Different layout



The MBT plants of Rome



Main features of MSW → heterogeneity and variability

RDF vs SRF

At first, in Italy, mechanical-biological treatment plants are authorised to produce Refuse Derived Fuel (RDF), CER 19 12 10, for waste-to-energy plants with characteristics observing the technical standard UNI 9903 (2004).

The RDF was abrogated by the issue of the Decree 205/2010, and the so called Solid Recovered Fuel (SRF) was introduced. (CER 19 12 10)

The Italian Thermotechnical Committee (CTI), associated to the National Agency for Standardization (UNI), has elaborated Guidelines documents, in accordance with European standard UNI EN 15359 (2011) and UNI EN 15442 (2011), that represents the Italian technical standard in order to establish all the characteristics, definitions, sampling methods, parameters of interest and analytical methods for the SRF. These Guidelines became the UNI/TS 11553:2014 (CTI 8:2012) and UNI TR 11581:2015 (CTI 11:2012).

UNI EN 15359 (2011) identifies 125 classes of limit values instead of 2 provided by UNI 9903 (2004)

Parameter for Specification of RDF

Parameter	Unit	Limit (RDF)	Limit RDF-HQ
Moisture	% ar	max 25	max 18
Net calorific value (NCV)	kJ/kg ar	min 15,000	min 20,000
Ashes	% d	max 20	max 15
Arsenic (As)	mg/kg	max 9	max 5
Cadmium (Cd) + Mercury (Hg)	mg/kg	max 7	max 3 (Cd) max 1 (Hg)
Clorine (Cl)	% ar	max 0.9	max 0.7
Chromium (Cr)	mg/kg	max 100	max 70
Soluble Copper (Cu)	mg/kg	max 300	max 50
Manganese (Mn)	mg/kg	max 400	max 200
Nickel (Ni)	mg/kg	max 40	max 30
Volatile Lead (Pb)	mg/kg	max 200	max 100
Sulfum (S)	% ar	max 0.6	max 0.3

ar: as recived
d: dry

Classification system for SRF

Classification property	Statistical measure	Unit	Classes				
			1	2	3	4	5
Net calorific value (NCV)	Mean	MJ/kg (ar)	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3
Chlorine (Cl)	Mean	% (d)	≤ 0.2	≤ 0.6	≤ 1.0	≤ 1.5	≤ 3
Mercury (Hg)	Median	mg/MJ (ar)	≤ 0.02	≤ 0.03	≤ 0.08	≤ 0.15	≤ 0.50
	80^{th} percentile	mg/MJ (ar)	≤ 0.04	≤ 0.06	≤ 0.16	≤ 0.30	≤ 1.00

ar: as recived
d: dry

Parameter for specification of SRF

Parameter	Unit			
Ashes	% (d)			
Moisture	% (d)			
Parameter	**Unit**	**Statistical measure**	**Max value (UNI/TS 11553:2014 - CTI 8)**	**Max value (End of waste) DM 14/2/2013 n. 22**
Antimony (Sb)	mg/kg ar	Median	150	50
Arsenic (As)	mg/kg ar	Median	15	5
Cadmium (Cd)	mg/kg ar	Median	10	4
Chromium (Cr)	mg/kg ar	Median	500	100
Cobalt (Co)	mg/kg ar	Median	20	18
Copper (Cu)	mg/kg ar	Median	2000	500
Lead (Pb)	mg/kg ar	Median	600	240
Manganese (Mn)	mg/kg ar	Median	600	250
Nickel (Ni)	mg/kg ar	Median	200	30
Thallium (Tl)	mg/kg ar	Median	10	5
Vanadium (V)	mg/kg ar	Median	150	10

ar: as recived

d: dry

The following slides assessed the quality of the dry light flow (until 2010 indicated as refuse derived fuel, RDF) to qualify the solid recovered fuel (SRF) produced by the two mechanical biological treatment plants of AMA Rome (Italy).

