MICROPOLLUTANTS PRODUCTION IN RDF-COAL CO-COMBUSTION IN THE FUSINA-VENICE POWER PLANT

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Abstract
A significant experience in producing and using Refuse Derived Fuel (RDF) has been achieved in Fusina-Venice, on the basis of a formal agreement between the Veneto Region, the Province and the Municipality of Venice, and ENEL (Italian largest company in producing and selling energy). VESTA RDF production plant was built and equipped to produce RDF in pellet shape and the existing Fusina power plant, usually fed with coal, was equipped with a system to receive, grind and send to the boiler the RDF, with a continuous monitoring system and a treatment line, to reduce the pollutants contained in the gaseous effluents.
In order to establish the efficiency of the gas cleaning system, an important industrial experimentation of RDF-coal co-firing, authorized by Veneto Region, was carried out in the ENEL power plant between years 2003 and 2005; the concentration of several pollutants (included PCDD/PCDF, PCB and PAHs) in gaseous effluents, DeSOx system and ashes were measured. Every phase of the experimentation was monitored by a Technical Control Group that defined the protocols for the environmental measurements and controls to be made. The results of these experiments gave the basis for an industrial process which is now operative.

Introduction
VESTA RDF plant is located in the industrial area of Venice (Figure 1), close to the Venice lagoon (a particularly protected area) and began working in 2002.

Figure 1: integrated centre of MSW treatment

The RDF plant treats the residual waste from separated collection of MSW (and a little quantity of non Hazardous/Special Wastes); the average quantity of incoming material corresponds to 550 tons per day (about 140.000 tons per year). The corresponding RDF production is about 350 tons per day (about 80.000 tons per year, half of which are used to produce energy in the ENEL power plant). The treatment includes a biological pre-phase to dry the material, with a concurrent bio-stabilization of the waste; subsequently, a mechanical selection subdividing the material into different classes is performed, according to the material typology. The average percentages emerging from the treatment are the following (figures are given in weight of the incoming material): RDF (56 %), magnetic metals (4 %), non magnetic metals (1 %), mineral fraction (11 %) and loss of material (H_2O and CO_2 from biological treatment - 28 %).
The RDF production process is shown in the flow chart of figure 2.

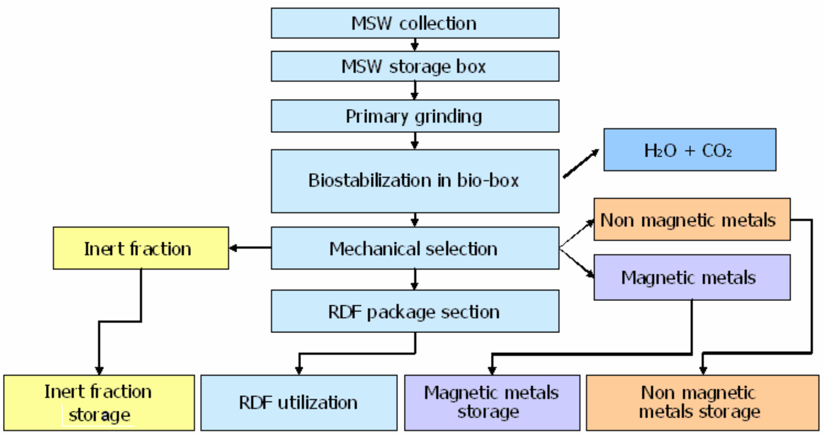


Figure 2: RDF production process flow chart

The result is RDF suitable for industrial uses (LCV = 17000 kJ/kg), being its chemical qualities in compliance with the Italian environmental laws.

The ENEL plant (Figure 3), which usually burns coal as combustible, comprises four coal-burning thermoelectric units, two of which (the biggest ones, with a nominal power of 330 MWe each) was equipped with a specifically designed treatment and supplying section for the RDF co-combustion experimentation. The boilers have assisted circulation, vacuum combustion chambers, resuperheating and tangential burners arranged on five burner levels, equipped to operate with coal, dense fuel oil and natural gas. The coal dust/air mixture is fed through five mill/exhauster units, each of which powers one level of burners.

