TBU Stubenvoll GmbH

Information for reference visit in Villach and Arnoldstein

October 2018

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TECHNOLOGY PROVIDER

Stationary fluidized bed boilers

Internal circulating fluidised bed boilers

SNCR-systems

Dry and semidry gas cleaning

Wet flue gas cleaning including gypsum process

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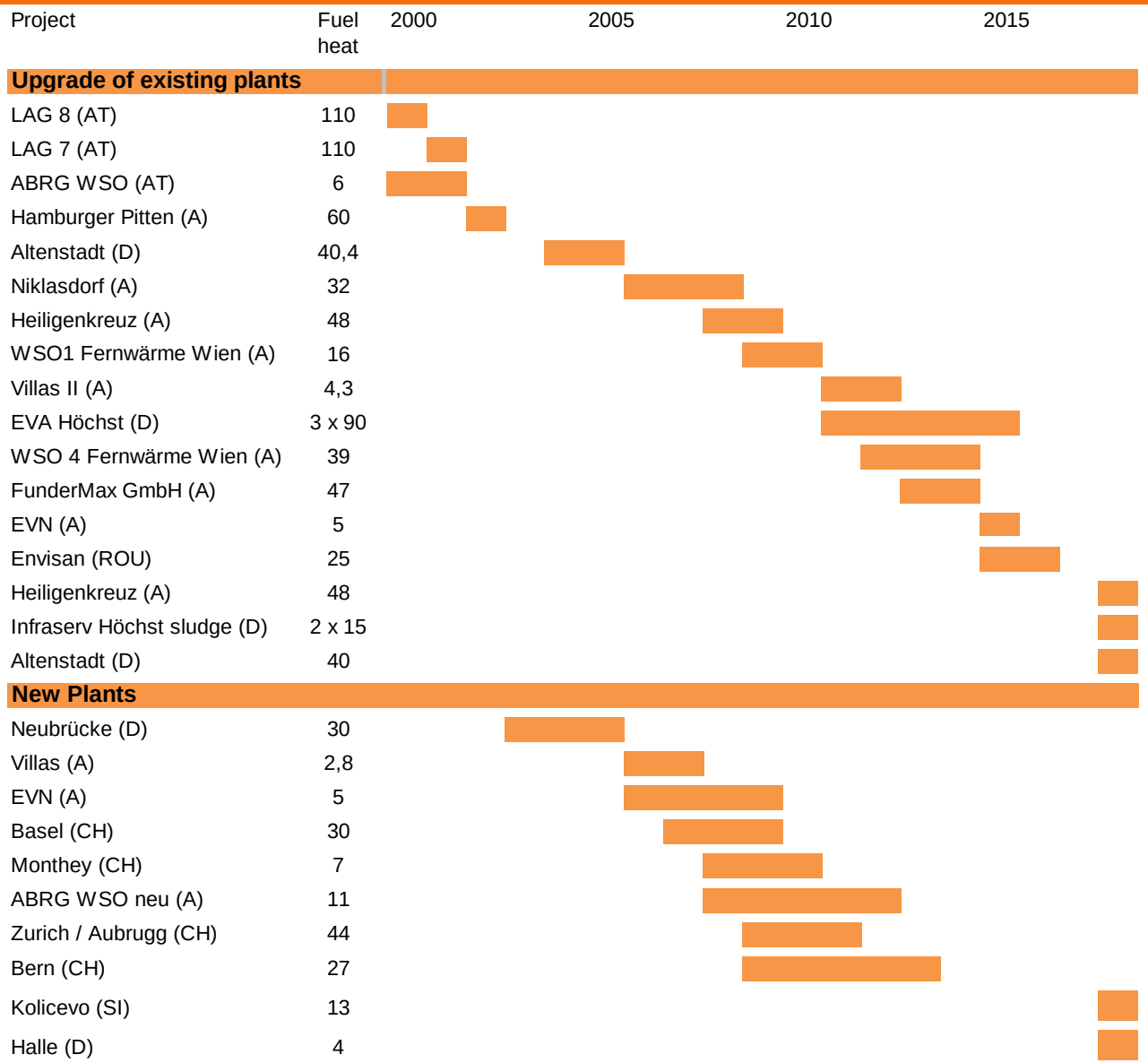
REFERENCES FOR FLUIDISED BED BOILERS



