

**RECYCLING WASTE FOR POWER
GENERATION
THE OPERATING EXPERIENCE OF
LOMELLINA ENERGIA**

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SUMMARY

The Lomellina Energia waste-to-energy plant located at Parona, a village in the vicinity of Milan (Italy), started its commercial operation on 1st October 2000.

It is owned by Lomellina Energia, a project company specifically established for the operation of the plant.

The plant is authorised and designed to treat 200,000 t/y of Municipal Solid Wastes (MSW) and special non-hazardous wastes, producing Refused Derived Fuel (RDF), ferrous and aluminium and stabilised organic fraction (SOF).

RDF is burned in a circulating fluidised bed (CFB) – Foster Wheeler technology, producing steam which feeds the turbine generator. The flue gases are treated in a conditioned dry adsorption unit with lime and activated carbon injection.

This paper presents the plant performances during the first two years operation, with particular attention to reliability, fuel flexibility and environmental friendliness.

GENERAL INFORMATION

Located about at 40 km from Milan, the Lomellina Energia resources recovery plant is owned by Foster Wheeler Italiana (49%) and Merloni Group (51%).

Foster Wheeler developed, engineered and built the plant according to this schedule:

- | | |
|---|---------------|
| - start of works: | February 1998 |
| - start of commercial operation of wastes pre-treatment unit: | October 1999 |
| - start of commercial operation of energy recovery unit: | October 2000 |

A consortium of fourteen private banks financed the project.

PLANT DESCRIPTION

The Lomellina plant, shown in fig.1, is laid on an area of approximately 55,000 m².

The power output (17MW) is sold at incentivated for renewable source price to the Italian formerly national utility ENEL, in the framework of CIP6/92 regulation.

The main sections of the plant are as follows:

- Waste pre-treatment and RDF production
- Power generation facility:
 - Furnace and steam generator
 - Steam cycle
 - Flue gas cleaning
- Electrical system
- Auxiliaries

Waste treatment section operates 6 days a week in two shifts of 7 hours. The boiler, flue gas cleaning system and the steam cycle operate continuously with an expected availability factor of 85%.



Fig.1 – View of the plant.

PLANT DESCRIPTION

Waste pre-treatment and RDF production

In this section the following processes takes place:

- Waste sorting, accomplished in 3 lines (2 operating, 1 spare) composed of a shear shredder (screw type), a two stage trommel (rotary sieve), which mechanically separates the dry fraction from the organic one, and magnetic and induction-type separators for metals recovery.
- RDF preparation, accomplished in 2 lines (1 operating, 1 spare) composed of a secondary shredder (hammermill) and magnetic separators.
- Organic fraction stabilisation with forced ventilation.
- Refining of the stabilised organic fraction.
- Bio-filtration of air from waste pre-treatment buildings.

In fig.2 is outlined the waste pre-treatment and RDF production scheme.

