Field trip to

WTE facility Spittelau/Fernwaerme Wien GmbH

Vienna, Austria, December 22, 2005

by Werner Sunk

On December 22nd, 2005, Werner Sunk of Columbia University/WTERT/EEC visited the WTE facility Spittelau in Vienna, Austria. He met Herbert Heindl, administrator of the plant (herbert.heindl@fernwaermewien.at) on site to discuss his questions and see the operating facility.

General and history

In 1969, the Vienna City Council entrusted Fernwaerme Wien GmbH with the tasks to operate and maintain the metropolitan district heating supply, as well as orderly disposal of municipal solid wastes and built the WTE facility of Spittelau.

Since then, an ongoing expansion program has created a district heating network that is today fed by a total of 10 individual plants with an installed capacity of more than 2,500 MW. With some 900 km of pipeline, more than 200,000 dwellings and approximately 4,400 industrial consumers are supplied with district heating energy for space and water heating purposes. The reason for the construction of the Spittelau district heating at its present location was the need to provide heat for the general hospital that was situated about two kilometers away. With a rated capacity of 460 MW, the Spittelau plant is the second largest supplier of Vienna's district heating network. The WTE plant of Spittelau has a capacity of 250,000 tons of municipal solid wastes per year and is linked into the network, providing an annual average (i.e. base load) of 60 MW. In addition, 400 MW (peak load coverage) is supplied from another five gas or gas/oil-fired boilers.

In compliance with continuous adjustment to state-of-the-art flue gas cleaning technology, the Spittelau WTE facility was equipped with a flue gas scrubbing system in 1986/89, as well as an ultra-modern SCR-DeNOx and dioxin controlling facility in 1989. At the same time, the outer façade of the entire plant was re-designed by the painter and architect Friedensreich Hundertwasser (see Figure 1). The previously functional structure was transformed into a unique work of art which is an example of a fusion of technology, ecology and art, and makes a major contribution to the reduction of 'visual pollution' of the urban environment.

The Austrian Waste Management Act, which came into force in 1990, has for the first time focused attention on the creation of a sustainable waste management system, by establishing the following main targets: (1) protection of the environment, (2) conservation of natural resources, (3) careful management of landfill volumes, and (4) restriction of land filling to inert wastes.

In Vienna the first step towards an environmentally sound disposal strategy was made as early as 1961, with the decision in favor of thermal waste treatment. Meanwhile, this was ideally complemented by the introduction of a waste collection system covering the whole city, incorporating the separation and recycling of glass, paper, metal, plastic and biological waste.

In effect since 1 January 2004, the Austrian Landfill Ordinance stipulates that only wastes with an organic carbon content of less than 5 % may be landfilled, i.e. in all cases wastes must be subjected to pretreatment before final disposal.

Figure 1: Left: WTE facility Spittelau before re-design; Right: Re-designed WTE facility Spittelau

Equipment

1. Weighing device: 2 Weighbridges
2. Waste bunker: Capacity: 7,000 m^3 or 2600 t
   Tipping points: 8
3. Furnace feeding: 2 Bridge cranes with 2-cable tong grabs,
   Grab capacity: 4 m^3
4. Incineration: 2 incineration lines
   Max. throughput capacity per line: 18 t/h

4.1. Firing grate: Air-cooled Martin two-track reverse-acting stoker grate
   Grate length: 7.5 m
   Grate width: 4.6 m
   Inclination: 26 °

4.2. Furnace: (replacement in 2010) Thermal output per line: 41.1 MW
   Furnace temperature: > 800 °C
   Lower heating value of waste: 8,200-9,600 kJ/kg
   Primary air preheating: 180 °C
   Refractory lining: SiC monolithic lining material
   Firing control parameters: Steam output, oxygen content, furnace temperature

4.3. Auxiliary firing: 2 gas burners per line
   Thermal output per burner: 9 MW

5. Slag discharging: Water-filled ram type slag discharger
   Slag discharger volume: 5 m^3
6. Waste heat boiler: Natural circulation radiant type boiler
   Max. steam output per line: 50 t/h (saturated steam)
   Max. operational pressure: 34 bar
   Max. operational temperature: 245 °C
   Effective heating surface: 2,420 m^2
7. Turbine generator: Saturated steam back pressure turbine
   Max. power output: 6.4 MW
   Back pressure: 4.5 bar
8. Flue gas treatment: 2 lines (SCR-DeNOx facility: 1)
   Volumetric flow of flue gas per line: 85,000 Nm^3/h