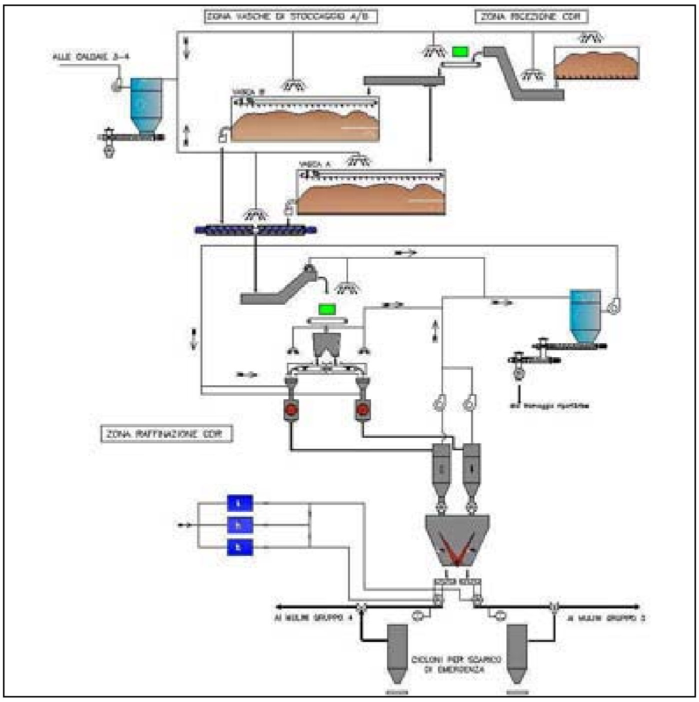


Figure n. 3: lay-out of the present system for receiving, storing and feeding the RDF.

The units are equipped with electrostatic filters for the abatement of light ash, catalytic denitrification for the abatement of NOx and a desulphurisation system equipped with pre-scrubber and scrubber with limestone-

gypsum cycle for the abatement of SOx. After this treatment line, the combustion fumes are released into the atmosphere by a single chimney with two flues.
The system for receiving, storing and feeding the RDF, was designed to feed 9 tons/hour to unit 4. The ground RDF was designed to be injected into the connection pipe between the output of the grader of the mills that feed the 2nd, 3rd and 4th burner levels and the mill exhauster; at the injection point, the ground RDF is mixed with the air-coal dust current that, after the exhauster, is divided into four secondary flows that fed the corner burners. After the first experimentation phase it was decided to upgrade the system (from July to November 2004) to increase the total grinding capability and to feed simultaneously both the coal mills of units 3 and 4. Figure 3 shows the lay-out of the present system.

Materials and methods

In order to estimate the environmental advantage in RDF-coal co-combustion, a series of experimental activities started in 2003 with the aim to demonstrate the technical and economic feasibility of producing energy from RDF, and reducing waste disposal problems and at the same time decreasing coal uses with lower CO_2 emissions. Two experimental phases were carried out respectively between March and October 2003 and from May 2004 to April 2005 by measuring stack emissions of pollutants during the combustion of coal and different quantities of RDF, keeping the same total caloric power which was developed by 100 tons/hour of coal. The most part of that activities was performed by ARPAV (Regional Agency for Environment Protection), and a committee of environmental and medical experts was set up by Veneto Region Authority to evaluate results coming out from the experimentation phases. Several series of analytical tests were performed on all of the material flows of the process: RDF in input, gas emission, residual ashes from combustion, liquid waste from gas combustion treatment.
The first experimental activity of co-combustion was carried out in the thermoelectric section 4 of the plant, which generates 330 MW of electric power. Stack emissions of pollutants (dusts, hydrochloric and hydrofluoric acids, ammonia, metals, organic micropollutants (PCDD/PCDF, PAHs, PCB), during the co-combustion of coal (100 tons/hour) respectively with 3.5 - 5.5 - 8 tons/hour of RDF, were measured. During the second experimental phase the same measurements were performed in sections 4 and 3 of the plant, to verify the influence of higher quantities of RDF (6 and 9 tons/hour) on the concentration of pollutants. Gaseous samples were collected in the flue gas of the horizontal piping of sections 3 and 4 of the plant, before the gas goes into the stack.
Given the good results obtained in the experimental phase, the power plant has been burning RDF since February 2006. As requested by the Province of Venice Authority, between years 2005 and 2006 two continuous sampling systems for PCDD/PCDF control were installed on units 3 and 4. The one installed on unit n. 4 has been working since February 2006 and it was already tested, the second one (on unit n. 3) has been working since May 2006 and it is still to be tested for a recent upgrade. The two samplers are set up to take a maximum of 30 days samples for each unit, stopping automatically when a unit is out of order or the RDF is not fed. Every sample taken from the two systems is sent to a laboratory equipped for PCDD/PCDF determination. The control activities include also a manual sampling every three months for pollutants determination (included PCDD/PCDF, PAHs, PCB) on gas emissions.
Since February 2006 the total amount of RDF recovered in ENEL power plant (until April 2007) is equal to 39504 tons and the corresponding energy produced corresponds to 64169 MWh, with an overall energy conversion efficiency of 35.4 %. Concerning the environmental controls, 20 samples were taken in 2006 by the continuously sampling systems, by ARPAV and a second laboratory. Overall data emerging from tests are shown in the next section.