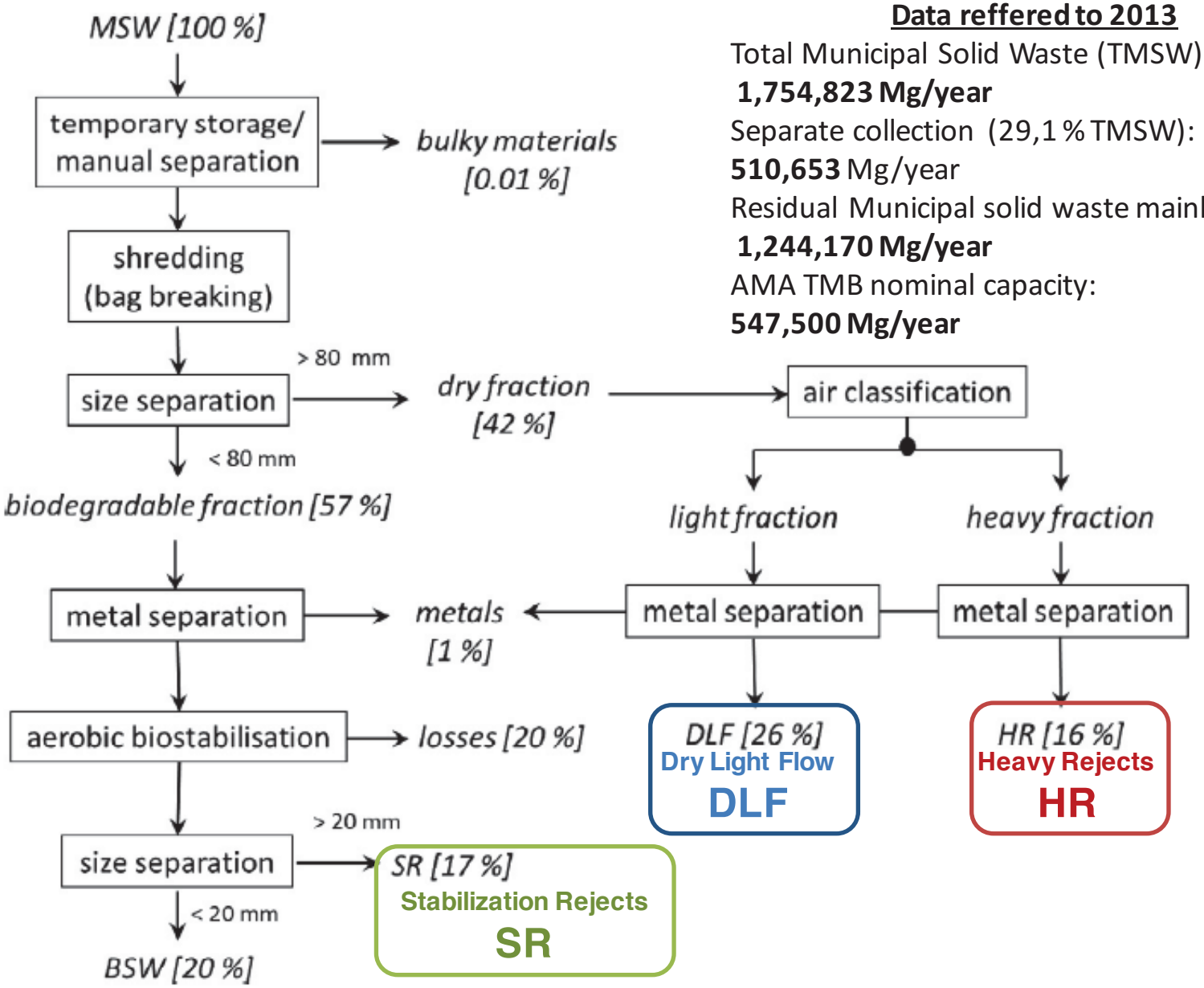
SRF classification and specifications were evaluated first on the basis of RDF historical characterisation methods and data and then applying the sampling and analytical methods laid down by the recently issued SRF standards.