8.1. Electrostatic precipitator: Operational voltage: 60 kV
   Dust removal efficiency: > 99.5 %

8.2. Flue gas scrubbing: <u>1st stage:</u> Quenching and removal of hydrogen chloride (HCl), hydrogen fluoride (HF), dust, heavy metals
Design: Cross flow scrubber
Absorption agent: Water and lime slurry
HCl removal efficiency: > 98 %
<u>2nd stage:</u> Removal of sulphur dioxide (SO2)
Design: Countercurrent scrubber
Absorption agent: Soda lye
SO2 removal efficiency: > 98 %

8.3. DeNOxing and dioxin destruction: SCR catalytic converter, 3 catalyst stages
Operational temperature: 280 °C
NOx destruction rate: > 95 %
Dioxin destruction rate: > 95 %

9. Induced-draught fan: 1 radial fan per line
Max. flow capacity: 137,000 Nm^3/h
Power requirement: 1 MW

10. Stack: Steel, partially brick lined
Height: 126 m
Diameter: 2.5 m

11. Area: 17,500 m^2

12. Personnel: 120 people total
12 people management
5 shift groups of 10 people (3 shifts of 8 hours each)
Remaining personnel for maintenance

The process (see Figure 5)

<u>1. Energy recovery (combustion)</u>

The Viennese municipal solid waste, light commercial waste and bulky waste are delivered to the Spittelau WTE facility from Monday to Friday between 7.00 am and 3.00 pm. Daily up to 250 delivery vehicles pass over one of the two weighbridges to establish the weight of the waste, before emptying their loads into the 7,000 m^3 waste bunker at one of a total of 8 tipping points (see Figure 2). Following thorough mixing in the bunker (in order to homogenize the heating value) the waste is transferred to the two incineration lines by one of the two bridge cranes with a capacity of 4 m^3. The capacity of the bunker is large enough for 3 delivery-free days.

Figure 2: Eight tipping points to unload MSW into the bunker

The facility consists of two incineration lines, each with a flue gas treatment plant, and a SCR-DeNOx-system including a dioxin destruction facility serving both lines. Furthermore, a waste water treatment plant for the wastewater generated in the flue gas scrubbing system is installed.

Via the furnace feed chute and hydraulic ram feeder, the waste moves from the bunker to the firing grate. Up to 18 tons of waste per hour can be thermally treated on the inclined, 35 m^2 Martin two-track reverse-acting stoker grate. The pre-heated (180 °C) combustion air is injected from beneath the grate; the secondary combustion air is injected over the combustion bed from the side to guarantee good out burn of the flue gas. During the transient incinerator start-up and shut-down, two 9 MW gas burners ensure a furnace temperature of > 800 °C, and thus achievement of total burnout of the flue gas as required by law. In normal operation, use of the auxiliary burners is not necessary, as the lower heating value of 8,600 kJ/kg of the waste is by far sufficient to maintain an autogenous incineration process.

The 850 °C flue gas transfers its heat to the boiler. Both lines generate a total of 90 tons per hour of saturated steam at 33 bar. During power generation, this steam is reduced to 4.5 bar in a back pressure turbine; then the heat in the low pressure steam is transferred to the returning water of the district heating network by means of condensation in the heat exchanger bank.

The incombustible components (about 50-60,000 t/y bottom ash = “slag”) arriving at the end of the firing grate are quenched in the water-filled slag discharger. Figure 3 shows the back-end of the quench and the discharging of the ash on a conveyer belt. From there, the cooled bottom ash is transported to a bunker by a conveyor belt, after removal of the ferrous scrap by overhead electromagnets (see Figure 4). About 6000 t/y of ferrous scrap are recovered every year.