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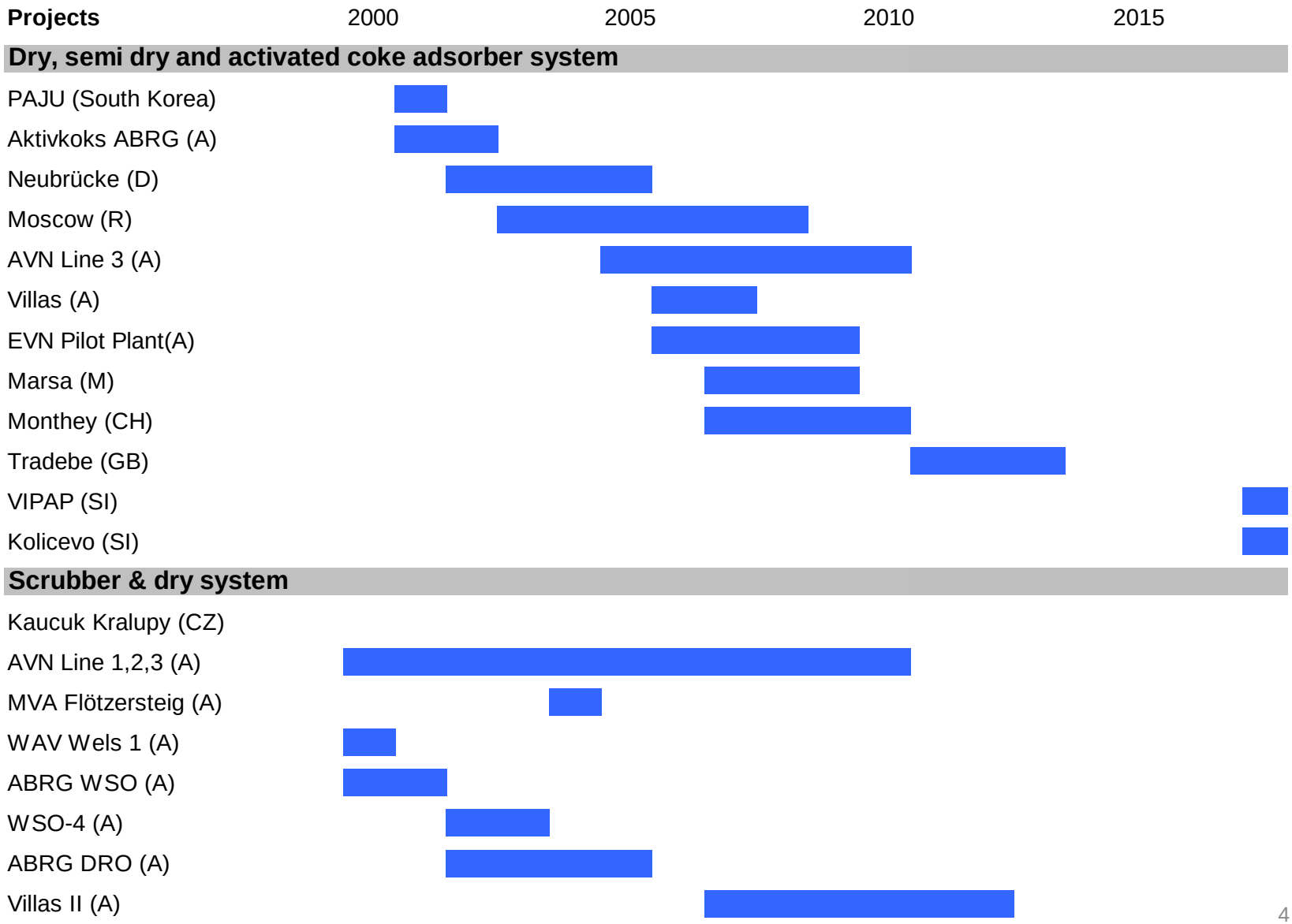
REFERENCES FOR GAS CLEANING PLANTS



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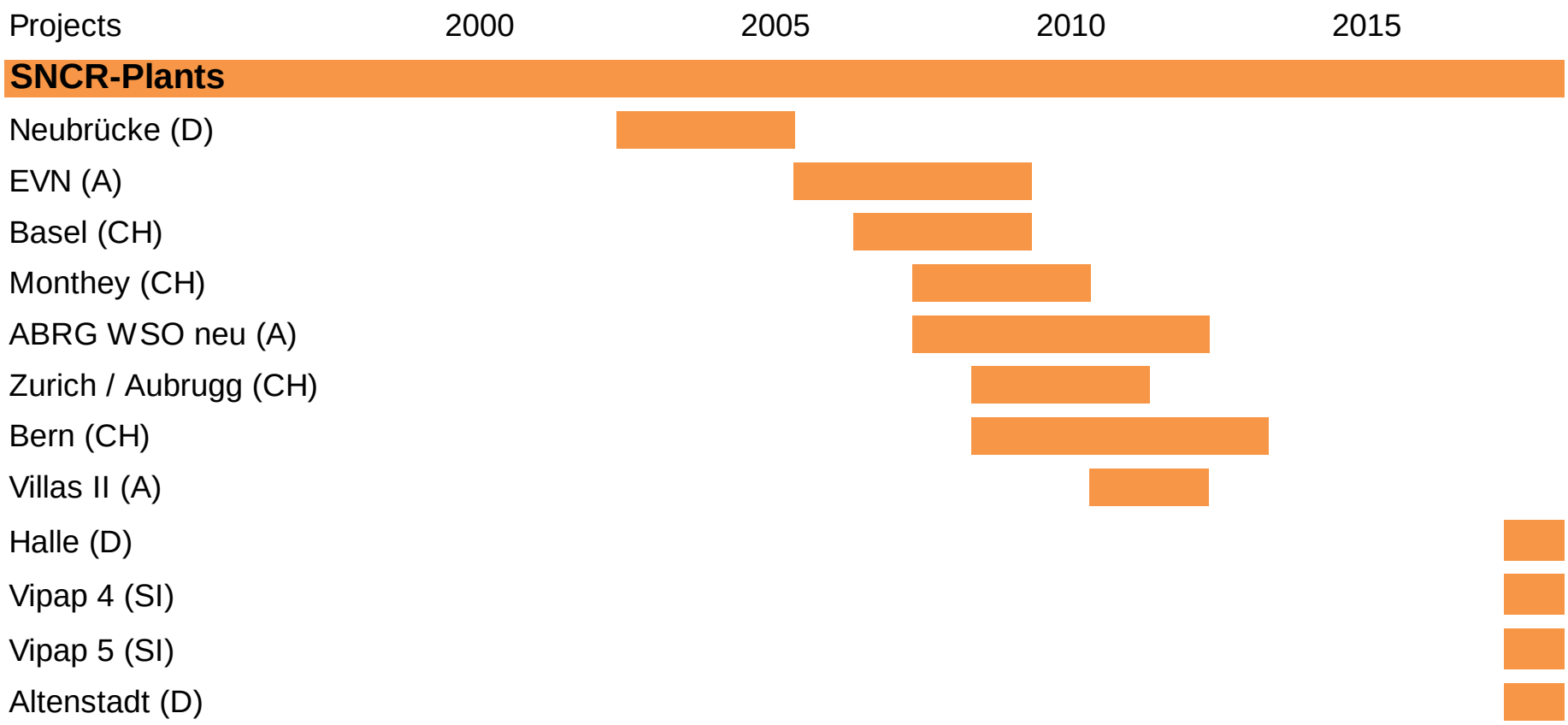
REFERENCE FOR SNCR-PLANTS