Results and Discussion

Table 1 shows data emerging from analytical tests performed on all emission gas samples taken. These preliminary results indicate that the measured values of the concentration for each analyzed parameter complies with the standard set by the legislation in force (Decree of 5 February of 1998 and Decree of 11 May of 2005). The reported data show an increase of dioxins/furans concentrations during the co-combustion. Since dioxins/furans are formed by burning chlorine-based chemical compounds with hydrocarbons, there is a close relationship between the content of chlorine, which is higher in RDF than in the coal, and the formation of these pollutants.

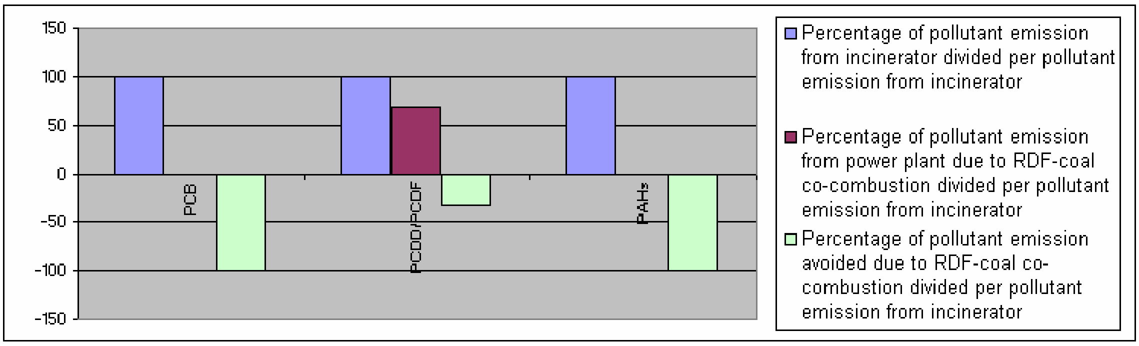
Tests results from gaseous effluents samples - average values								
Parameters		Experimentation phase 1 - unit 4				Exp. phase 2 - units 3 e 4		
	MU 6% O_2	Blank	3 t-RDF	5,5 t-RDF	8 t-RDF	Blank	6 t-RDF	9 t-RDF
PCDD/PCDF	pg I-TEQ/Ncm	0.179	1.369	1.814	4.229	0.013	0.739	0.778
PCB sum	ng/Ncm	0.348	0.193	0.517	0.302	0.0625	0.205	0.177
PAHs sum	ng/Ncm	216.7	239.8	115	965	560.1	588	510
Parameters		Continuously operation from February 2006 units 3 e 4						
	MU 6% O_2	Only coal – blanks average		Coal – RDF (9 t/h)		Limits		
PCDD/PCDF	pg I-TEQ/Ncm	0.0 96		1.6		100		
PCB sum	ng/Ncm	0.205		0.120		-		
PAHs sum	ng/Ncm	388.4		60		10.000		

Table1: Data coming out from overall tests on gas emissions

On the other hand, burning the quantity of MSW needed to produce the RDF employed in ENEL power plant in a traditional incinerator (energy conversion efficiency 10 %) would increase the total amount of micropollutants released in the atmosphere per treated MSW ton, as reported in the mass balance in table 2 (blank concentration values were calculated as average of the two blank campaign performed during the experimental phases, RDF-coal co-combustion concentration values were calculated as average of the second experimental phase - 9 RDF tons/h and the industrial phase, dry gas flow rate was calculated as average of the values obtained during the second experimental phase and VESTA incinerator pollutants concentration values were calculated as average of available data from the latest four years activity).

	ENEL POWER PLANT			**INCINERATOR**		**BALANCE**
Dry gas flow Nmc/h:	1'020'000			42'000		
RDF flow t/h:	0	9		-		
MSW flow t/h:	-			6.3		
	Concentration		***Flow due to RDF***	***Conc.***	***Flow***	***Δ flow***
	Blank	*RDF-coal*	*g/t(MSW)*		*g/t(MSW)*	*g/t(MSW)*
PCB (pg/Nmc)	205	148	No increases	2000	1.33E-05	-0.0000133
PCDD/PCDF (pg I-TEQ/Nmc)	0.096	1.19	6.94E-08	15.2	1.01E-07	-0.00000003
PAHs (pg/Nmc)	388400	285000	No increases	230000	0.0015	-0.0015

Table 2: Specific emission from ENEL power plant and VESTA incinerator - environmental balance



Graph 1: Percentage of avoided emissions in respect to incinerator emissions per ton of treated MSW

Tests results performed on the other flows coming out from the power plant (residual ashes from combustion, liquid waste from gas combustion treatment) have shown no significant micropollutants' increase.
As a final consideration, it can be said that the RDF co-combustion in industrial processes to produce energy gives two important advantage, in fact increase the energy conversion efficiency and decrease the amount of pollutant released in the atmosphere.