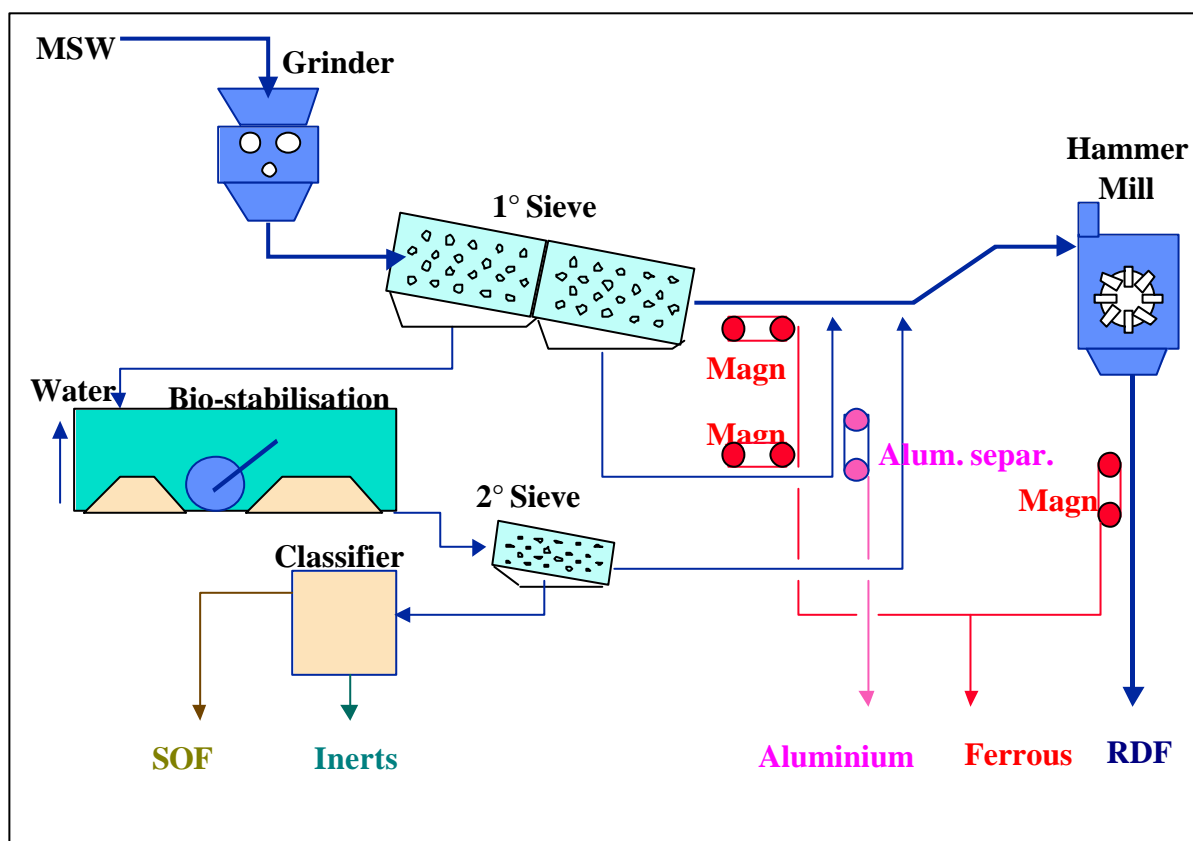


Fig.2 – Waste pre-treatment and RDF production.

Power Generation Facility

Circulating Fluidised Bed

The CFB boiler - Foster Wheeler technology - is composed of:

- RDF feeding system
- Fluidised bed furnace
- Cyclone separator, where unburned particles entrained in flue gas are separated and recycled into the furnace lower section via the "Intrex"
- Heat recovery section with steam generation
- Ash extraction (dry type) with heat recovery

Generated steam design conditions are 400 to 440°C and 62 bar g.