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TBU ENGINEERING SERVICES

Engineering package for standardised stationary fluidised bed plants for

sewage sludge and

pretreated waste fuels

Individual services according to the client´s requirements such as:

basic- und detail engineering,

supervision of production and assembly,

start-up and

delivery of special components and plant equipment

CFD flow simulation

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Experiences with Different Technologies in Different Countries

Our engineering is based on many years of experience in the field of advanced environmental plants all over the world. We have successfully engineered projects in:

Dürnrohr(Austria)

Marsa (Malta)

Frankfurt (Germany)

Zürich / Aubrugg (Switzerland)

- Austria
- Australia
- China
- Croatia
- Czech Republic
- France
- Germany
- Great Britain
- Greece
- Hungary

- Italy
- Korea
- Malta
- Netherlands
- Russia
- Switzerland
- Slovakia
- Slowenia
- South Africa
- Taiwan

Kaucuk Kralupy (Czech Republic)

Neubrücke (Germany)

Moscow (Russia)

Lenzing (Austria)

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EXPERIENCE WITH DEWATERED SLUDGE

Combustion of sludge in 18 lines

- Waste fuel as main fuel in 12 lines
- Sludge as main fuel in 6 lines

Total capacity for dewatered sludge: more than 1.500.000 t/a

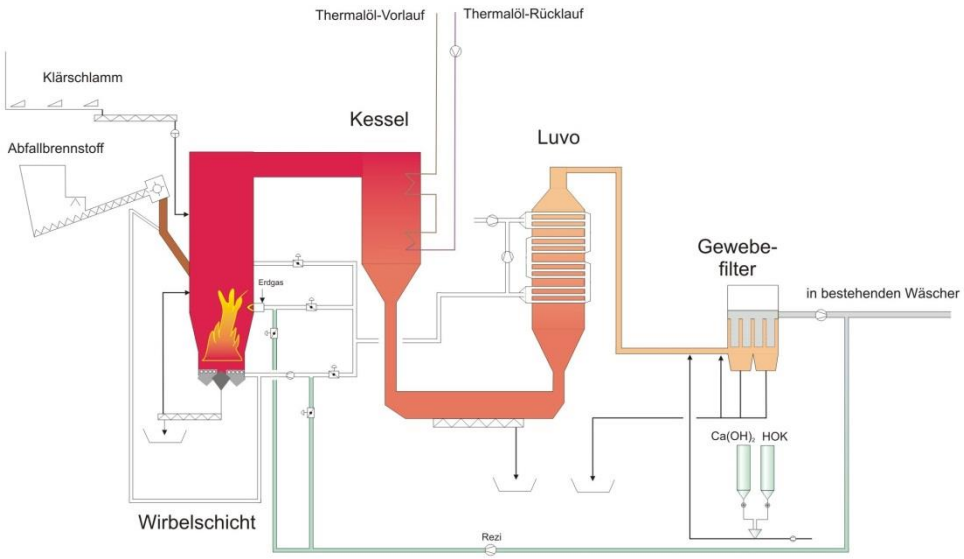
1st Fluidised Bed Incineration Plant VILLAS Austria GmbH (Austria 2005-2006)

Project Description:

- ✓ Fluidised bed incinerator for industrial waste and sewage sludge
- ✓ Energy transfer to thermal oil system

Capacity:

- ✓ 2,8 MW fuel heat capacity
- ✓ Emission limits according to Austrian law



Plant Concept:

- ✓ Fluidised bed combustion with boiler and flue gas air pre-heater unit
- ✓ Baghouse filter and existing scrubber with NaOH-dosing station

TBU: approval procedure, basic engineering, detail engineering, supervision of production and commissioning, start-up

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Capacity Increase of Fluidised Bed Incinerator Villas Energie GmbH (Austria 2011-2012)

Stationary Fluidised Bed Combustion for:

- ✓ Production wastes
- ✓ Sewage sludge
- ✓ Treated waste fuels

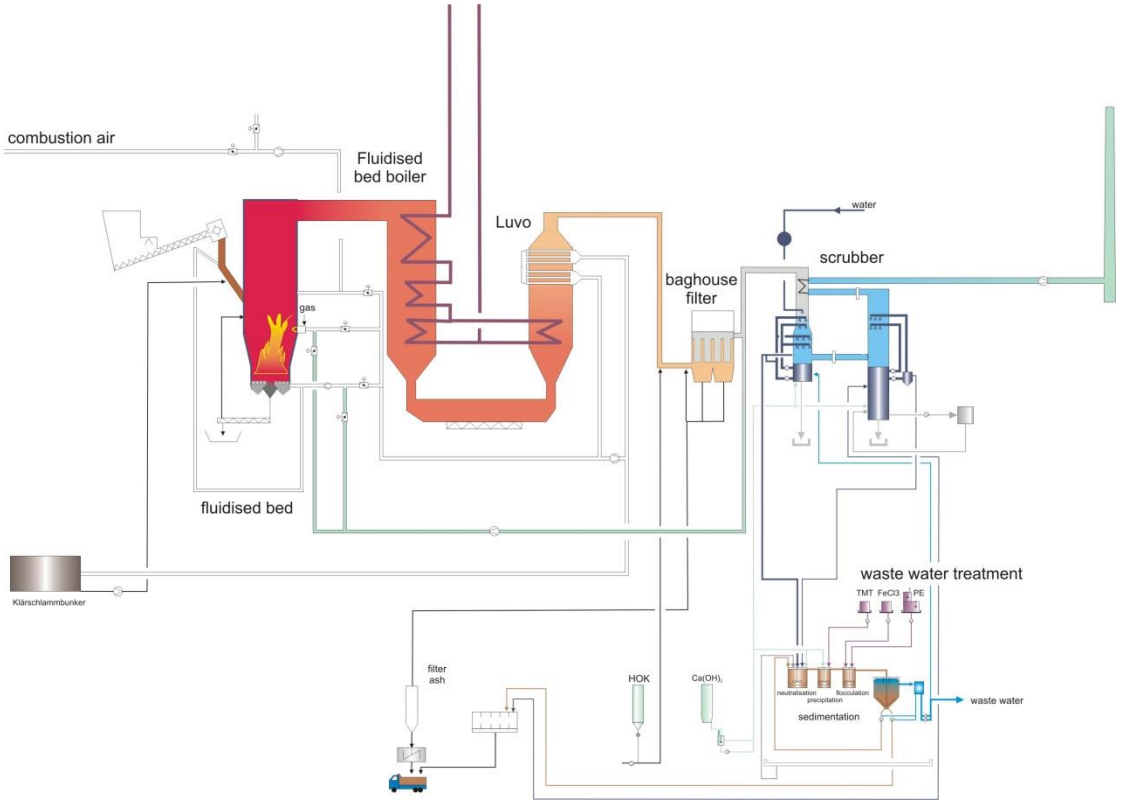
The **produced energy** is used to:

