The Spittelau Thermal Waste Treatment Plant sustains our lifestyle.
In 1969 the Vienna City Council entrusted the newly-founded FERNWÄRME WIEN GmbH (formerly: Heizbetriebe Wien) with the following operational objectives: build-up, operation and maintenance of the metropolitan district heating supply, as well as orderly disposal of municipal solid wastes by operation of the Spittelau Thermal Waste Treatment Plant which was then under construction.

Meanwhile, an ongoing expansion programme has created an interconnected 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 it is one of the largest in Europe. At present, 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 Works at its present location was the need to provide heat for the New General Hospital situated about two kilometres away. With a rated capacity of 460 MW, the plant is the second largest supplier of Vienna’s district heating network. The thermal waste treatment plant located at the works has a capacity of 250,000 tons of waste per year and is linked into the network, providing an annual average of 60 MW, i.e. the base load. In addition, some 400 MW (peak load coverage) can be supplied from a further 5 gas or gas/oil-fired hot water boilers.

In compliance with continuous adjustment to state-of-the-art flue gas cleaning technology the Spittelau Thermal Waste Treatment Plant was equipped with a flue gas scrubbing system in 1986/89, as well as an ultra-modern SCR-DeNOx and dioxin destruction facility in 1989. At the same time the outer façade of the entire district heating works was re-
designed by the famous painter and architect Friedensreich Hundertwasser. The previously sober, functional structure was transformed into a unique work of art which is not only a successful example of a harmonious marriage of technology, ecology and art, but also makes a major contribution to the reduction of ‘visual pollution’ of the urban environment.
The Viennese municipal solid wastes, i.e. domestic waste and non-hazardous commercial wastes of similar composition, are delivered to the Spittelau Thermal Waste Treatment Plant from Monday to Friday between 7.00 a.m. and 3.00 p.m. Daily up to 250 delivery vehicles first pass over one of the two weigh-bridges to establish the weight of the waste, before emptying their loads into the 7,000 m³ waste bunker at one of a total of 8 tipping points.

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, whose tong grabs each have a capacity of 4 m³.

Josef Kapoun controlling the hydraulic ram feeder of the incinerator, which is the heart of the thermal waste treatment process.
The thermal waste treatment plant consists of two incineration lines, each with a flue gas treatment plant, with a SCR-DeNOx and dioxin destruction facility serving both lines, and a treatment plant for the waste water arising from the flue gas scrubbing system.

Via the furnace feed chute and hydraulic ram feeder, the waste passes from the bunker to the firing grate situated at the lower end of the furnace. Up to 18 tons of waste per hour can be thermally treated on the inclined, 35 m² two-track reverse-acting stoker grate. During the transient incinerator start-up and shut-down operational phases, 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 at 8,600 kJ/kg the lower heating value of the waste is by far sufficient to maintain an autogenous incineration process.
Annual energy balance-sheet, 1999

- Energy from natural gas: 52,000 MWh/y (5,188,620 m³)
- Energy from waste: 650,000 MWh/y (263,156 tons)

Total Energy: 702,000 MWh/y

Useful Energy: 528,200 MWh/y

- Energy Loss: 173,800 MWh/y
- Boiler and Waste heat losses: 159,200 MWh/y
- Other losses: 14,600 MWh/y
- Internal heat consumption: 10,200 MWh/y
- Internal power consumption: 21,000 MWh/y
- Power output: 15,500 MWh/y

Heat output: 481,500 MWh/y

Boiler efficiency: 81%

Roman Baumgartner working at the slag discharger (left)

Looking into the incinerator furnace
The 850 °C flue gas arising from the incineration process gives off its heat to the surfaces of the waste heat boiler. Both lines generate a total of 90 tons of saturated steam (33 bar) per hour. For power generation, this steam is first reduced to 4.5 bar in a back pressure turbine, before the heat is transferred to the returning water of the district heating network by means of condensation in the following heat exchanger bank.

The incombustible components (slag) arriving at the end of the firing grate are quenched by dumping into the water-filled slag discharger. From there, the cooled slag is transported to the slag bunker by a conveyor belt following removal of the ferrous scrap by overhead electromagnets. The extraction 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 odour and dust emissions from the tipping points into the ambient air. In addition, the use of a well-tried computerized firing control system ensures optimum incineration along the grate, and thus maximum slag and flue gas burnout.

Averaged over the year, more than 5 MW of power for internal consumption and infeed to the public grid as well as some 60 MW of district heating energy - the space heating equivalent of approximately 15,000 80 m² dwellings - are recovered from the waste’s energy content in this way.
Norbert Kernbichler under the electrostatic precipitator, the first stage of the flue gas cleaning process.

The second wet scrubber, which removes sulphur dioxide from the flue gas (left).

