Environmental Protection and Energy Production in the Municipality of Bolzano's New Refuse Incineration Plant

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ABSTRACT

The municipal solid waste incinerator of Bolzano is owned by Commune di Bolzano, Italy, and operated by a private organization (association of 50 communities) named Ecocenter SPA. The paper gives a broad perspective on the history and performance of the incineration plant. Six years of operational experience with Line 1 has influenced the design of the newly built line, which was commissioned in January 1995. Each line is designed for the combustion of 5 to 8 tons of municipal waste per hour. The combustion capacity of the plant is defined by the calorific value of the waste (LHV 1500 to 2500 kcal/kg) and the thermal capacity of the boiler (12,500,000 kcal/h). Regardless of the EEC legislation for environmental protection, which possibly will come into force in Italy in 1996, the Authorities of the Provincia di Bolzano decided to upgrade Line 1 and to design the new line to follow the regulations of the German 17. BImSchV (Federal Immission Control Act).

Pollutant [mg/m³]	Italy 203/88	Germany/ EEC Draft	City of Bolzano Old	New
PM	30	10	10	5
org. C	20	10	20	10
HCl	50	10	50	50
HF	2	1	2	1
SO_x	300	50	100	50
NO_x	500	200	300	100
CO	100	50	100	50
Heavy metals [µg/m³]				
Cd		50		
Tl		50		
Hg		50		
Hg+Tl+Cd	200		200	200
other heavy metals	500	500		500
D/F [ng/m³ ITEF]	0.5	0.1	0.3	0.1

Table 1. Waste Incineration - Regulatory Status.

INTRODUCTION

The city of Bolzano produces 200 TPD of municipal waste, which includes the contribution from neighboring towns stretching from Merano to Salorno to its west and south. It was thus faced with the necessity of finding means and technologies for converting, neutralizing, and disposing of this refuse without disturbing the delicate ecological equilibrium of soil, water and air in its environment.

The municipality of Bolzano assigned particular weight to the consideration that the latest refuse incineration and combustion residues purification technologies, in addition to substantial energy returns, provide sufficient assurances of efficiency and health and environmental protection. With the present state of the art, these technologies make it possible to cut down on the use of dumps and landfills. Their operation results in an extremely small volume of inert residues, very low dust and acid gas concentrations, and an extremely small concentration of micro pollutants emitted to the atmosphere.

Furthermore, in view of the non-heterogeneous composition of solid urban wastes, the most reliable projects for their appropriate treatment and disposal and that of their transformation products naturally includes the installation of a plant that is the outcome of the combination of several technologies, each chosen for the attainment of one or more objectives.

Experience gained in the course of a rather long period of development has shown that in systems for the treatment of solid wastes, materials separation and reclamation can make the operation of both the upstream and downstream equipment easier. For instance, categorized collection of paper, plastics, glass etc., and separation of ferrous metal and conversion of the remaining fraction into products beneficial to agriculture. The organic fraction can be biodegraded by fermentation through both aerobic composting and anaerobic digestion. It has also been shown that non-polluting incineration is feasible, and that the electricity produced from the combustion heat produced by waste is more than enough to run the plant itself, such that the operation is rendered advantageous in economic terms.

Incineration as a means for the conversion and reduction of the fraction of refuse that cannot be dealt with directly by biodegradation has thus come back into favor. This is done by dependable advanced technological solutions capable of both reducing pollution of the atmosphere to negligible proportions, and by gaining the maximum benefit from the energy recovered. The municipality of Bolzano has adopted this philosophy. Its composting line has been supplemented by a new incineration plant with an operating potential of 200 TPD for waste and 120 TPD for the residuals from the composting line. The new plant includes a heat recovery system with a steam boiler and turbo generator for the basic production of electricity. The steam turbine that drives the generator can operate partly in condensation mode, and partly in bleeding mode so as to produce both electricity to run the plant, and steam for service purpose. Implementation of co-generation allows the bled off steam to produce superheated water for addition to the cities district heating network.

Description of the Plant

The plant consists of 2 lines. The first one began operation in June of 1988. The second unit began operation in January of 1995. Both lines were designed and built by Snamprogetti SPA, Milano, Italy, and operated by Snamprogetti until 1994. The units have since been operated by Ecocenter SPA.

1. Combustion Section

The fraction of urban wastes with an average or high heat value that cannot be directly biodegraded in the composting line is deposited into the holding pit (1), as shown in Figure 1. In the event that the composting line is out of action, refuse from the city can be tipped into this pit straight from the collection trucks. The pit is fully enclosed and kept under negative pressure by aspiration of the combustion air. Two overhead cranes (2), one of which acts as a stand-by, are provided to carry the refuse to the furnace hopper (3). The furnace is of the grate type with a separate hydrodynamic feeder (4).