- ✓ heat supply of production of Villas Austria GmbH

Installation of a wet flue gas cleaning plant

Capacity:

- ✓ Capacity increase from 2,8 MW to 4,3 MW



TBU: concept engineering, approval procedure, procedural engineering, processing and start-up for combustion and flue gas cleaning

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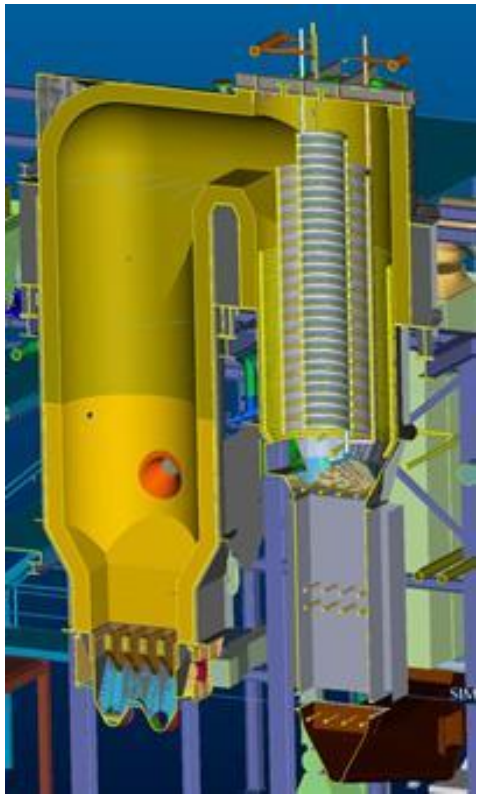
THERMAL OIL BOILER FOR VILLAS



Combustion and boiler

High temperature coils of the boiler

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WET FLUE GAS CLEANING PLANT FOR VILLAS

Wet flue gas cleaning and water treatment plant

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ABRG ARNOLDSTEIN, AUSTRIA

Traditional industrual site

Mining of lead since 13th century

Hut for lead since 15th century

Hut at site since 1882

Fluidised bed and rotary kiln

1970 – 1973

European Energy Award in Gold

e5-city

27. Position in Europe

Soft tourisme region

National Park Dobratsch since 2001

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Industrial Park EURO NOVA

Industrial park develloped from former hut

by using the existing infrastructur

Recycling of the site with 38 companies

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ABRG GmbH

Reconstruction of the former hut into treatment for hazardous waste

2000 - 2001
Reconstruction of existing fluidised bed boiler for burning hazardous waste and Installation of a new several step flue gas cleaning plant

2002 – 2005
Reconstruction of the discontinuously operated rotary kiln to a continuously operated rotary kiln for hazardous waste. Installation of an after burning chamber and new several step flue gas cleaning plant

2008 – 2011
Installation of a new fluidised bed boiler, bag house filter and turbine
Usin of the 2001 installed flu gas cleaning plant

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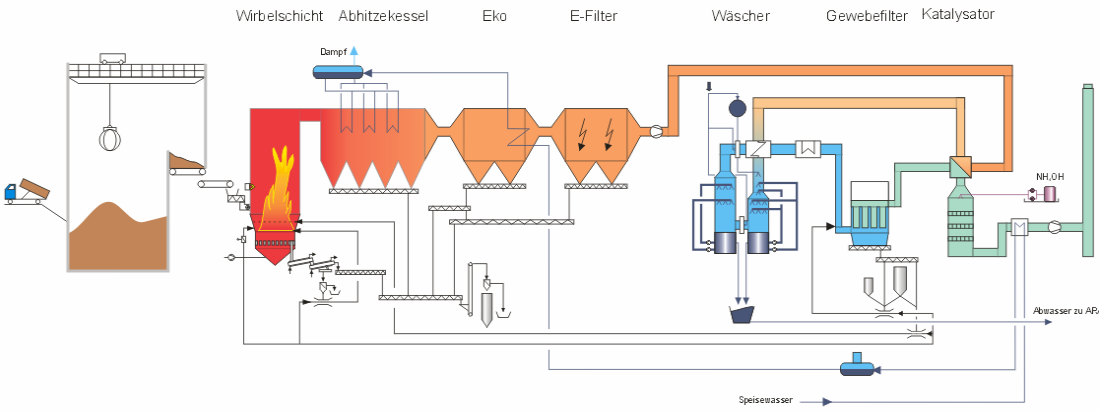
Waste Fluidised Bed Incineration Plant ABRG Arnoldstein (Austria 2000-2001)

Project Description:

- ✓ Fluidised bed incinerator for hazardous and nonhazardous waste
- ✓ Upgrade of incinerator, boiler and flue gas cleaning plant

Capacity:

- ✓ 6 MW fuel heat capacity
- ✓ Total capacity: 30.000 tons per year



Plant Concept:

- ✓ Stationary fluidised bed reactor with waste heat boiler
- ✓ Electrostatic precipitator, two stage scrubber, dry adsorption system with coke powder and lime and selective catalytic reduction of NOx
- ✓ Waste water treatment plant