Figure 3: Back-end of the bottom ash quench from where the ash is conveyed to the magnetic separation

Figure 4: Left: Overhead electromagnets recover ferrous scrap from the bottom ash; Right: Recovered ferrous scrap

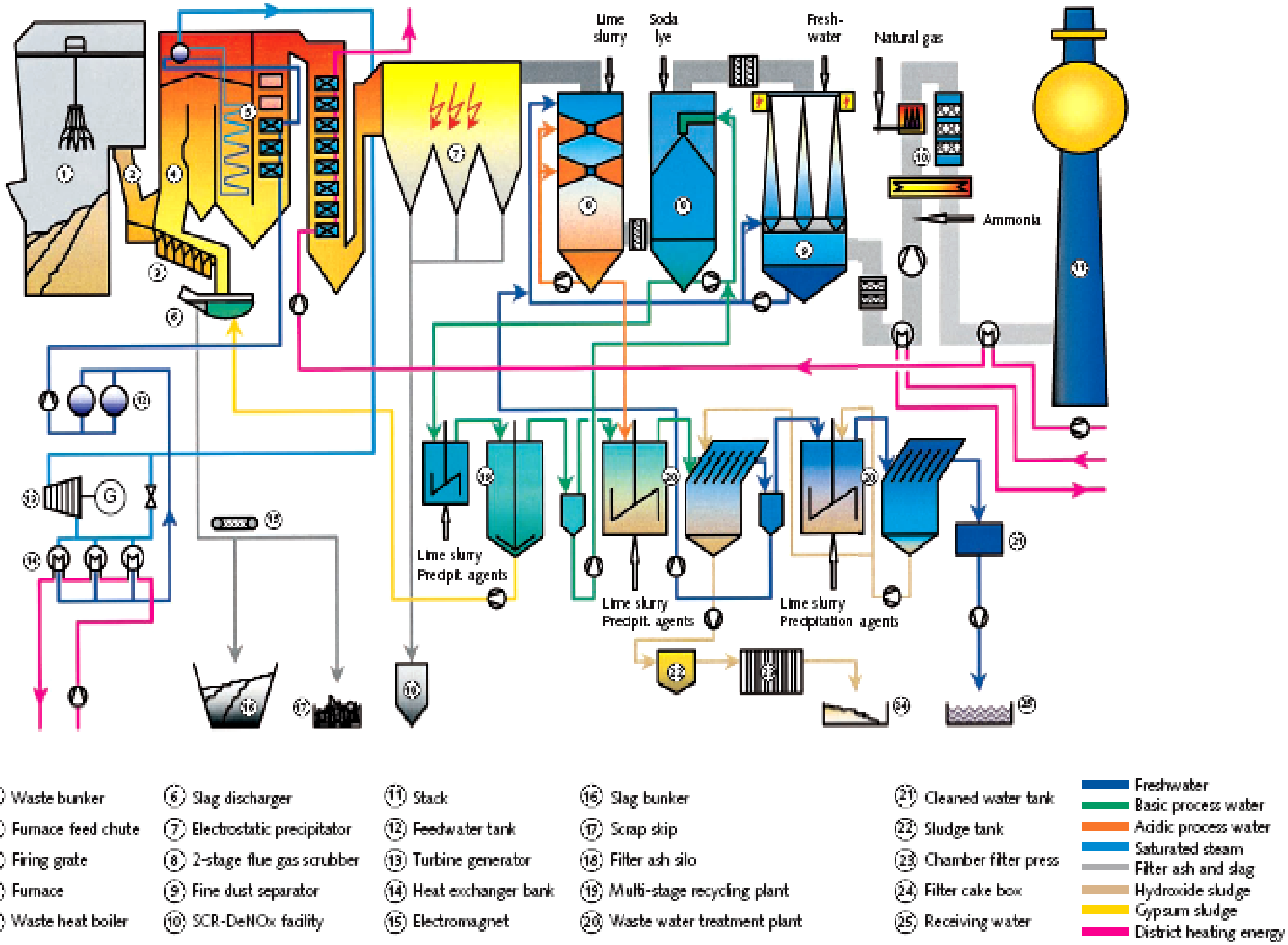


Figure 5: Processing scheme of the WTE facility Spittelau

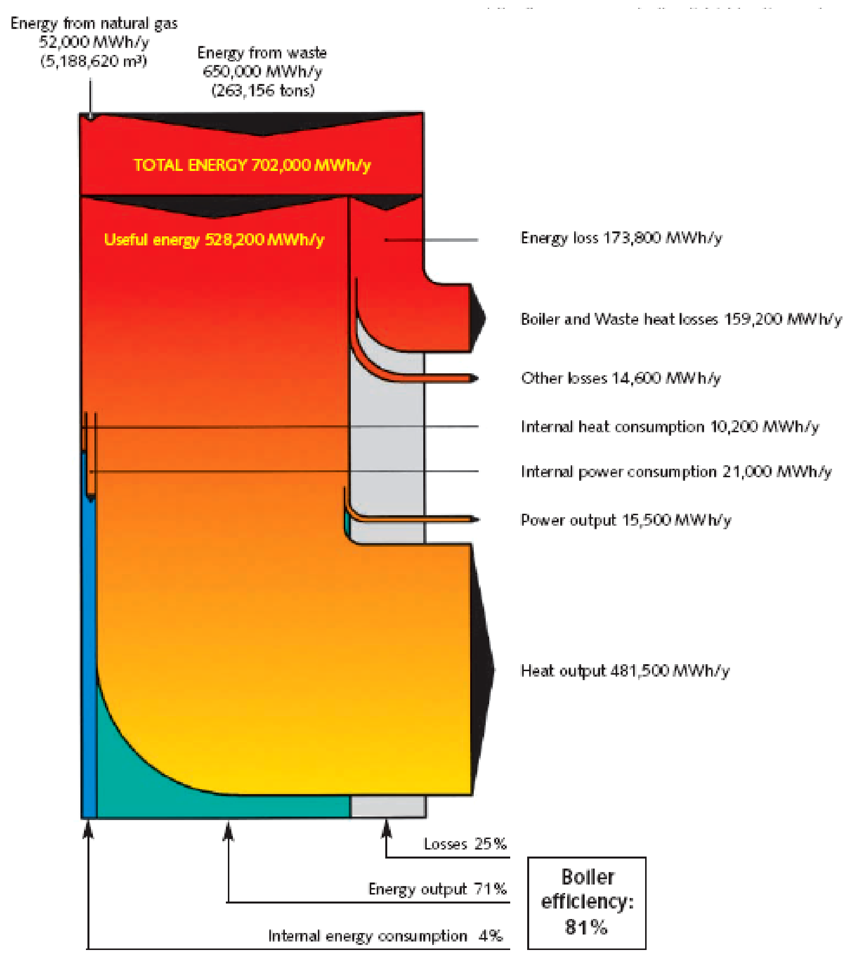


Figure 6: Annual energy balance (1999)

The exhausting of the fresh air required for the incineration process from the waste bunker maintains the latter in a constant state of partial vacuum, thus minimizing odor and dust emissions from the tipping points into the ambient air. In addition, the use of a firing control system (see Figure 7) ensures optimum incineration along the grate, and thus maximum bottom ash and flue gas burnout. Averaged over the year, over 5 MW of electricity for internal consumption and feed to the public grid, as well as some 60 MW of district heating energy - the space heating equivalent of approximately 15,000 80m^2 dwellings - are recovered from the MSW feed. Figure 6 shows the 1999 energy balance – the numbers have not changed much since then.

Figure 7: Control room of the WTE facility Spittelau

2. Flue gas treatment

When commissioned in 1971, the thermal waste treatment plant already had an electrostatic precipitator. In 1986, this was augmented by a 2-stage flue gas scrubber with downstream fine dust separator (electrodynamic Venturi). By retrofitting these three treatment stages and installing a SCR-DeNOx facility downstream to a scrubber in 1989, the Spittelau facility became one of the best in flue gas cleaning and emission reduction for thermal waste treatment.

The flue gas leaves the first heat exchanger downstream from the waste heat boiler at a temperature of 180 °C, and is initially cleaned by the 3-stage electrostatic precipitator to a dust content of < 5 mg/nm^3; the ESP ash is transferred via a mechanical-pneumatic conveyor system to a 125 m^3 silo and stored separated from the bottom ash.

The almost fully de-dusted flue gas then enters the quencher of the first scrubber, where it is cooled to saturation temperature (60-65 °C) by open-circuit water injection. The first scrubber, operated at a pH value of 1, removes hydrogen chloride (HCl), hydrogen fluoride (HF) and dust, as well as particle bound and gaseous heavy metals, through intensive gas-liquid contact in the cross flow. The second scrubber stage, which is designed as a countercurrent washer and operates at a pH value of 7, is responsible for the removal of sulphur dioxide (SO_2) from the flue gas. In the next treatment stage, the electrodynamic Venturi (see Figure 8), the residual dust content is reduced to < 1 mg/nm^3 by adiabatic expansion of the flue gas, followed by separation of the fine dust particles after they have been moistened and then charged by means of a central electrode. In the second heat exchanger, the flue gas is reheated to 105 °C and fed to the DeNOx and dioxin destruction facility by means of an induced-draught fan.