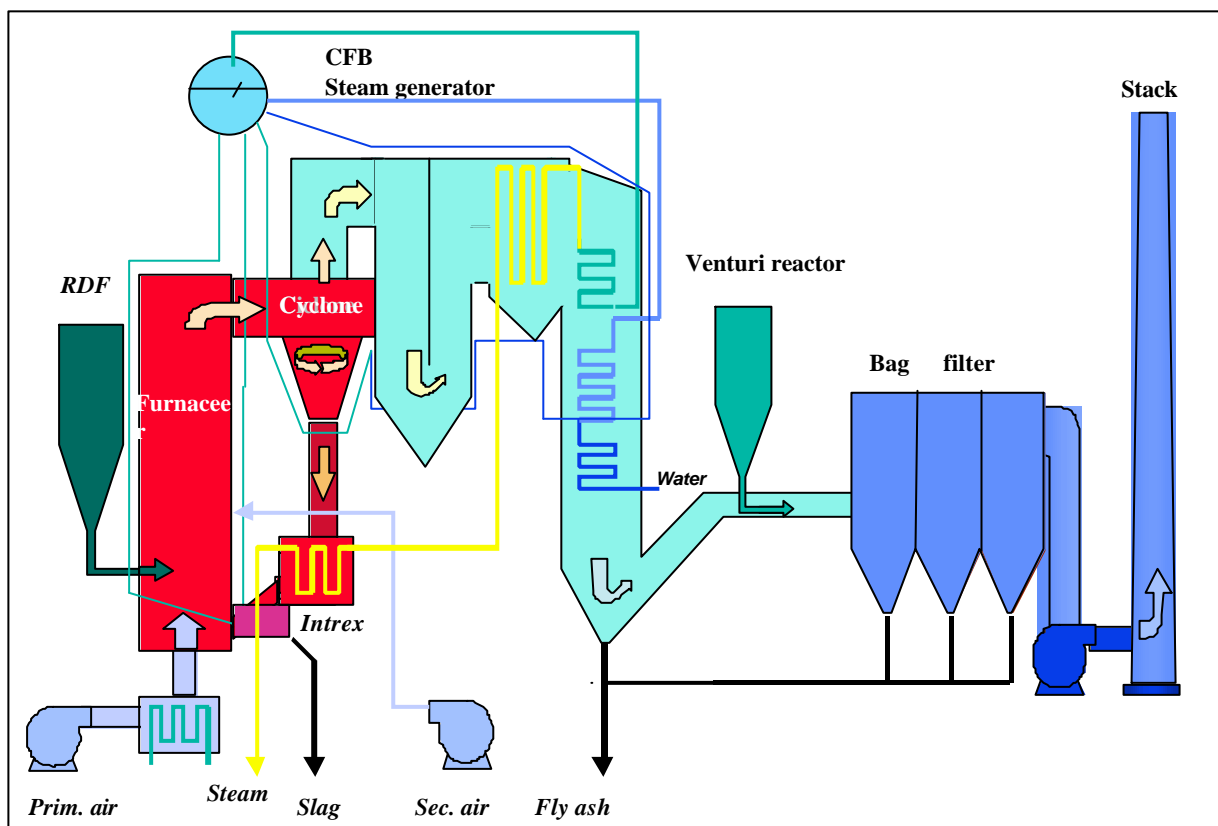


Fig.3 –Circulating Fluidised Bed.

Steam cycle

Generated steam feeds a conventional 19MW condensing turbine with 3 uncontrolled steam extraction used for services such as condensate preheating and de-aerating, combustion air preheating.

Exhaust steam condenses in an air condenser at 0.1 bar absolute.

Flue gas cleaning

The flue gas treatment, conditioned dry adsorption type, is composed of:

- Pre-heater (flue gas cooled at 160°C)
- Conditioning tower for flue gas moisture and temperature (140-150°C) control
- Reactor fed with lime to neutralise acid compounds, and with activated carbon to remove heavy metals and organic pollutants
- Bag filter to remove ashes, neutralisation reaction products and lime

Fly ashes are extracted, stored in a silo and conditioned with cement and blast furnace slag before being disposed to landfill.

Electrical system

The electric generator, coupled with steam turbine, supplies the national 132 kV system. The generator is connected through a 11 kV circuit breaker switchboard to a two windings step-up transformer.

A 11/6.3 kV step-down transformer feeds auxiliaries through a 6 kV distribution switchboard.

On the same board is available an emergency connection to national grid.

A 6/0.42 kV step-down transformer feeds in single end low-voltage users directly through PMCC and indirectly through MCC's.

PLANT PERFORMANCES

The plant performances recorded during the test runs are outlined in the following Table 1 and Table 2.

Table 1 reports the most significant operating parameters measured by the plant control system as well as the calculated heat and fuel balances.

Table 2 reports the emissions at stack measured by a specialised laboratory as well as the emission limits set forth by the permit.

All emissions are referred to dry gas @ 11 % volume O₂ content.

Table 1.		
Plant performances		
	Unit of measure	Data recorded during the test
RDF flow rate to the CFB	kg/h	18850 ⁽¹⁾
Low heating value	kcal/kg	3060 ⁽¹⁾
Heat fired	MWt	67.07
Steam temperature	°C	400
Steam flow rate	kg/h	86800
Steam pressure	Bar g	61.5
Boiler efficiency (based on LHV)	%	87.5
Gross electric power	MWe	18.05
Internal consumption	MWe	2.6
Net electric power	MWe	15.45
Gross efficiency	%	26.9
Net efficiency	%	23.0
Sound pressure level at fence	dB(A)	56.0-59.0
Bottom + Conditioned fly ashes	kg/h	3580

(1)Average on 15 operating days.

Table 2.							
Environmental performances during the test runs – Hourly average values							
Component	Unit of measure	Provisional Test		Final Test			Permit hourly limits
		1 st test	2 nd test	3 rd test	4 th test	5 th test	
CO	mg/Nm ³	12	15	4.7	3.2	25	100
Particulate	“	0.84	0.68	0.44	0.31	0.54	30
TOC	“	1	1	<0.1	<0.1	<0.1	20
HCl	“	2.1	1.5	2.1	1.28	2.7	40
HF	“	<0.1	<0.1	<0.1	<0.1	<0.1	4
SOx	“	<1	<1	12.6	14.6	9.1	200
NOx	“	87	98	12.6	7.9	9.9	400
Cd+Tl	“	<0.001	<0.001	<0.005	<0.005	<0.005	0.05
Hg	“	0.004	0.006	0.039	0.043	0.041	0.05
Sb+Pb+Cu+Mn +V+Sn+Cr+As +Co+Ni	“	0.028	0.022	0.0132	0.0102	0.0065	0.5
PAH *	ng/Nm ³	0.001	0.001	0.033	-		10
PCDD+PCDF *	ng/Nm ³	0.075	0.092	0.0743	-		0.1

* Sampling period : 8 h

PLANT OPERATION

In the tables that follow, the main operating data is presented. That data was extracted from the monthly operation reports prepared by the operator. The tables cover the period of time from January 2001 through December 2002.