The electrodynamic Venturi, which completely separates the dust fraction from the flue gas (right).
When commissioned in 1971, the thermal waste treatment plant already had a highly effective electrostatic precipitator, and in 1986 this was augmented by a 2-stage flue gas scrubber with downstream fine dust separator (electrodynamic Venturi). By retrofitting these 3 treatment stages and installing Europe’s first SCR-DeNOx facility downstream to a scrubber in 1989, the Spittelau plant became an international leader in flue gas cleaning and emission reduction for thermal waste treatment plants. From the outset, the existing process under-shot by a wide margin the emission limit values for domestic waste-fired steam boiler plants imposed by the Austrian Clean Air Act a year earlier.

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/nm³, the filter ash thus collected being transferred to a 125 m³ silo via a mechanical-pneumatic conveyor system.

The almost fully dedusted flue gas then enters the quencher of the first scrubber, cooling it 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 counter-current washer and operates at a pH value of 7, is responsible for the removal of sulphur dioxide (SO₂) from the flue gas. In the next treatment stage, the electrodynamic Venturi, the residual dust content is reduced to < 1 mg/nm³ 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.
The DeNOx facility, as the final stage of the flue gas treatment process, utilizes selective catalytic reduction (SCR). The flue gas streams from both treatment lines are combined, mixed with vaporized ammonia water (NH₃) and heated to a reaction temperature of 280 °C by a heating tube and gas duct burners.

Passing through the 3 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.
Flow sheet of the Thermal Waste Treatment Plant

1. Waste bunker
2. Furnace feed chute
3. Firing grate
4. Furnace
5. Waste heat boiler
6. Slag discharger
7. Electrostatic precipitator
8. 2-stage flue gas scrubber
9. Fine dust separator
10. SCR-DeNOx facility
11. Stack
12. Feedwater tank
13. Turbine generator
14. Heat exchanger bank
15. Electromagnet
16. Slag bunker
17. Scrap skip
18. Filter ash silo
19. Multi-stage recycling plant
20. Waste water treatment plant
21. Lime slurry
22. Soda lye
23. Fresh-water
Mass flow balance-sheet, 1999

1. Input flow (relating to 1 ton of waste)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat requirement (covered by in-plant generation)</td>
<td>39 kWh</td>
</tr>
<tr>
<td>Power requirement (covered by in-plant generation)</td>
<td>80 kWh</td>
</tr>
<tr>
<td>Natural gas requirement</td>
<td>19 m³</td>
</tr>
<tr>
<td>Freshwater requirement</td>
<td>731 kg</td>
</tr>
<tr>
<td>Lime consumption</td>
<td>3.1 kg</td>
</tr>
<tr>
<td>Consumption of soda lye, 30%</td>
<td>2.8 kg</td>
</tr>
<tr>
<td>Consumption of ammonia, 25%</td>
<td>3.2 kg</td>
</tr>
<tr>
<td>Consumption of precipitation agents</td>
<td>0.2 kg</td>
</tr>
</tbody>
</table>

2. Output flow (relating to 1 ton of waste)

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat output</td>
<td>1,800 kWh</td>
</tr>
<tr>
<td>Power output</td>
<td>32 kWh</td>
</tr>
<tr>
<td>Slag and gypsum</td>
<td>218 kg</td>
</tr>
<tr>
<td>Ferrous scrap</td>
<td>24 kg</td>
</tr>
<tr>
<td>Filter ash</td>
<td>18 kg</td>
</tr>
<tr>
<td>Filter cake</td>
<td>0.9 kg</td>
</tr>
<tr>
<td>Cleaned waste water</td>
<td>449 kg</td>
</tr>
<tr>
<td>Cleaned exhaust gas</td>
<td>5,600 nm³</td>
</tr>
</tbody>
</table>

Waste throughput: 263,156 tons

Hours of operation, incineration line 1: 7,603

Hours of operation, incineration line 2: 7,735
All waste water emitted by the flue gas scrubbing system is processed in a special 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 sulphate-laden discharge water from the second scrubber is processed in the multi-stage recycling plant. Firstly, the sodium sulphate is precipitated as calcium sulphate (gypsum) by the addition of lime slurry, sedimented 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.
The solid residues of the thermal waste treatment process consist of approximately 280 kg of slag, ferrous scrap filter ash and filter cake per ton of waste input.

Following separate transport of slag (in covered wagons) and filter ash (in silo transporters) to a special processing plant, 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 removed from the raw slag at the Spittelau plant itself is returned to the material cycle (steel production). At present as there is no possibility for cost-effective utilization of the residue from the waste water treatment plant, the filter cake, this is transported to Germany by rail in big bags, and used there as infill in a disused salt mine.
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 targets:

1. protection of the environment,
2. conservation of natural resources,
3. careful management of landfill volumes, and
4. restriction of landfilling to inert wastes.