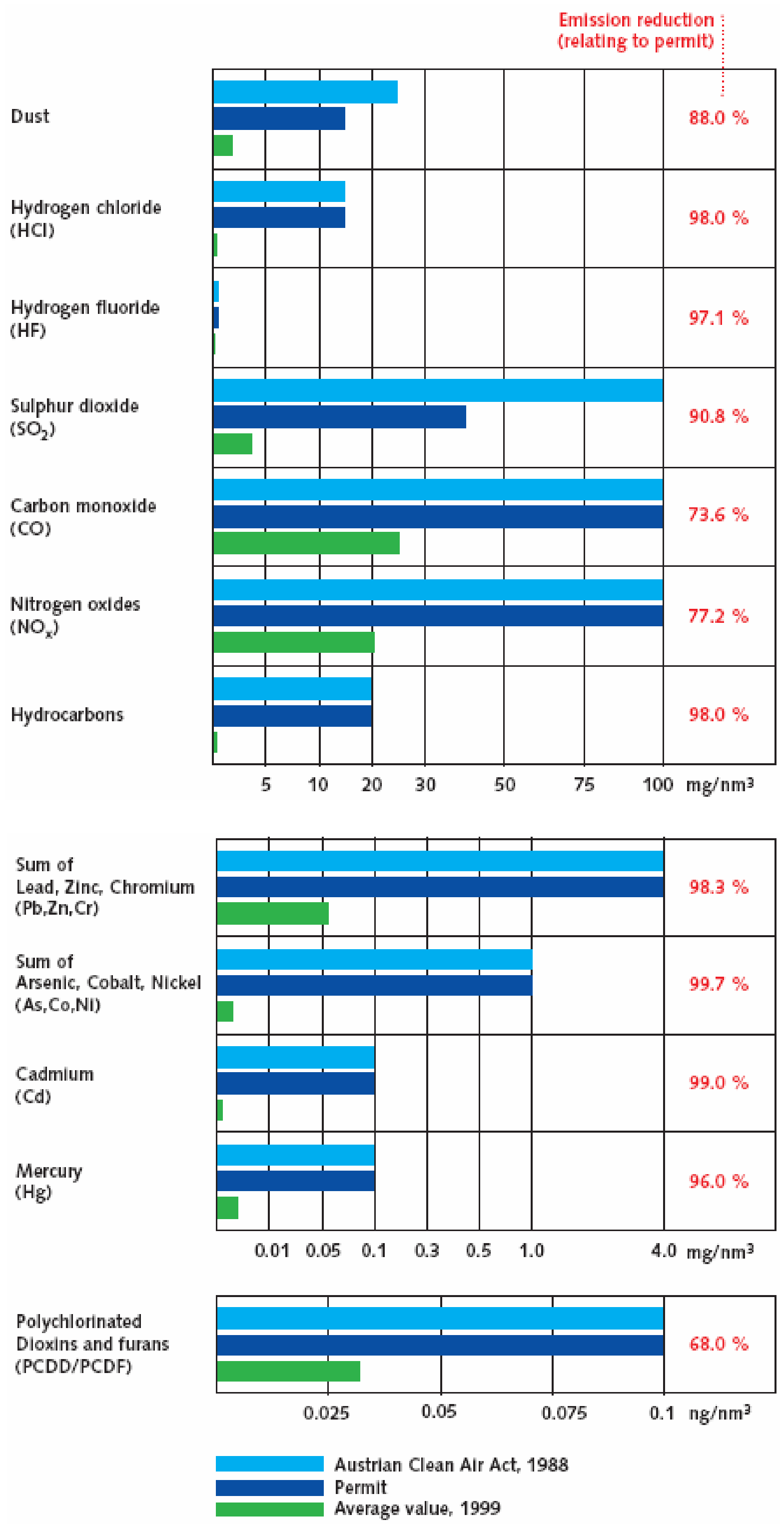
Figure 8: Electrodynamic venturi reduces the dust content to < 1mg/nm^3

The DeNOx facility (see Figure 9), the final stage of the flue gas treatment process, utilizes selective catalytic reduction (SCR). The flue gas streams from both lines are combined, mixed with vaporized ammonia water (NH_3) and heated to a reaction temperature of 280 °C by a heating tube and gas duct burners. Passing through the three catalytic converter stages causes the nitrogen oxides (NOx) to react with the added ammonia and the oxygen in the flue gas to form nitrogen and steam, and also results in dioxin and furan destruction. The resultant exhaust gas is then cooled to 115 °C in the third heat exchanger and finally released into the atmosphere through a 126 m high stack.