The "Düsseldorf system" combustion grate is the first of its kind to be installed in Italy. It consists of cylindrical rollers with a diameter of 1.5 m (5). Each roller is sealed on its two sides by the walls of the furnace, and is composed of a hollow shaft with a metal framework carrying cast iron grate bars.

Each roller is powered by a variable speed drive directly splined to its hollow shaft. The number of roller revolutions can be varied to the ratio of 10:1. The rollers rotation can be set individually or together. Because only 50% of the grate surface is exposed to the flame, the other 50% is cooled by primary combustion air underneath the grate coming from the primary air fan (20). Ordinary cast iron has been employed for the grate bars. The grate is thus particularly suitable for the combustion of wastes with a high heat value.

Furthermore, and in contrast with conventional grates, there is no relative movement between the grate bars. The result of this arrangement is a longer service life and minimal downtimes due to blockages. The increasing calorific value of the waste (more plastics, less organics) required changes in the grate design of the new plant. In order to prevent erosion and corrosion of the grate bars, the angle of grate inclination has been changed from 30 to 20 degrees. This results in a better controlled height of the bed.

2. Post Combustion

The furnace is composed of two combustion chambers in series. The first houses the grate (5) and is shaped to impose a cocurrent flow on the gases and the material to be burnt. The second or post combustion chamber (6) holds the gases at a temperature above 950°C for a residence time of about two seconds. A high gas flow rate and the introduction of secondary air (21) ensure a sufficient oxygen concentration and swirl pattern. This arrangement allows for very fast and virtually complete decomposition of organo-chlorinated micro pollutants, such as dioxins and furans. In the *new plant*, both the furnace and the post combustion chamber walls are cooled by boiler water tubes.

3. Heat Recovery

The combustion products (flue gas) are cooled down to about 250°C in a water tube waste heat boiler (7). This boiler produces superheated steam, and has been specifically designed to cope with gases derived from the combustion of solid waste. Special consideration has been given to avoid serious fouling of the heat exchange surfaces. The evaporating section is formed of five rising and descending ducts waterwall flue gas passes. Heat exchange in these ducts is predominantly the result of radiation. Gases at a temperature of less than 500°C then enter a horizontal boiler pass holding the hanging pipe bundles of the superheater and economizer (7A). No special device is provided in the radiation past to clean the vertical passes, whereas the hanging pipe bundles are cleaned by steam soot blowers. The fly ash discharged from