The quality in terms of solid recovered fuel (SRF) of the heavy rejects and stabilisation rejects, produced by the same plants, was evaluated too, applying the sampling and analytical methods laid down by the recently issued SRF standards.

As for the reject flows, on the basis of their SRF classification and specification parameters, different simulations were carried out combining these flows with the dry light flow to evaluate if these resulting flows could be also treated in combustion plants instead of landfilled.

Finally, the study wants to prove that the introduction of SRF definitions, classification and specification procedures, could lead to an upgrade of the waste as co-fuel in cement kilns and power plants, but may anyhow provide new possibilities for energy recovery from waste by increasing the types of mechanically treated waste flows that may be thermally treated.

STUDIES ON TMB PLANTS OF AMA SPA - ROME



Data reffered to 2013

Total Municipal Solid Waste (TMSW):
1,754,823 Mg/year
Separate collection (29,1 % TMSW):
510,653 Mg/year
Residual Municipal solid waste mainly to TMB:
1,244,170 Mg/year
AMA TMB nominal capacity:
547,500 Mg/year

Comparison between the former RDF and the current methodologies for SRF classification and specifications

SRF classification of DLF based on RDF historical data.

Characteristics	Arithmetic mean	Max	Min	SD	Mean (95% CI)	Median	80th percentile	SRF classes
Plant A								
NCV (MJ/kg ar)	16.71	18.87	15.61	0.9	16.30			3
Cl (% *d*)	0.17	0.29	0.03	0.07	0.20			2
Hg (mg/MJ ar)	0.01	0.03	0.01	0.006		0.006	0.008	1
Ashes (% *d*)	16.37	18.96	12.35	2.35				
Moisture (% ar)	22.58	25.37	19.26	1.85				
Plant B								
NCV (MJ/kg ar)	16.94	18.36	15.32	0.9	16.53			3
Cl (% *d*)	0.18	0.25	0.11	0.05	0.20			2
Hg (mg/MJ ar)	0.01	0.09	0.01	0.02		0.006	0.006	1
Ashes (% *d*)	14.19	18.61	7.03	3.67				
Moisture (% ar)	19.62	24.61	12.95	3.50				

Median values of the metal contents (mg/kg d) for RDF historical (SRF specification parameters)

Metals	RDF historical data		Limits	
	Plant A	Plant B	CTI	EoW
Sb	0.1	0.1	150	50
As	0.2	0.2	15	5
Cd	0.1	0.1	10	4
Cr	5.7	3.0	500	100
Co	0.1	0.1	20	18
Cu	2.9	0.9	2000	500
Pb	21.0	14.6	600	240
Mn	78.1	32.0	600	250
Ni	2.3	1.4	200	30
Tl	4.4	2.4	10	5
V	2.3	2.3	150	10

Conclusive response:

On the basis of the historical characterisation and specification based on former RDF standard methods, the dry light fraction could be qualified as a SRF "fuel" (EoW) potentially usable for co-combustion in cement and power plants.

Sampling methods for RDF and SRF.