Sorting Unit Performance

Description	Year 2001	Year 2002	Remarks
Total MSW received, t	159423	177183	
Total RDF received, t	20278	13307	
Total Waste received, t	169757	190490	
Non processible waste, t	1962	2351	
Fe scraps to sale, t	5317	5317	2,8 % on waste (2002)
Non Fe scraps to sale, t	188	590	0,3 % on waste (2002)
Inerts, t	826	1470	
Stabilised organic fraction, t	27670	30990	

Power Generation Facility Performance

Description	Year 2001	Year 2002	Remarks
Total RDF burnt, t	NA	152600	80 % on waste (2002)
Total Steam produced, t	591375	650792	
Total exported power, MWh	99992	113214	
Bottom ash to landfill, t	11185	6860	4,5 % on RDF (2002)
Screened bottom ash to recycle, t	1072	6550	4,3 % on RDF (2002)
Fly ash to landfill, t	19922	21950	14,4 % on RDF (2002)
Sand consumption, t	2191	2084	
Lime consumption, t	2301	2650	17,4 kg/t RDF (2002)
Activated carbon consumption, t	42	42	Less than 50 mg/Nm ³
Cement consumption, t	1280	1073	
Slag consumption, t	NA	1190	
Stabilised organic fraction, t	27670	30990	

Table 5 – Exported Electric Power – December 2002			
Date	Exported net power (MWh)	Date	Exported net power (MWh)
1/12/2002	378,56	16/12/2002	385,06
2/12/2002	386,36	17/12/2002	388,44
3/12/2002	390,52	18/12/2002	387,14
4/12/2002	374,92	19/12/2002	384,80
5/12/2002	385,32	20/12/2002	387,40
6/12/2002	382,46	21/12/2002	381,94
7/12/2002	387,14	22/12/2002	391,82
8/12/2002	381,68	23/12/2002	383,50
9/12/2002	379,60	24/12/2002	382,20
10/12/2002	386,62	25/12/2002	391,04
11/12/2002	373,36	26/12/2002	385,84
12/12/2002	392,86	27/12/2002	381,94
13/12/2002	378,04	28/12/2002	387,92
14/12/2002	388,18	29/12/2002	385,06
15/12/2002	387,66	30/12/2002	390,78
		31/12/2002	392,08
		TOTAL	11.940,24
		MONTHLY	385,17
		DAILY AVERAGE	

By-product recycle

As detailed above, it is to be noted that, in addition to the commonly recycled ferrous and non ferrous scraps (mainly aluminium), some 50 % of the bottom ash have been recycled to cement kilns with a saving in the disposal costs. This is possible as the bottom ash are dry and without coarse or aggregated materials.

In fact, the bottom ashes are extracted from the fluid bed pneumatically in a batch operation initiated by the high bed level in the furnace.

They are stripped for the recovery of unburned particles, cooled, screened and partly recycled to the furnace to keep the solid inventory.

The excess of the screened bottom ashes can be reused in cement kilns without further treatment with a positive impact on the ash disposal costs.

Flexibility

As outlined in table 4, the plant receives appreciable quantities of highly calorific wastes like plastic scraps, commercial wastes which can be burnt without pre-treatment.

The CFB installed at Lomellina Energia was tested to burn RDF with a low calorific value as high as 6000 kcal/kg (25000 kJ/kg) without the need of mixing with lower calorific value waste as it is typically done for a mass burn incinerator-boiler (wit air cooled stokers).

Stability of Operation

Table 5 shows that a continuous table operation at the design capacity was attained and the waste pre-treatment effectively reduces plant outages due to the waste heterogeneity.

Plant Outages and Equivalent Availability

Table 6 - Forced Outage Reason and Duration (hours)		
Description	Year 2001	Year 2002
ENEL maintenance	4	-
Scheduled maintenance	220	778
Electrical storm/132 kV line	20	-
Tubes leak	1365	400
Fans	50	6
T/G	-	62
Flue Gas Treatment	51	12
Conveyor failures	11	5
DCS	9	33
Plant equivalent availability, % (plant capacity factor)		
Sorting	80,6	85,8
Power plant	76,1	86,2

Excluding load reduction, the total outage hours for the year 2001 were some 1700 hours. Approximately 13 % of the outage hours were for scheduled maintenance work, while approximately 78 % of the outage hours were related to tube leaks, even though during these outages additional work was performed.