Figure 9: DeNOx facility

The continuously measured emissions of the air pollutants carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), hydrogen chloride (HCl), dust and hydrocarbons in the cleaned exhaust gas are transmitted online to the Vienna's environmental protection authorities, thus permitting continuous monitoring of compliance with the emission limit values. The statutory atmospheric emission limit values (1988 Austrian Clean Air Act) are undershot in normal operation (including compliance with the emission limit values for dioxins and furans). Table 1 shows the emission values of the cleaned exhaust gas.

Table 1: Emissions values of cleaned exhaust gas (1999)



<u>3. Waste water treatment</u>

All wastewater emitted by the flue gas scrubbing system is processed in a treatment plant before being released into the receiving water (Danube channel).

The heavy metal compounds dissolved in the discharge water from the first scrubber are first converted to insoluble form in a precipitation reactor, by dosing lime slurry as well as special precipitation and flocculation agents. Thereafter, separation of the heavy metal hydroxide suspension thus created takes place in the laminar clarifier which is connected in series. Following repetition of the precipitation and separation stages, the resultant hydroxide sludge is dewatered to a residual moisture content of approximately 30 % in a chamber filter press and filled in big bags as filter cake. After a final check of volumetric flow, temperature, pH value and conductivity, the cleaned waste water is passed into the receiving water.

The sodium sulfate-laden discharge water from the second scrubber is processed in the multi-stage recycling plant. Firstly, the sodium sulfate is precipitated as calcium sulfate (gypsum) by the addition of lime slurry, precipitated in the settlement tank and, as gypsum sludge, pumped into the slag discharger. The soda lye reclaimed from the precipitation process is returned back into the water circulation system of the second scrubber.

4. Solid residues treatment

The solid residues of the WTE facility consist of approximately 280 kg of bottom ash, ferrous scrap, filter ash and filter cake per ton of waste input.

Following separate transport of bottom ash (in covered wagons) and filter ash (in silo transporters) to a special processing plant (Waste treatment facility Rinterzelt, Vienna), these two residues are sieved, scanned again to remove any ferrous scrap, mixed with cement and water, and used in landfill construction for border walls as a slag-filter ash concrete with an eluate quality approaching that of drinking water.

The ferrous scrap (6000 t/y) removed from the raw bottom ash at the Spittelau WTE facility is recycled in steel smelters.

At present there is no possibility for cost-effective utilization of the residue from the wastewater treatment plant. The filter cake is transported to Germany by rail in big bags, and is used as filler in an extinct salt mine. Table 2 shows the mass flow balance of 1999.

Table 2: Mass flow balance (1999)

Input flow (relating to 1 ton of waste)	
Power requirement (covered by in-plant generation)	80 kWh
Heat requirement (covered by in-plant generation)	39 kWh
Natural gas requirement	19 m^3
Freshwater requirement	731 kg
Lime consumption	3.1 kg
Consumption of soda lye, 30%	2.8 kg
Consumption of ammonia, 25%	3.2 kg
Consumption of precipitation agents	0.2 kg

Output flow (relating to 1 ton of waste)		
Heat output	1,800 kWh	
Power output	32 kWh	
Bottom ash and gypsum	218 kg	21.8 %
Ferrous scrap	24 kg	2.4 %
Filter ash	18 kg	1.8 %
Filter cake	0.9 kg	0.09 %
Cleaned waste water	449 kg	
Cleaned exhaust gas	5,600 nm^3	

Waste throughput	263,156 t
Hours of operation, incineration line 1	7,603 h
Hours of operation, incineration line 2	7,735 h

Acknowledgments:

The author greatly appreciates the information provided by Herbert Heindl, administrator of the Spittelau WTE facility/Fernwaerme Wien GmbH, Vienna during his visit of the facility. This visit is part of a study on WTE metals recovery sponsored by the Waste-to-Energy Research and Technology Council and North American Metals Company.

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