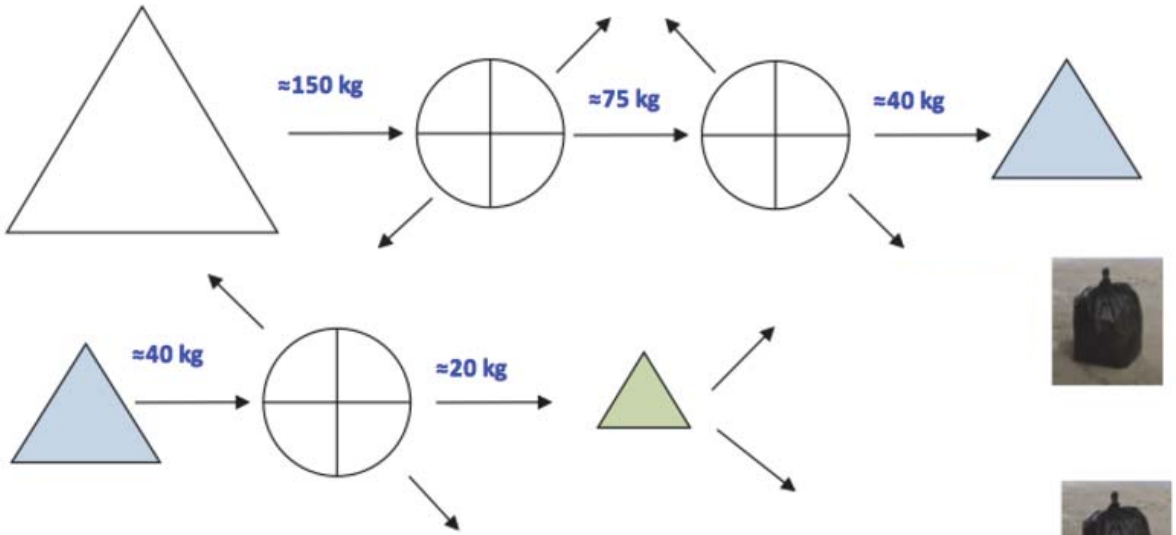
		SRF		
	RDF	DLF	HR	SR
Lot	5 weeks production	Weekly production	Weekly production	Weekly production
Number of lots	5	10	10	10
Sampling procedure	Manually from drop flow	Manually from drop flow	Manually from stationery conveyor	Manually from drop flow
Numbers of increments per day	8	6	6	6
Numbers of increments per week	40	30	30	30
Increment size	54 kg	5 kg	7 kg	3 kg
Combined sample size per week	2200 kg	150 kg	210 kg	90 kg
Sub sample for lab analysis per week	Post quartering 10 kg	Post dimensional reduction/ quartering 5 kg	Post dimensional reduction/ quartering 5 kg	Post dimensional reduction/ quartering 5 kg

STUDIES ON TMB PLANTS OF AMA SPA - ROME

1.200 Mg/week

DLF
Weekly production
10
Manually from drop flow
6
30
5 kg
150 kg
Post dimensional reduction/ quartering 5 kg

STUDIES ON TMB PLANTS OF AMA SPA - ROME



STUDIES ON TMB PLANTS OF AMA SPA - ROME

800 Mg/week

HR

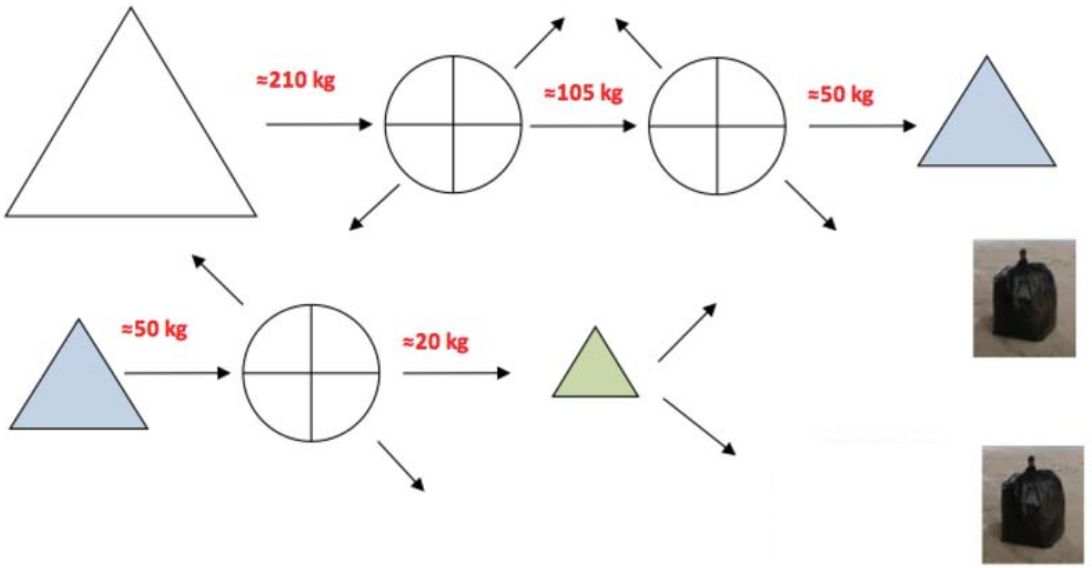
Weekly production
10
Manually from stationery conveyor
6
30
7 kg
210 kg
Post dimensional reduction/ quartering 5 kg