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

With effect from 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. The current view is that thermal waste treatment (using the waste’s energy content for power and heat generation) represents the most economically viable and environmentally sound alternative of all treatment and disposal technologies in respect of plant availability, operational safety and compliance with the objectives laid down in the Waste Management Act.
Compared to the direct land-filling of untreated domestic waste, thermal waste treatment offers a number of advantages:

1) Reduction of the amount of landfilled waste to 10 % of the original volume;
2) Destruction of the organic pollutants contained in the waste (e.g. dioxins);
3) Rendering inert most of the inorganic components contained in the waste;
4) Targeted withdrawal of pollutants from the environment;
5) Extraction of usable or easily disposable inert residues;
6) Easy control of the processes concerned, and of the emissions released into the environment;
7) Primary energy substitution by means of exploitation of the waste’s energy content (generation of power and heat);
8) Reduction of greenhouse effect causing gases (especially methane).

Thanks to the continuous improvement of the flue gas and waste water treatment measures, the Spittelau Thermal Waste Treatment Plant, which went into operation in 1971, has now reached the current maximum achievable level of emission reduction.

Since 1994, in accordance with the objectives of the Environmental Information Act, an electronic display board situated in the immediate vicinity of the plant site has given passers-by an at-a-glance view of current exhaust gas quality.
The continuously measured emissions of the air pollutants carbon monoxide (CO), sulphur dioxide (SO₂), nitrogen oxides (NOₓ), hydrogen chloride (HCl), dust and hydrocarbons in the cleaned exhaust gas are transmitted online to the City of Vienna’s environmental protection authorities, thus permitting continuous monitoring of compliance with the emission limit values.

The statutory atmospheric emission limit values are undershot by a considerable margin in normal operation (including compliance with the much discussed emission limit values for dioxins and furans, established for the first time anywhere in the world by the 1988 Austrian Clean Air Act). Current research, based on an environmental assessment method, is therefore focused on optimization of the measures for dealing with the solidified slag and filter ash residues.

Last but not least, the incorporation of the Spittelau plant with its high flue gas cleaning standards in the district heating network, as well as the resultant substitution of primary energy sources such as gas and oil by the fuel ‘waste’, has brought about a considerable improvement in Vienna’s emission and air-borne pollutant balance-sheet.
### Technical specifications

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Weighing device:</td>
<td>Weighbridge, number: 2</td>
</tr>
<tr>
<td>2.</td>
<td>Waste bunker:</td>
<td>Capacity: 7,000 m³, Tipping points: 8</td>
</tr>
<tr>
<td>3.</td>
<td>Furnace feeding:</td>
<td>Bridge crane with 2-cable tong grabs, number: 2, Grab capacity: 4 m³</td>
</tr>
<tr>
<td>4.</td>
<td>Incineration:</td>
<td>Number of lines: 2, Max. throughput capacity per line: 18 tons/h</td>
</tr>
<tr>
<td>4.1</td>
<td>Firing grate:</td>
<td>Air-cooled two-track reverse-acting stoker grate, Grate length: 7.5 m, Grate width: 4.6 m, Inclination: 26°</td>
</tr>
<tr>
<td>4.2</td>
<td>Furnace:</td>
<td>Thermal output per line: 41.1 MW, Furnace temperature: &gt; 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</td>
</tr>
<tr>
<td>4.3</td>
<td>Auxiliary firing:</td>
<td>Gas burners, number per line: 2, Thermal output per burner: 9 MW</td>
</tr>
<tr>
<td>5.</td>
<td>Slag discharging:</td>
<td>Water-filled ram type slag discharger, Slag discharger volume: 5 m³</td>
</tr>
<tr>
<td>6.</td>
<td>Waste heat boiler:</td>
<td>Natural circulation radiant type boiler, Max. steam output per line: 50 tons/h (saturated steam), Max. operational pressure: 34 bar, Max. operational temperature: 245 °C, Effective heating surface: 2,420 m²</td>
</tr>
<tr>
<td>7.</td>
<td>Turbine generator:</td>
<td>Saturated steam back pressure turbine, Max. power output: 6.4 MW, Back pressure: 4.5 bar</td>
</tr>
<tr>
<td>8.</td>
<td>Flue gas treatment:</td>
<td>Number of lines: 2 (SCR-DeNOx facility: 1), Volumetric flow of flue gas per line: 85,000 nm³/h</td>
</tr>
<tr>
<td>8.1</td>
<td>Electrostatic precipitator:</td>
<td>Operational voltage: 60 kV, Dust removal efficiency: &gt; 99.5%</td>
</tr>
<tr>
<td>8.3</td>
<td>DeNOx ing and dioxin destruction:</td>
<td>SCR catalytic converter, number of catalyst stages: 3, Operational temperature: 280 °C, NOₓ destruction rate: &gt; 95%, Dioxin destruction rate: &gt; 95%</td>
</tr>
<tr>
<td>9.</td>
<td>Induced-draught fan:</td>
<td>Radial fan, number per line: 1, Max. flow capacity: 137,000 nm³/h, Power requirement: 1 MW</td>
</tr>
<tr>
<td>10.</td>
<td>Stack:</td>
<td>Design: Steel, partially brick lined, Height: 126 m, Diameter: 2.5 m</td>
</tr>
</tbody>
</table>
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