RDF/SRF evolution and MSW bio-drying

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Abstract

In Europe the mechanical/biological treatment (MBT) is an increasing option as a pre-treatment either before landfilling or before combustion. In this paper, taking into account the new EU directives and in particular the Italian situation, differences between fuel derived from MSW (RDF) and Solid Recovery Fuel (SRF) are presented. In agreement with the new EU directives, RDF/SRF can be produced from approaches based both on the one-stream plant concept and on the conventional two-stream process. The first option refers to bio-drying. The effect of different strategies of selective collection of MSW is analyzed in term of characteristics of the residual MSW and its suitability to be converted into RDF/SRF. The role of respirometry is discussed too.
Keywords: municipal solid waste, lower heating value, refuse derived fuel, respirometry, selective collection, solid recovered fuel.

1 Introduction

The amount of municipal solid waste (MSW) has strongly grown in the last decade and continues to do so worldwide. The mechanical/biological treatment (MBT) is a term generally used for a number of waste management processes such as material recovery facilities (MRF), refuse derived fuel production, mechanical separation, sorting, composting and pasteurizing. Originally the MBT-concept has been developed in the 80s in order to divide the waste stream in wet fine fraction and dry coarse fraction. Later, with the introduction of selective collection of the dry recyclable fraction and the development of the waste-to-energy sector, MBT was presented also in the option treating the entire waste stream for producing a fuel.

The aim of MBT is to minimize the environmental impact associated with landfilling of biodegradable waste and to obtain additional value from waste by

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recovery of recyclable materials such glass, metals, waste-derived solid fuels fractions. Even if MBTs are based on biological processes, generally one of the final products is used in different combustion plants in order to obtain energy, taking into account the European Union (EU) regulation both on the material recovery and on the energy valorization (2001/77/EC).

The MBT treatment plants are more adopted in Germany, Italy, Austria, France, Spain. With the new European Union requests (1999/31/EC) regarding the decrease of the organic matter in landfilling, 35% of the 1995 level by 2014 with the possibility to have 4 years derogation, this kind of plant has become more and more interesting for countries recently entered in the EU. The EU Member States must implement source-separation strategies or waste sorting plants for the biodegradable fraction of MSW or alternatively divert waste to other treatment methods. To this concern, in this paper, taking into account the new EU directives and in particular the Italian situation (regulated by the decree 205/2010), differences between fuel derived from MSW, that is Refuse Derived Fuel (RDF) regulated by the decree 5/02/1998, and the new one named Solid Recovery Fuel (SRF) according to the decree 205/2010, are presented together with some considerations on the way to produce them.

Finally, a few scenarios of selective collection and their consequences on the characteristics of residual MSW and the obtainable RDF/SRF are analyzed.

2 RDF and SRF characterization

In Italy, the first definition for RDF was introduced by the Italian Decree 22/97 art. 6: "RDF *is fuel derived from municipal solid waste through treatments aimed to the elimination of substances hazardous for combustion and to guarantee an adequate lower heating value (LHV), and to comply with the technical norms for its characterization"*.

The technical norm was issued, in Italy through the Decree 5/02/1998 that contains 14 technical documents (norms UNI 9903:1-14) establishing all the characteristics, definitions, sampling methods, parameters of interest and analytical methods for refuse derived fuel (RDF) and for the refuse derived fuel of high quality (RDF_Q). The technical specification for RDF and RDF_Q are presented in table 1.

In 2006, thanks to the Decree 152/2006 (*Testo Unico Ambientale*), at article 183, the RDF and RDF_Q were the fuel obtained from non hazardous municipal solid waste and special waste (limited to a contribution of maximum 50%) through treatment aimed to obtain a LHV adequate to its use; additional aims related to the RDF concept were the decrease and control of the environmental and sanitary risk, of the presence of metals, glass, inert, putrescible materials and water content and of the presence of hazardous substances, in particular related to combustion. RDF and RDF_Q were also classified as special waste and only RDF_Q was considered a renewable source, according to Article 2, paragraph 1, letter a) of Legislative Decree 29 December 2003, No 387, in proportion to the biodegradable fraction contained in it.

Table 1: Technical specifications for RDF and RDF_Q (d.m. = dry matter; as is = wet basis).