SR

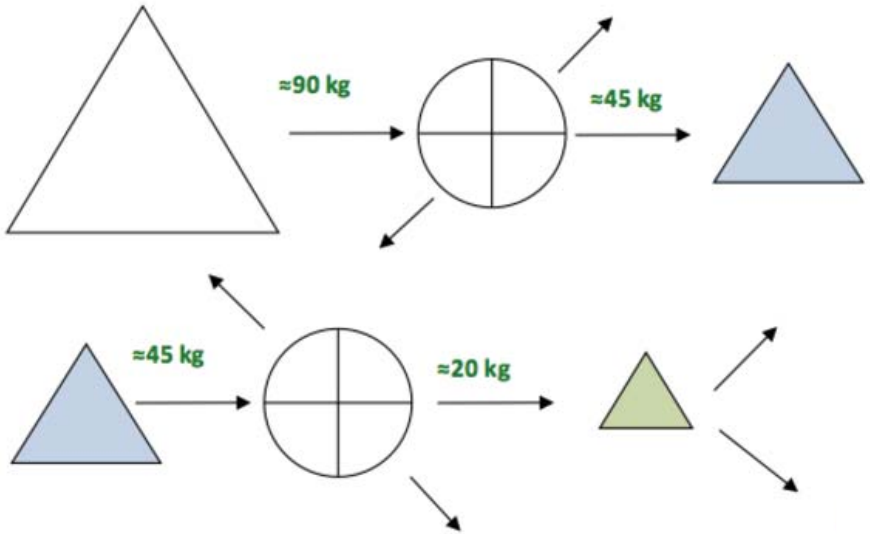
Weekly production
10
Manually from drop flow
6
30
3 kg
90 kg
Post dimensional reduction/ quartering 5 kg

800 Mg/week

STUDIES ON TMB PLANTS OF AMA SPA - ROME



STUDIES ON TMB PLANTS OF AMA SPA - ROME



SRF classification and specifications based on current sampling and characterisation methods

SRF classification of DLF based on current data.

Characteristics	Arithmetic mean	Max	Min	SD	Mean (95% CI)	Median	80th percentile	SRF classes
Plant A								
NCV (MJ/kg ar)	14.09	17.20	12.40	1.66	13.06			4
Cl (% *d*)	0.29	0.39	0.19	0.07	0.33			2
Hg (mg/MJ ar)	0.03	0.10	0.01	0.03		0.024	0.035	1
Ashes (% *d*)	18.29	22.10	15.20	1.87				
Moisture (% ar)	29.91	36.20	19.80	6.37				
Plant B								
NCV (MJ/kg ar)	13.91	15.10	12.70	0.97	13.31			4
Cl (% *d*)	0.35	0.77	0.11	0.21	0.48			2
Hg (mg/MJ ar)	0.014	0.02	0.01	0.004		0.014	0.015	1
Ashes (% *d*)	16.41	26.80	12.30	4.04				
Moisture (% ar)	28.44	31.20	21.20	2.84				