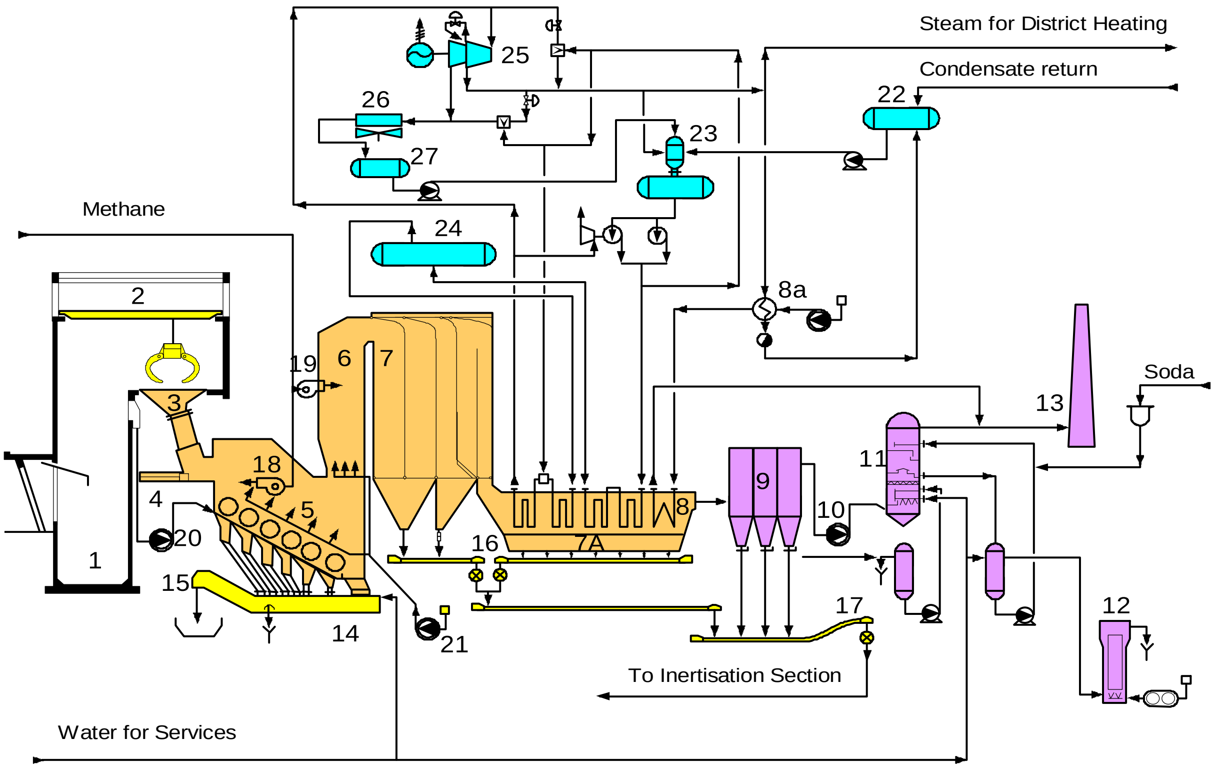

Figure 1. Schematic Diagram of Waste Combustion Plant.

the hoppers under the boiler is conveyed (16) to the same system used to treat fly ash discharged (17) from the bag filters.

To allow for the continuously increasing calorific value of the waste (from 1500 to 2100 kcal/kg) in the *new plant*, the heat transfer surface of the heat recovery system was increased to maintain the processing of the forecasted amount of residuals (200 t/d).

4. Electricity Generation and District Heating Section

The boiler (7) produces 16.8 t/h of superheated steam (360°C) at a pressure of 39 bar. As mentioned earlier, all this steam is directly employed by a condensation (25, 26) and extraction turbine. The bleeding pressure is 5 bar with a maximum delivery rate of 15 t/h. The calories extracted via the bled steam can be fed into the city's district heating network. The power output of the alternator (25) reaches 2760 kW at minimum bleeding. The generator chosen for the plant is of the synchronous type and allows operation "in isolation" in the event of a failure on the part of the municipal mains. The unextracted steam is condensed in an air cooled condenser (26) dimensioned to handle the boilers total steam output potential. Even if the alternator breaks down, steam can still be discharged through two reduction and de-superheating stations, or to the low pressure district heating network, or straight to the condenser, so as to ensure uninterrupted operation of the plant and hence, a smooth disposal of refuse and wastes. Due to the increased steam production in Line 2, the capacity of the generator has been increased from 2760 to 3250 kW.

5. Flue Gas Purification, Water and Dust Treatment Section

Major in-depth planning was required for the flue gas purification facility so as to ensure the attainment of very low emission levels. Dust collection and acid gas absorption are the work of two separate units installed in series: a bag filter (9) and a tower with a 2-stage wet scrubber circuit (11). A flue gas air-heat exchanger (8) is provided to reduce the temperature of the flue gas leaving the boiler (250°C) to 200°C at the filter inlet. To avoid corrosion in the flue gas/air heat exchanger the inlet air is preheated by a steam/ air heat exchanger (8a).

The fabric filter (9) was initially equipped with conventional TEFLON® needle felt filter bags. Its operating temperature was about 200°C with 220°C peaks. About one year after startup of Line 1, the pressure drop was measured to be greater than 30 mbar. After 6000 hours of operation, attempts were made to regenerate the filter bags by washing them. Again, the pressure drop increased to 27 mbar after 4000 hours of operation. At this point, GORE-TEX® membrane/GORE-TEX® felt filter bags were installed. The pressure drop has been maintained at 21 mbar after more than 40,000 hours of operation, as shown in Figure 2. The emissions downsteam of the fabric filter remain constantly below 1 mg/m^3, which has proven beneficial to the performance of the wet scrubber. The efficiency of this material, especially the excellent particle retention rate and the low pressure drop are so highly valued by the plant management that they specified this type of expanded PTFE membrane filter bags for their new, second line as well.

The hot air from the gas/air heat exchanger is mixed with the scrubbed flue gas to raise the temperature and reduce the plume at the top of the chimney (13). After particulate removal, the flue gas is delivered to the scrubbing tower by an ID-fan (10) located downstream from the bag filter (9). The tower with the 2-stage scrubbing cycle (11) absorbs the noxious gases. The bottom cycle operates in acidic conditions (pH 1-3) and absorbs halogenated acids (HCl and HF) and gaseous trace heavy metals. The top cycle operates in basic conditions (pH 7.1) through the addition of caustic soda and absorbs sulphur dioxide.