RDF				***RDF_Q***		
Charact.	Units	Limit of acceptance		Charact.	Units	Limit of acceptance
Moisture	% as is	max. 25		Moisture	% as is	max. 18
LHV	MJ/kg as is	min. 15		LHV	MJ/kg d.m.	min. 20
Ash content	% d.m.	max. 20		Ash content	% d.m.	max. 15
As	mg/kg d.m.	max. 9		As	mg/kg d.m.	max. 5
Cd	-	-		Cd	mg/kg d.m.	max. 3
Hg	-	-		Hg	mg/kg d.m.	max. 1
Cd+Hg	mg/kg d.m.	max. 7		Cd+Hg	-	-
Total Cl	% as is	max. 0.9		Total Cl	% d.m.	max. 0.7
Cr	mg/kg d.m.	max. 100		Cr	mg/kg d.m.	max. 70
Soluble Cu	mg/kg d.m.	max. 300		Soluble Cu	mg/kg d.m.	max. 50
Mn	mg/kg d.m.	max. 400		Mn	mg/kg d.m.	max. 200
Ni	mg/kg d.m.	max. 40		Ni	mg/kg d.m.	max. 30
Volatile Pb	mg/kg d.m.	max. 200		Volatile Pb	mg/kg d.m.	max. 100
S	% as is	max. 0.6		S	% d.m.	max. 0.3
Glass content	% d.m.	*		Glass content	% d.m.	*
Fe	% d.m.	*		Fe	% d.m.	*
Fluorine	% d.m.	*		Fluorine	% d.m.	*
Al	% d.m.	*		Al	% d.m.	*
Sn	% d.m.	*		Sn	% d.m.	*
Zn	% d.m.	*		Zn	% d.m.	*
Exterior aspect	-	*		Exterior aspect	-	*
Dimensions	mm	*		Dimensions	mm	*
Ash softening	°C	*		Ash softening	°C	*
* for this parameter a limit is not set.				* for this parameter a limit is not set.		

In December 2010, in Italy the RDF sector was changed by the issue of the Decree 205/2010, referring to 30 technical documents (mainly in the range of norms UNI CEN/TS 15357 - 15747) that establish all the characteristics, definitions, sampling methods, parameters of interest and analytical methods for the solid recovered fuel (SRF).

The SRF definition was introduced in Italy by the Italian Decree 205/2010: *"SRF is the solid fuel prepared (means processed, homogenized and up-graded* *to a quality that can be traded amongst producers and users) from non-hazardous waste to be utilized for energy recovery in incineration or co-incineration plants and meeting the classification and specification requirements laid down in CEN/TS 15359".*

The classification system for SRFs is based on limit values for three important fuel properties that are presented in table 2.

Table 2: Technical specifications for SRF (ar=as received; d = dry).

Classification property	*Statistical measure*	*Unit*	*Classes*				
			1	*2*	*3*	*4*	*5*
Net calorific value	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	≤ 0.5
	80^{th} percentile		≤ 0.04	≤ 0.06	≤ 0.16	≤ 0.30	≤ 1.0

Each property is divided into 5 classes with limit values. The SRF shall be assigned a class number from 1 to 5 for each property. A combination of the class numbers makes up the class code. The parameters are of equal importance and thus no single class number determines the code.

These classes have been determined as a tool for identifying and pre-selecting SRF. However, the performance of the plant where a SRF can be used depends on the properties of the SRF and more significantly on the design and operating conditions of the chosen plant. In table 3 an overview of SRF specifications requested for the use in different plants are presented.

Table 3: Overview of specifications (end-users).

	Unit	*Cement*	*Hard coal*		*Brown coal*	*FBC*	*FBC (AC)*
			DBB	*WBB*	*DBB*		
LHV	MJ/kg	5 to 22	13.5 to18	17 to 22	13.5 to 18	13.5 to 18	13.5 to 18
Cl	% ar	0.5 to 3	0.5 to 1.0	1.0 to 2.0	0.4 to 0.7	0.4 to 1.4	0.4 to 1.4
Hg	mg/MJar	0.08 to 0.33	0.065	0.034	0.085	0.028	0.26
Cd	mg/MJar	6.90	1.21	0.25	0.42	0.63	85

AC: active coal used absorbent
ar = as received
DBB= dry bottom boiler pulverized coal, dry ash
WBB= wet bottom boiler pulverized coal, molten slag
FBC= fluidized bed combustion

An important parameter for the SRF characterization is the potential rate of microbial self heating. This rate can be determined by the real dynamic respiration index (RDRI = average value of the respiration indexes, referred to total dry solids, TDS, representing 24 h showing the highest aerobic micro-activity). Until 2010 in Italy this parameter has been requested only for the stabilized organic fraction (UNI/TS 11184, 2006) and not for fuels. With the transposition of the technical norm CEN/TR 15590 in decree 2005/2010, this RDRI parameter has become a key parameter for SRF. Different potential microbial self heating of an SRF are presented in table 4.