Median values of the metal contents (mg/kg d) for RDF (specification parameters)

Metals	RDF historical data		DLF current data		Limits	
	Plant A	Plant B	Plant A	Plant B	CTI	EoW
Sb	0.1	0.1	9.0	6.5	150	50
As	0.2	0.2	1.0	2.0	15	5
Cd	0.1	0.1	0.5	0.5	10	4
Cr	5.7	3.0	30.5	32.0	500	100
Co	0.1	0.1	5.0	2.0	20	18
Cu	2.9	0.9	85.0	67.5	2000	500
Pb	21.0	14.6	74.0	65.5	600	240
Mn	78.1	32.0	98.0	76.5	600	250
Ni	2.3	1.4	15.0	15.5	200	30
Tl	4.4	2.4	1.0	1.0	10	5
V	2.3	2.3	6.5	5.0	150	10

Conclusive response:

On the basis of the current characterisation, based on classification results, the dry light fraction could be qualified only as a SRF "refuse".

SRF classification of the reject flows.

Characteristics	Arithmetic mean	Max	Min	SD	Mean (95% CI)	Median	80th percentile	SRF classes
Plant A – HR								
NCV (MJ/kg ar)	10.72	12.80	7.90	1.62	9.72			5
Cl (% *d*)	0.24	0.40	0.10	0.11	0.31			2
Hg (mg/MJ ar)	0.04	0.16	0.01	0.05		0.029	0.045	2
Ashes (% *d*)	20.66	29.50	12.20	5.45				
Moisture (% ar)	30.43	46.10	21.50	8.18				
Plant B – HR								
NCV (MJ/kg ar)	10.18	12.1	8.4	1.21	9.43			5
Cl (% *d*)	0.30	0.63	0.10	0.16	0.40			2
Hg (mg/MJ ar)	0.03	0.14	0.01	0.05		0.010	0.032	1
Ashes (% *d*)	22.52	31.40	17.20	4.17				
Moisture (% ar)	33.73	39.80	21.40	5.82				
Plant A – SR								
NCV (MJ/kg ar)	7.55	11.30	5.80	1.73	6.47			5
Cl (% *d*)	0.57	0.94	0.20	0.30	0.76			3
Hg (mg/MJ ar)	0.08	0.14	0.03	0.04		0.070	0.113	3
Ashes (% *d*)	48.35	56.80	39.80	5.97				
Moisture (% ar)	29.22	37.60	23.50	4.57				
Plant B – SR								
NCV (MJ/kg ar)	9.53	13	5.3	2.14	8.20			5
Cl (% *d*)	0.40	0.71	0.10	0.22	0.54			2
Hg (mg/MJ ar)	0.03	0.06	0.02	0.01		0.025	0.040	1
Ashes (% *d*)	43.50	56.00	27.40	11.45				
Moisture (% ar)	20.14	25.10	16.20	2.85				

Metals	Heavy rejects		Stabilisation rejects		Limits
	Plant A	Plant B	Plant A	Plant B	CTI
Sb	5.0	5.0	8.5	5.0	150
As	1.0	1.0	3.5	3.5	15
Cd	0.5	0.5	0.8	0.6	10
Cr	11.0	15.0	19.0	31.0	500
Co	5.0	2.0	5.0	7.0	20
Cu	61.0	41.0	270.0	381.0	2000
Pb	36.5	20.0	267.5	120.0	600
Mn	73.5	61.5	308.0	624.5	600
Ni	6.5	7.0	30.0	59.0	200
Tl	5.0	1.0	5.0	1.0	10
V	5.5	6.5	14.0	15.5	150

Conclusive response:

On the basis of the current characterisation, based on classification results, the Heavy rejects could be qualified as a SRF "refuse".