Acid blow-down from the bottom cycle is neutralized with lime, whereas blow down from the top cycle is oxidized with air to transform sulphites into sulphates (12). Both blow-downs are then routed to the water treatment system so as to bring their characteristics within the limits set by the water anti pollution act (law no. 319 of 1976). In this section of the plant, water polluted with sulphides, cadmium, lead, mercury, etc. is homogenized, oxidized with hydrogen peroxide, neutralized with lime, clarified and flocculated, and then filtered through a sand and activated carbon bed before being discharged to the environment. The flue gas is particulate-free and the temperature is above the dew point, ensuring optimum operating conditions for the draft fan (10) located between the bag filter and the wet scrubber (11). The scrubbed flue gas is then mixed with hot air and released to the atmosphere at a temperature of 90 - 100°C through the 45 meter high chimney stack (13). The particulates removed by the bag filter and from the boiler (16,17), and the sludge from the scrubber blow-down treatment is rendered inert with hydraulic binders and special additives to render it fit for discharge into a type 2B landfill. In March of 1996 both lines will be equipped with a SCR deNOx System from Haldor Topsøe.

As shown in Table 2, the flue gas cleaning system easily meets regulations except for NO_x (100 mg/m^3) and PCDD/PCDF (0.1 ng/m^3). These components will be under control after the start-up of the catalytic converter. European experiences have proven that SCR-systems reduce NO_x as well as organic compounds like dioxins/furans.

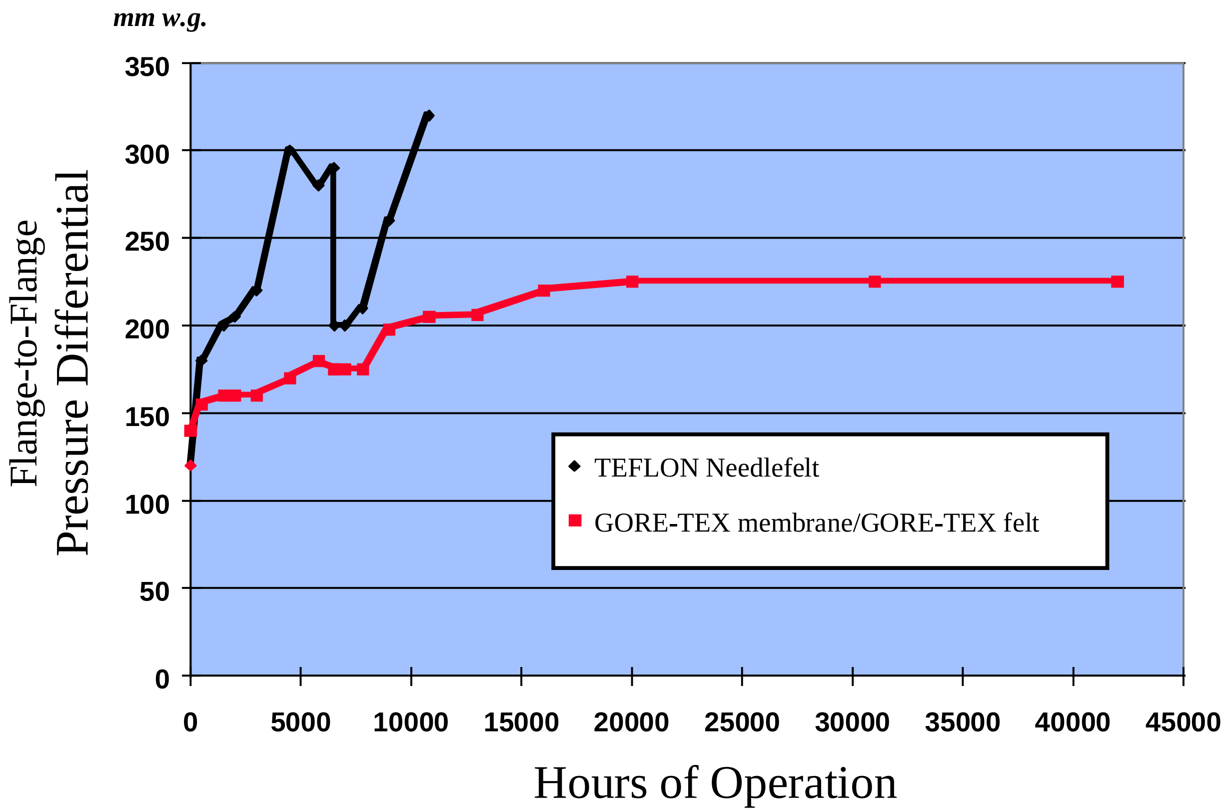

Figure 2. Development of Pressure Differential Across the Fabric Filter Collector.