Table 4: RDRI values.

RDRI mg $_{O2}$ kg^{-1}_{TDS} h^{-1}	Potential microbial self heating
< 500	very low
500 to 1000	low
1000 to 2000	moderately high
2000 to 3000	high
> 3000	very high

The solution for producing SRF can influence the RDRI, because of the presence of putrescible materials in the treated waste. In Germany (BMU, 2001) and Austria (BKA, 2004) the respiration activity and the self –heating test as stability parameter for biologically treated waste have been common since a few years.

Generally, there are two technologies which have been developed in order to generate, from non hazardous fractions of MSW, a high calorific fraction which can be used as SRF/RDF:

- the one-flow treatment of MSW (based on **bio-drying**): the aim is the exploitation of the exothermic reactions for the evaporation of the highest part of the moisture in the waste, with the lowest conversion of organic carbon;
- the two-flow treatment of MSW (based on **bio-stabilization or anaerobic digestion**): the waste is first divided in two flows: undersieve and oversieve. The oversieve is used in order to obtain RDF/SRF.

The quality of RDF/SRF can be improved adding other post-treatments of refining.

In some two-flow process cases, when the first step (sieving) is not well performed, the quantity of putrescible material in the oversieve is not negligible; in this case a bio-drying process should be applied also to this stream: in practice, by the RDRI parameter adoption, an approach based on a simple screening of RMSW is expected to be avoided.

The SRF generated from non hazardous special waste can come from industrial waste, commercial waste, waste from construction and demolition, sewage sludge, etc. The SRF can be produced also form source-separated processed dry combustible fraction which cannot be used for recycling as for example cardboard drink containers or PE/PET bottles contaminated by PVC, packaging waste or rejects from manufacturing, scrap tyres, discarded biomass (i.e. straw, untreated wood waste, dried sewage sludge), waste textiles, residues from car dismantling operations, etc.). Industrial waste used as SRF has to be processed to meet industry specifications: homogenization, consistent LHV, limiting chlorine, etc. The limit of 50% of special waste can make less critical the presence of putrescible waste in the streams of RMSW to be classified as SRF.

3 MSW selective collection, bio-drying and RDF/SRF generation

In the last years, in Italy the efficiency of selective collection (SC) has increased giving also the possibility to obtain a residual MSW (RSMW) with an interesting energy content and a low level of contamination (less heavy metals, etc.).

A question raised in the sector concerns the potential classification of RMSW directly as SRF, complying with the requirements of CEN/TS 15359.

For a better understanding of this aspect, a quick example is presented in this paper. A MSW similar to the one representative of the average Italian waste was considered for the calculations [1].

Five scenarios of SC (fig. 1) were adopted, taking into account the composition of the generated MSW presented in a national Italian study [2, 3]. The SC efficiencies are presented in table 5. In the chosen scenarios the Drop-off (scenarios 1 and 2) and Kerbside (scenarios 3, 4, 5) collections were considered.

Table 5: Specific segregation rates for each fraction of MSW (S# = scenario #).

	S1	S2	S3	S4	S5
Total SC efficiency	35%	50%	50%	65%	70%
Paper	65%	70%	47%	64%	64%
Wood	64%	88%	65%	80%	80%
Plastics	47%	57%	45%	60%	60%
Glass	62%	96%	60%	90.5%	90.5%
Metals no Al	55.4%	70%	27%	40%	40%
Aluminum	55.1%	92%	34%	88%	88%
Food waste	0%	0%	48%	60%	85%
Green waste	75%	100%	75%	92%	85%

In fig. 1 the composition of RMSW for the five scenarios is presented. Taking into account the results from fig. 1, in this paper the bio-drying process was applied only for the scenarios from one to four. The fifth scenario was considered not suitable because the quantity of food waste in the RMSW resulted only 20%. In the literature it was demonstrated that a low percentage of food waste is not compatible with an industrial exploitation of the characteristics of bio-drying [4]: the balance costs – benefits of a bio-drying plant can be unfavorable.