The Stabilisation rejects ***could non be qualified*** *as a SRF "refuse", with respect to CTI limits.*

Simulation of different material flows for SRF classification and specifications

On the basis of their SRF classification and specification parameters, different simulations were carried out combining these flow with the dry light flow to evaluate if these material flows could be also treated in combustion plants instead of landfilled.

F1 [DLF (26%$_{MSW}$) + HR (16%$_{MSW}$)] = 60% DLF + 40% HR

F2 [DLF (26%$_{MSW}$) + SR (16%$_{MSW}$)] = 60% DLF + 40% SR

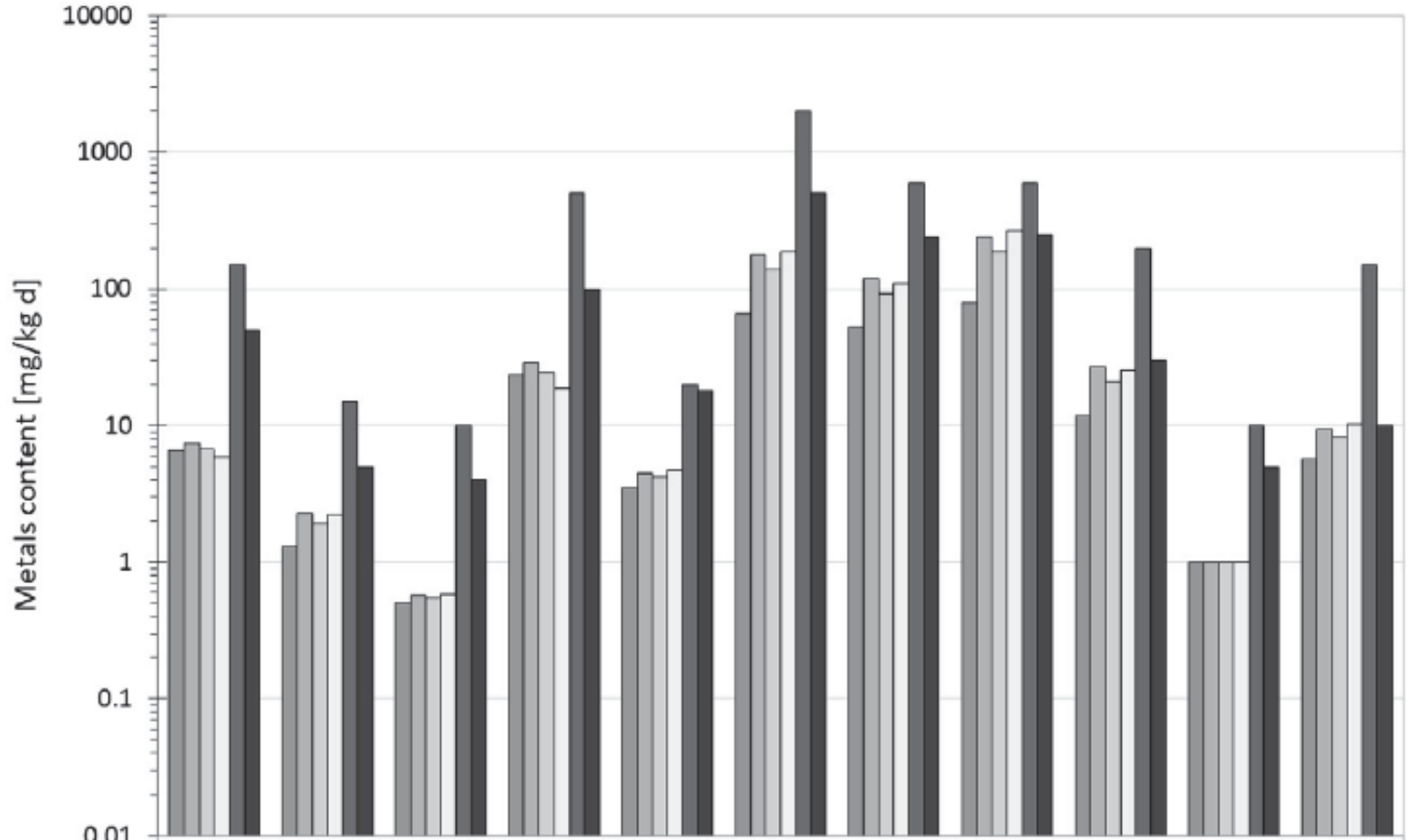
F3 [DLF (26%$_{MSW}$) + HR (16%$_{MSW}$) + SR (16%$_{MSW}$)] = 44% DLF + 28% HR + 28% SR