Pollutants [mg/m³]	**Clean Gas** June 26 1995	**Regulations**
PM	< 1	5
org. C	< 2.2	10
HCl	1.4	50
SO_2	0.5	50
NO_x	127	100
heavy metals [µg/m³]		
Cd + Tl +Te+ Hg	< 20	200
∑heavy metals	< 100	5000
Dioxins / Furans [ng TE/m³]	< 0.5	0.1

Table 2. Emissions of the New Incineration Plant, City of Bolzano.

6. Design Data

Main specifications used to design the plant.
Detail and Process Design: Snamprogetti

	Old Plant	New Plant
refuse holding pit capacity	2200 m³	2200 m³
combustion furnace	**Babcock**	**Lentjes**
potential with refuse as delivered	8330 kg/h	8330 kg/h
potential with composting residues	5000 kg/h	5000 kg/h
calorific value of residuals (LHV)	1500 kcal/kg	2100 kcal/kg
maximum heat load	12,500,000 kcal/h	18,000,000 kcal/h
grate working surface area	35.5 m²	35.5 m²
flue gas flow rate	33,200 Nm³/h	50,000 Nm³/h
combustion temperature (automatically controlled)	950 - 1100 °C	950 - 1100°C
post combustion chamber volume	88 m³	115 m³
waste heat boiler	**Sices**	**Sices**
steam delivery rate	16,800 kg/h	21,500 kg/h
outlet steam temperature	360°C	360°C
outlet steam pressure	39 bar	39 bar
feed water temperature	138°C	138°C
flue gas inlet temperature	1050°C	1050°C
Flue gas outlet temperature	250°C	250°C
bag filter	**Fläkt**	**Cifa**
actual flue gas flow rate @200°C	62,000 m³/h	93,000 m³/h
operating temperature	200 - 230°C	200 - 230°C
particulate load	6000 mg/Nm³	6000 mg/Nm³
clean gas particulate matter concentration	1 mg/Nm³	1 mg/Nm³
filter bag material	336 GORE-TEX® membrane/ GORE-TEX felt	624 GORE-TEX® membrane/ GORE-TEX felt
ID-fan	**Boldrocchi**	**Boldrocchi**
designed flow rate (actual @220 °C)	76,500 m³/h	115,000 m³/h
total head	900 mm H_2O	900 mm H_2O
installed power	320 kW	425 kW
wet scrubber	**Koch**	**Koch**
number of cycles	2	2
bottom acid cycle: number of trays	1 graphite + 1 demister	1 graphite + 1 demister
recirculating water flow rate	70 m³/h	64 m³/h
top basic cycle: number of trays	2 Hastelloy C4 + demister	2 Hastelloy C4 + demister
recirculating water flow rate	60 m³/h	56 m³/h
hydrochloric acid absorption efficiency	99%	99%
sulphur dioxide absorption efficiency	90%	90%
DeNOx	**Haldor Topsøe**	**Haldor Topsøe**
heat cycle		
turbo generator power rating	2760 kW	3250 kW
steam extraction pressure	5 bar	5 bar
maximum heat equivalent for supply to district heating network	8,000,000 kcal/h	8,000,000 kcal/h

SUMMARY

The new composting and incineration facilities constitute an efficient refuse conversion and disposal system. They salvage a major part of the organic matter as well as the energy produced by combustion. Their operations also comply with the standards set for protection of the environment. The Bolzano installation, coupled with the categorized collection of paper and glass, together with the segregation at the source of particularly toxic wastes, such as batteries, unused drugs, non-assimilable industrial wastes, transformer oils, etc., at the present stage of technological progress provides a satisfactory solution to the by no means easy problems posed by refuse. The new complex, in fact both respects the requirements of a delicate environmental equilibrium and operates at a thrifty disposal costs level in relation to the totality of the payoffs obtained as shown on Table 3.

Total Investments	35.7	Waste fees (USD 114 /ton)	71.4
Operations	21.4	Energy production	35.7
Maintenance	14.3		
Spare parts	7.1		
Energy consumption	7.1		
Total	85.6		107.1

Table 3. Evaluation of Economic Efficiency of the Incinerator of Bolzano. Line 2 on a 10 year Basis (Values in MM USD).