TBU: approval procedure, basic engineering, detail engineering, supervision of production and assembly, start-up

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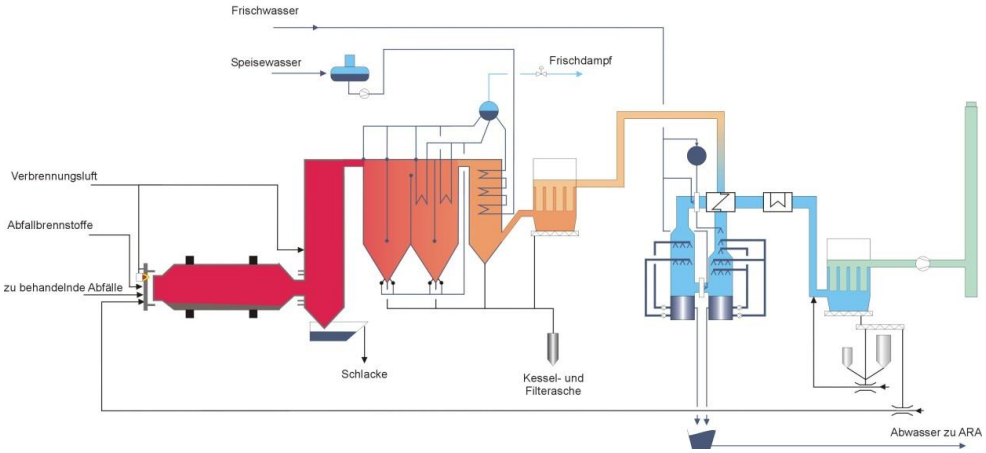
Hazardous Waste Incineration Plant Rotary Kiln ABRG ARNOLDSTEIN (Austria 2002-2005)

Project Description:

- ✓ Combustion of hazardous waste
- ✓ Recycling of heavy metals
- ✓ Steam production

Capacity:

- ✓ 8 MW fuel heat capacity
- ✓ Emission according to Austrian law
- ✓ Total capacity 20.000 tons per year0



Plant Concept:

- ✓ Rotary kiln with afterburning chamber
- ✓ Non-catalytic NOx-reduction
- ✓ Waste heat boiler
- ✓ Baghouse filter
- ✓ Two stage scrubber
- ✓ Dry adsorption system

TBU: approval procedure, basic engineering, detail engineering supervision of production and assembly, start-up

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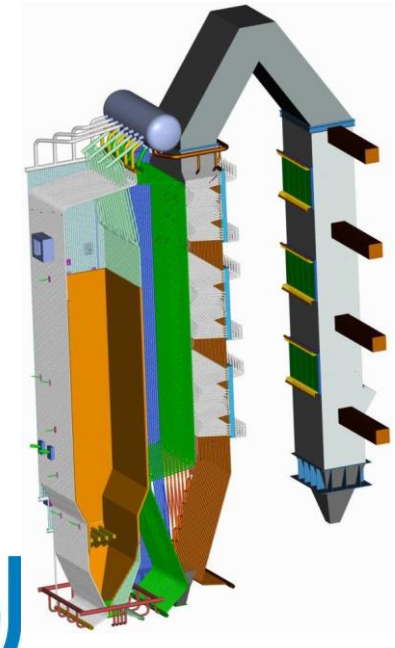
Fluidised Bed Incinerator ABRG Arnoldstein (Austria 2008-2011)

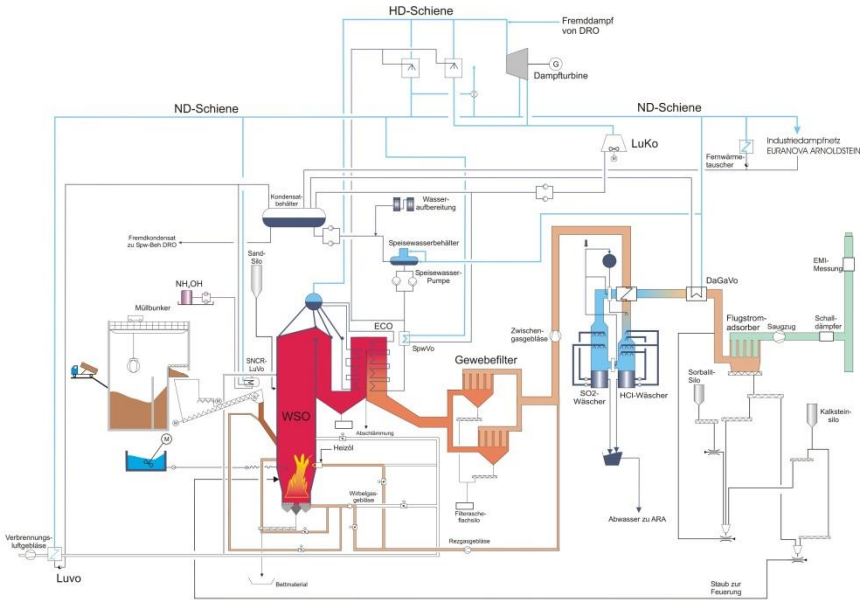
Project Description:

- ✓ Fluidised bed incinerator for solid, fluid and pasty hazardous and non-hazardous waste fuel
- ✓ Production of electrical energy and steam for steam network on-site

Capacity:

- ✓ 11 MW fuel heat capacity
- ✓ Total capacity: 42.000 tons per year





Plant Concept:

- ✓ Fuel feeding
- ✓ Fluidised bed combustion with SCNR-system
- ✓ Heat recovery steam boiler
- ✓ Baghouse filter, two stage scrubber, dry adsorption

TBU: approval procedure, basic engineering, detail engineering, supervision of production and assembly, as well as start-up of the whole plant with own know-how for combustion and flue gas cleaning