F4 [HR (16%$_{MSW}$) + SR (16%$_{MSW}$)] = 50% HR + 50% SR

SRF classification of the simulated flows.

Characteristics	Mean	Median	80th percentile	SRF classes
F1 [DLF (26%MSW) + HR (16%MSW)] = 60% DLF + 40% HR				
NCV (MJ/kg ar)	11.78			4
Cl (% *d*)	0.27			2
Hg (mg/MJ ar)		0.018	0.030	1
F2 [DLF (26%MSW) + SR (16%MSW)] = 60% DLF + 40% SR				
NCV (MJ/kg ar)	10.90			4
Cl (% *d*)	0.37			2
Hg (mg/MJ ar)		0.026	0.043	2
F3 [DLF (26%MSW) + HR (16%MSW) + SR (16%MSW)] = 44% DLF + 28% HR + 28% SR				
NCV (MJ/kg ar)	10.58			4
Cl (% *d*)	0.34			2
Hg (mg/MJ ar)		0.029	0.045	2
F4 [HR (16%MSW) + SR (16%MSW)] = 50% HR + 50% SR				
NCV (MJ/kg ar)	8.51			5
Cl (% *d*)	0.38			2
Hg (mg/MJ ar)		0.034	0.058	2

STUDIES ON TMB PLANTS OF AMA SPA - ROME



	Sb	As	Cd	Cr	Co	Cu	Pb	Mn	Ni	Tl	V
F1	6.7	1.3	0.5	23.8	3.5	65.4	52.3	79.1	11.8	1.0	5.8
F2	7.4	2.3	0.6	28.8	4.5	176.0	119.4	238.9	27.0	1.0	9.4
F3	6.7	1.9	0.5	24.2	4.2	138.3	92.1	187.4	21.0	1.0	8.3
F4	5.9	2.3	0.6	18.8	4.8	187.3	109.9	266.5	25.5	1.0	10.3
CTI limits	150	15	10	500	20	2,000	600	600	200	10	150
EoW limits	50	5	4	100	18	500	240	250	30	5	10

Conclusive response:

On the basis of the simulated data, based on current classification and specification results of the examined flows, it is observed as follows:

The simulated flow F1 [DLF (26%$_{MSW}$) + HR (16%$_{MSW}$)] = 60% DLF + 40% HR *could be qualified as a SRF "refuse" with the same classification (4 2 1) of the Dry Light Fraction flow.*

The simulated flow F3 [DLF (26%$_{MSW}$) + HR (16%$_{MSW}$) + SR (16%$_{MSW}$)] = 44% DLF + 28% HR + 28% SR *could be qualified as a SRF "refuse" with the classification 4 2 2, increasing from 26% to 58 % of initial MSW fed to TMB plant the amount that could be recovered as energy in WTE plant.*

In conclusion, the introduction of SRF definitions, classification and specification procedures, while not necessarily leading to an upgrade of the waste as co-fuel in cement kilns and power plants, may anyhow provide new possibilities for energy recovery from waste by increasing the types of mechanically treated waste flows that may be thermally treated.

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The application of SRF vs. RDF classification and specifications to the material flows of two mechanical-biological treatment plants of Rome: Comparison and implications

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