For the Chlorine and Mercury quantity in the waste fractions, data from literature were taken into account [5].

In fig. 2 the LHVs for the five scenarios, referred to all the products, are presented. For the assessment of the LHVs of the bio-dried material and of the SRF a bio-drying biochemical model was used [6]. The scenario S0 refers to the

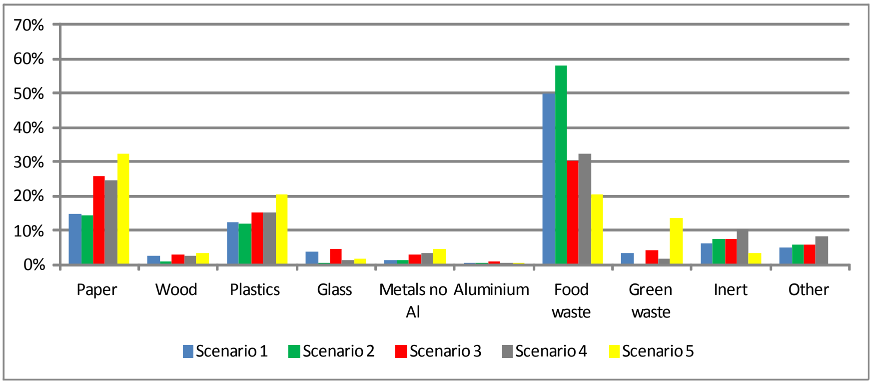

Figure 1: MSW composition for the four scenarios.

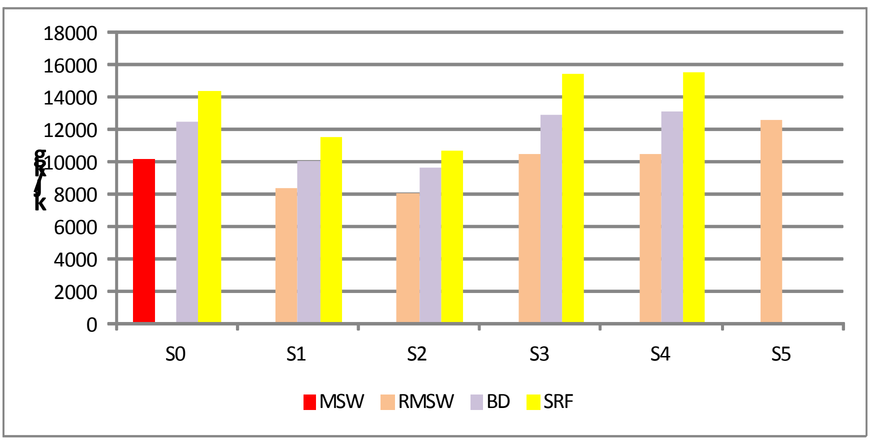

Figure 2: LHVs of the starting scenario (no SC) and of the five scenarios.

generated MSW, thus no RMSW is defined. The scenario S5 refers to a case with an extreme SC that makes it interesting the analysis of RMSW as a "product" as is.

In fig. 3 the LHV, Chlorine and Mercury values for the "potential" SRFs obtained from each scenario are presented.

Taking into account these data, the ones from fig. 2 and table 2, for the scenarios without SC of food waste (1 and 2) a similar SRF:5,1,1 could be obtained if RDRI were not considered. This SRF would be worse than the one obtainable by a simple classification of MSW: SRF:4,1,1. This last SRF would be similar to the one obtainable taking into account also SC of food waste: again SRF:4,1,1. In the cases with SC of food waste (3, 4 and 5) the differences of the LHVs would be not enough for changing the class and would be obtained thanks to a better efficiency of the SC: 48%, 60% and 85% respectively.