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BOILER DATA

HEAT CAPACITY **CALORIFIC VALUE** **MASS FLOW**	**7 – 11 MW** **5,7 – 17 MJ/kg** **2 – 5,3 t/h** **< 42.000 t/a**
KIND OF FUELS	**Hasardous and nonhasardous liquid and solid waste and sludges**
AREA OF WASTE	**Austria (South)** **Italy (North)** **Slovenia**

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EMISSION DATA

Continuously measured parameter [mg/m³]		Emission limit [mg/m³]
Dust	<1	10
CO	5 – 50	100
SO2	1-10	50
NOx	70 - 130	200

Discontinuously measured parameter		Emission limit
HCl	<1 [mg/m³]	10 [mg/m³]
HF	0,2 [mg/m³]	0,7 [mg/m³]
Hg	0,001 [mg/m³]	0,05 [mg/m³]
PCDD/F	0,016 [ng/m³]	0,1 [ng/m³]

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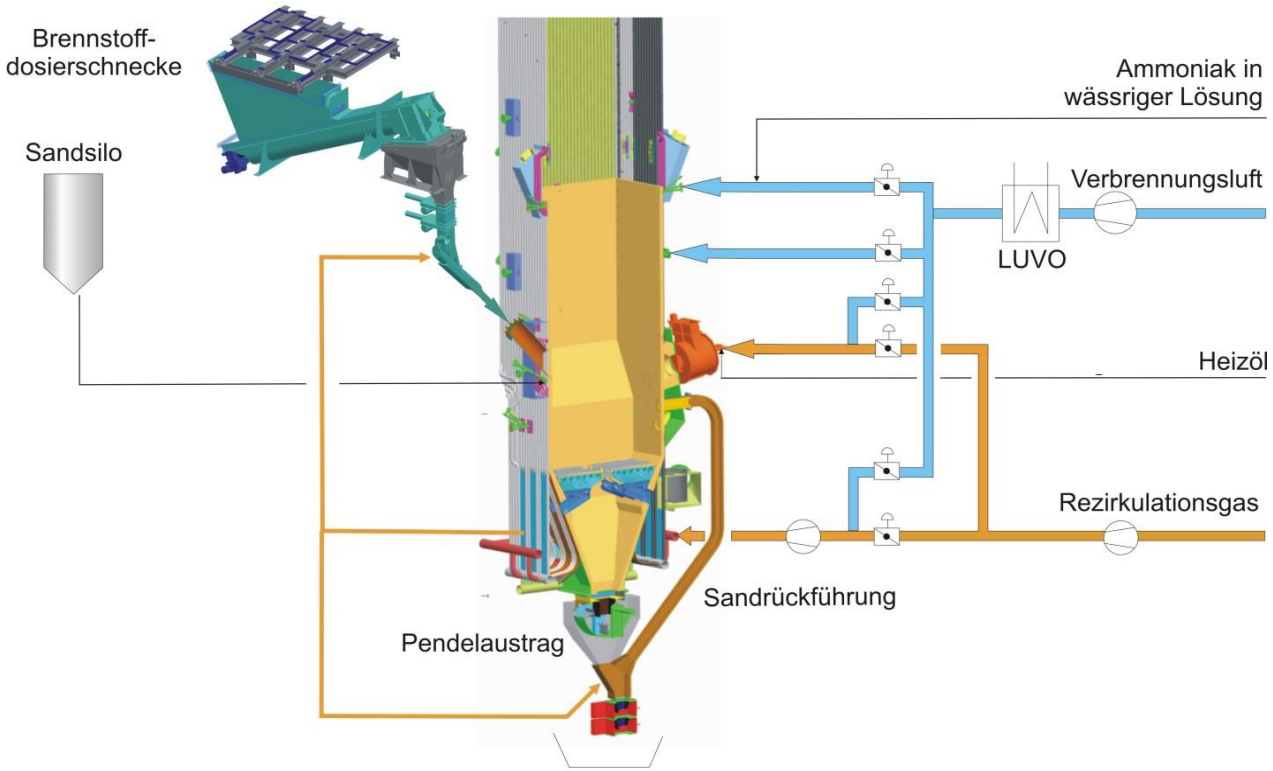
AVAILABILITY

Year	Hours in operation [h/a]	Availability [%]
2011	8106	92,5
2012	8400	95,6
2013	8510	97,1
2014	8467	96,7
2015	8523	97,3

OPERATED WASTE

Year	Solid waste [t/a]	sludges [t/a]	Liquid waste [t/a]
2011	16832	10770	6810
2012	16916	12756	10394
2013	17235	11647	10742
2014	15223	12438	10801

Stationary fluidised bed with staged combustion



Optimised Fuel and Residue system for RDF

- ✓ Short time storage with walking floor
- ✓ Dosing systems for solid and liquid waste and sludge
- ✓ Pneumatical feeder
- ✓ Open nozzle floor
- ✓ Pendular discharger
- ✓ Cross stream windsifter
- ✓ Pneumatical sand recirculation

Optimised combustion system for high flexibility of fuel

- ✓ Control of heat release in the fluidised bed and in lower freeboard by modulation of ratio of air to recirculation gas
- ✓ Combustion air is controlled by O2-content in flue gas and steam flöw.
- ✓ Fuel is controlled by steam flow and temperature at outlet of furnace
- ✓ Recirculation gas is controlled by temperature at outlet of furnace and O2-content in flue gas.