In the year 2002 the total outage hours dropped to some 1300 hours and the tube leaks incidence to 31 %.

The main activities during the scheduled maintenance outages include water washing and thickness measurement in the boiler section, repair of furnace nozzles and cyclone refractory, cleaning of the air condenser and various inspections.

In the year 2002 the turbine was inspected and the yearly maintenance performed and the generator was inspected, aligned and balanced.

Based on the experience in these plants, the rate of tube leaks incidents was judged not excessive.

Finally, the equivalent availability in the year 2002 has reached a satisfactory value of 86% for both the sorting and the power plant.

This value is inline with the figures of conventional mass burn incinerator-boilers in spite of a known higher complexity of the CFB technology.

Environmental Compliance

Table 7 and 8 show a statistic summary of the emission of specific pollutants whose continuous record is required by the Italian legislation. Non continuously measured gaseous emissions were checked 3 times a year according to the permit prescriptions, and all parameters were satisfactory.

The plant demonstrated very low and stable gaseous emissions.

Hourly averages kept well below law limits specific to the plant (DPR 503/97) and in most cases below the daily limits.

Table 7 Statistics on pollutants hourly averages (continuous recording). Year 2001							
Total operating time (hrs)		6663					
		HCl	CO	NO_x	SO_x	TOC	Partic.
Valid measures		6606	6607	6573	6601	6518	6398
Hourly law limits	mg/Nm³	40	100	400	200	20	30
Daily law limits	<i>mg/Nm³</i>	<i>20</i>	<i>50</i>	<i>200</i>	<i>100</i>	<i>10</i>	<i>10</i>
Measures under law limits	%	100	100	100	100	100	100
Average of hourly averages	mg/Nm ³	10.2	16.2	145.6	0.4	0.5	2.3
99° percentile of hourly averages	mg/Nm ³	26.3	69.2	194.8	3.0	2.5	10.4
98° percentile “ “	mg/Nm ³	22.5	59.5	185.9	2.1	1.9	8.8
95° percentile “ “	mg/Nm ³	18.5	45	174.8	1.3	1.3	6.9
HOURLY measures lower than DAILY limits	%	96.3	96.4	100	100	100	98.8

Table 8							
Statistics on pollutants hourly averages (continuous recording).							
Year 2002							
Total operating time (hrs)		7414					
		HCl	CO	NOx	SOx	TOC	Partic.
Valid measures		7349	7349	7349	7349	7349	7282
Hourly law limits	mg/Nm3	40	100	400	200	20	30
Daily law limits	<i>mg/Nm3</i>	<i>20</i>	<i>50</i>	<i>200</i>	<i>100</i>	<i>10</i>	<i>10</i>
Measures under law limits	%	100	100	100	100	100	100
Average of hourly averages	mg/Nm3	10.2	13.1	150	0.4	0.4	2.0
99° percentile of hourly averages	mg/Nm3	18.2	58.3	181.8	2.6	1.7	8.4
98° percentile “ “	mg/Nm3	16.8	49.6	177.1	2.0	1.4	7.1
95° percentile “ “	mg/Nm3	15.0	36.5	171.3	1.2	1.0	6.0
HOURLY measures lower than DAILY limits	%	99.5	98.0	100	100	100	100

CONCLUSIONS

The energy and environmental performances outlined above prove the validity of the CFB technology in the waste to energy business. In particular:

1. Circulating Fluidised Bed boiler proved to be environmentally friendly, efficient, fuel-versatile and stable.
2. Waste pre-treating system allows a more controlled combustion.
3. Owing to the good combustion characteristics, low emission limits are met with relatively simple, easy to operate flue gas cleaning system, with a positive impact on the plant reliability.
4. The CFB technology, owing to the controlled combustion temperature (850-950 °C) and the staged combustion air injection, cuts the formation of nitrogen oxides and is able to meet the NO_x emission limits without the need of DENO_x systems, or to meet more stringent limits with a simple SNCR system with limited ammonia slip.
5. The CFB technology best fits a modern waste management policy when coupled with the source separation of the waste (particularly food and green waste), maximising the recycle/reuse of the waste.