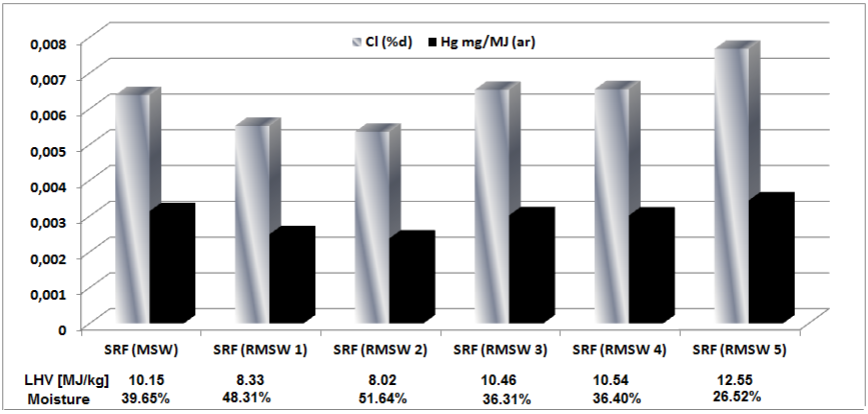

Figure 3: LHV, moisture, Cl and Hg content.

Depending on the high content of food waste in MSW and RMSW in the cases 1 to 4 (39.50% initial and 53.41%, 57.89%, 34.52%, 34.36%) and according to CEN/TR 15590, the expected value of the respirometric index, RDRI, will be high or moderately high. As SRF must be stored and managed under safe conditions, RDRI becomes the key parameter that makes compulsory a treatment plant for SRF generation. The last case is the most interesting for a simplified generation of SRF of good quality as the limited concentration of food waste (20.65%) could guarantee a low RDRI without a specific treatment.

For the SC scenarios except S5, the bio-drying process was applied in order to have data regarding possibility to obtain a better SRF or RDF. Taking into account data from fig. 2 and from tables 2 and 3, the SRFs obtained as bio-dried material change gaining a better class only in the case of the first and the last scenarios, depending on the segregation of dry materials.

When also a post-treatment of inert, glass and metals separation applied to bio-dried material is performed, all the scenarios gain an additional class if compared with the one of RMSW. In particular, the last scenario gains two classes, being the best result (SRF: 2,1,1).

It must be pointed out that if we consider all these results, only for the scenarios with food waste SC and with a post-refining step it will be possible to obtain a material that could be classified as RDF (scenarios 3 and 4) and as

RDF_Q (scenario 5). Instead with the new regulation all the obtained materials before and after the bio-drying step could be classified as SRF of different classes; thus, the importance of the additional parameter RDRI is clear in order to avoid too relaxed classifications. The importance of RDRI can be seen also from the user's point of view. Indeed in absence of a respirometric parameter that allows the classification of the quality of the product, all the analyzed SRFs could be received in a cement work and many SRFs could be burned in a FBC (RMSW in the scenario 5, bio-dried material according to the scenarios 3, 4 and 5, SRF from the scenarios 3 and 4).

For all the scenarios the RMSW could be landfilled if only their LHVs were the parameter to be taken into account (LHV < 13 MJ/kg). Also in the case of landfilling the respirometric index, RDRI, drives the strategy towards a pre-treatment plant.

The low Chlorine and Mercury content in MSW and RMSW for all the scenarios depend on a correct management of SC and special waste. Indeed special waste must be carefully taken apart from the stream of MSW, as supposed in the calculations.

4 Conclusions

For the RDF and RDF_Q, 14 technical documents norm UNI 9903: 1-14 could be used in order to manage all the aspects concerning these fuels. Instead for SRF, 30 technical documents, mainly in the range of norms UNI CEN/TS 15357 – 15747, can be used.

Presently in Italy, plants work taking into account the previous authorization for RDF production, and only when this authorization will end they must comply with the new one. The new decree on SRF gives more information and in this way the managers of MBT plants can organize their activity in a clearer context. However some problem must be solved:

- the increased cost for the MBT management caused by the increased amount of SRF analyses;
- the small number of laboratories certified for SRF characterizations;
- the lack of a national regulation regarding the SRF treatment for energy purposes.

As demonstrated by the presented calculations, an important aspect concerns the role of MSW selective collection. Its optimization can change the characteristics of RMSW but a treatment to become SRF is generally compulsory because of the adoption of a respirometric index that avoids too simplified schemes of SRF generation. In particular a scheme with a simple sieving in order to obtain an oversieve to be considered directly a "product" will be no longer present in the sector.

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