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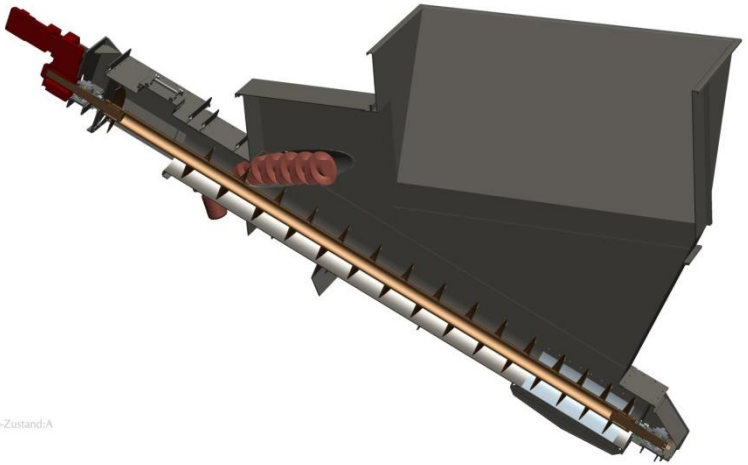
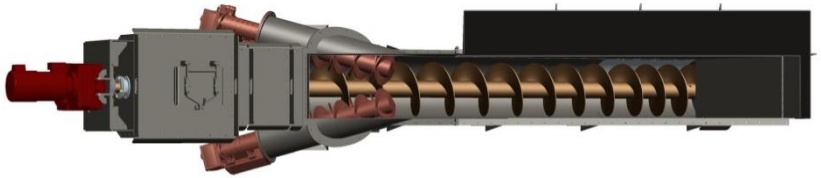
Dosing screw

- ✓ Supported on weight cells => continuous signal for mass of stored fuel
  - ✓ Control of feed to dosing screw
  - ✓ Control of homogeneous foel feed to furnace
- ✓ Dynamical Equalisation of level at the outlet by two screws
  - ✓ Constant level
  - ✓ No compression
- ✓ Design of screw with wide pitch and diameter
  - ✓ Low risk of blockage
  - ✓ Low wear





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Injector for solid fuel

Transport air is locked by temperature, pressure and difference of pressure

The gate valves are closed when paramters are not within the operating limits

Solid fuel is accelerated and distributed above the bed

Wear parts can be easily replaced

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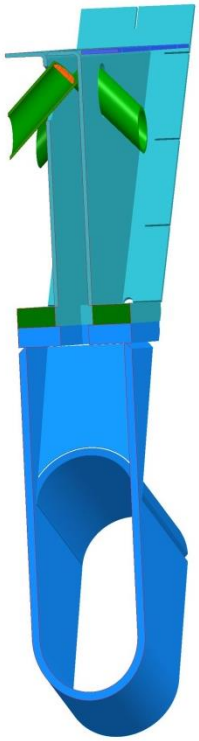
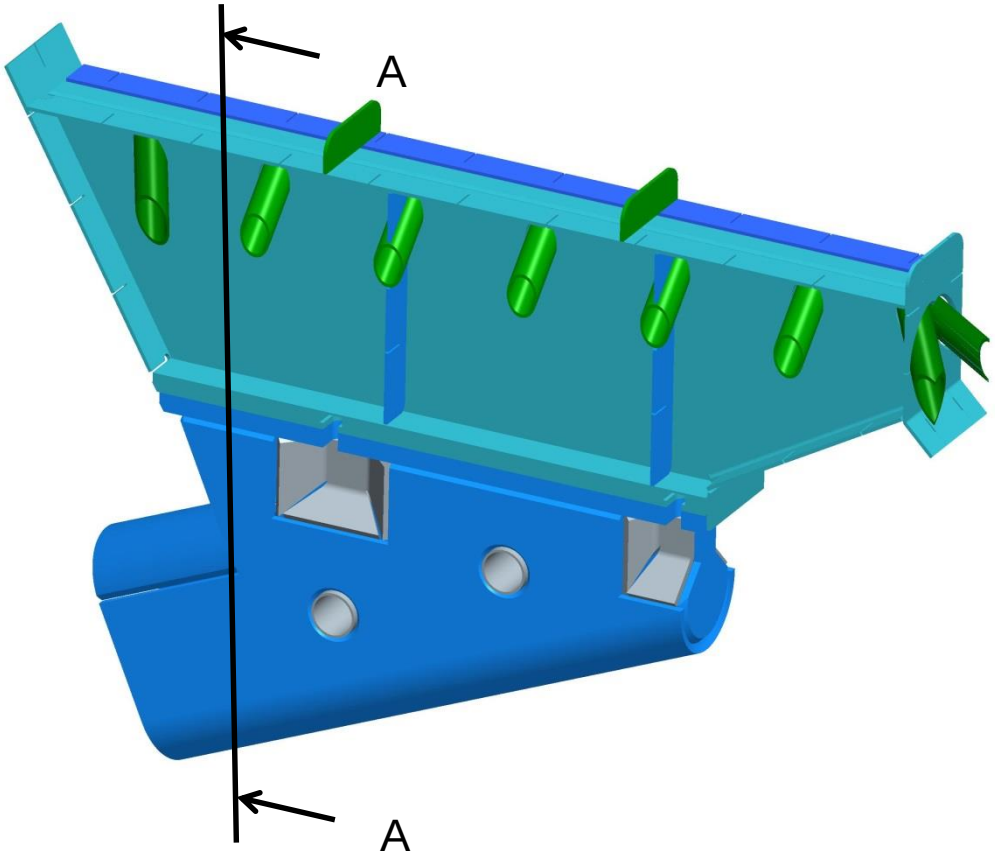
Nozzle bag without refractory

Schnitt A - A





Single nozzle

The nozzle is inclined to the bed to avoid backflow of sand

Drill-holes are at highest level in a small sheet => low risk of blocking

The löwer part of the nozzle bags is welded with the wall

Welded anchors in the upper part of the nozzle bag

Upper part of the nozzle bag

Completed and dried in workshop

⇒ **short time for assembly**

⇒ **simple replacement**

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Open nozzle floor

- ✓ Pitch of nozzle bags are designed according to maximum size of fuel
- ✓ Steep smooth walls in the cone

  => **optimised flow for bed material including impurities**
- ✓ All nozzles in one level

  => **Equal distribution of fluidisation gas**

  Low demand of pressure drop
- ✓ Outlet of nozzles inclined to bed
- ✓ Small drill-holes at highest level in a small sheet

  => **Low risk of blocking**

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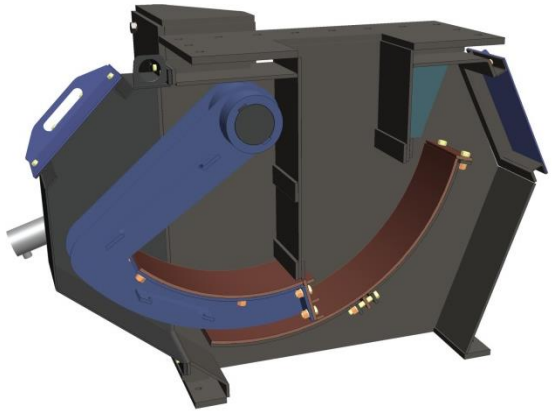
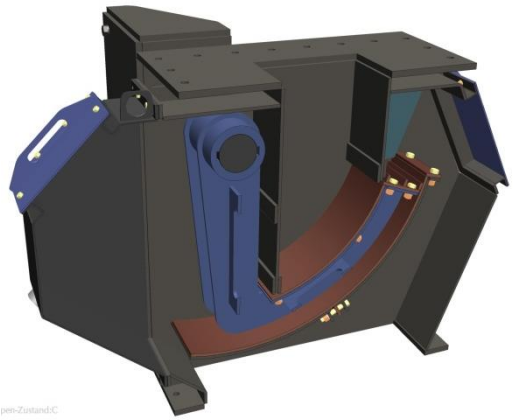
Bed ash pendular discharger

- ✓ **Lock and dosing device**
  - ✓ **Contolled discharche with pusher**
  - ✓ **Bed ash is supported**
- ✓ **Easy to maintain**
  - ✓ **Easy replaceable wear parts**
  - ✓ **Easy removeable**





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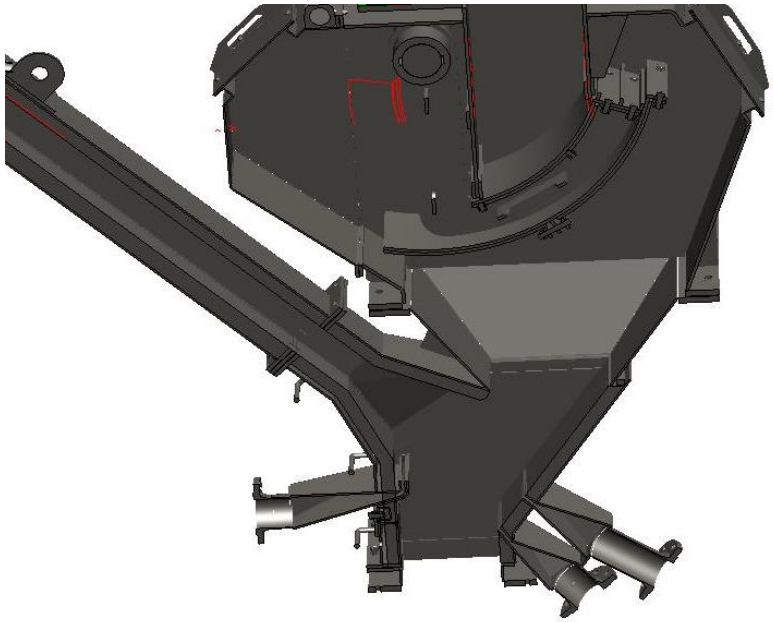
Cross stream wind sifter with pneumatical recirculation of fine ash



- **No cooling device for circulating bed ash**
- **No mechanical sieve**
- **Wear is reduced to few zones**
- **Easy removeable wear plates or ceramcal lining**

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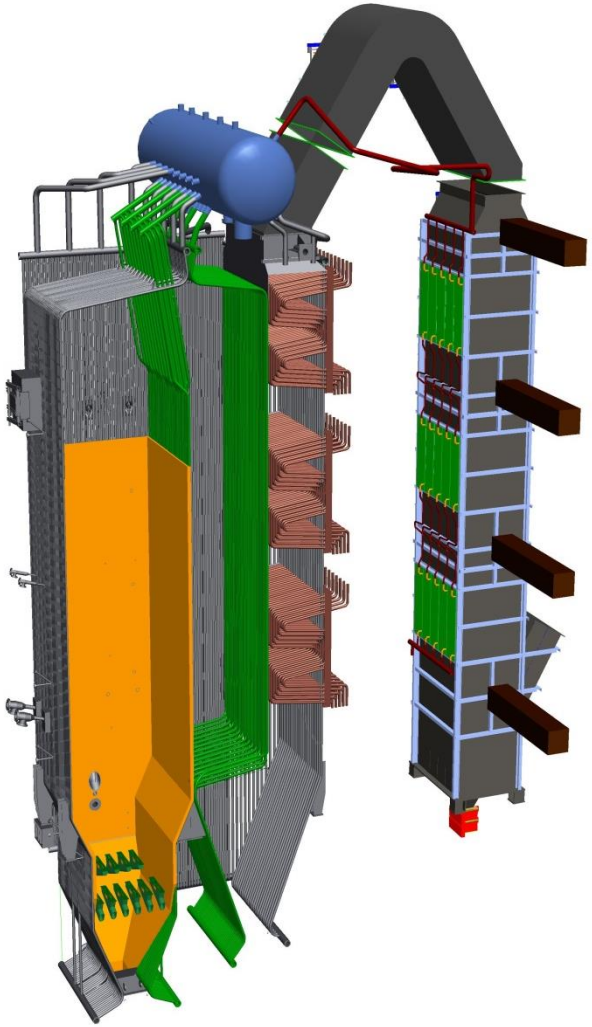
Boiler with integrated fluidised bed



- ✓ **Controlled temperature in furnace**
- ✓ **Temperature after radiatiom pass< 550 °C**
- ✓ **Low gas velocities**
- ✓ **Few fouling**

  Sootblowing each second day

  Cleaning in annual maintenance stop

  takes only some hours

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BOILER CONCEPT

- **Much assembling in workshop**
- **Low assemling time on site**
- **Removeable convection heat surfaces**

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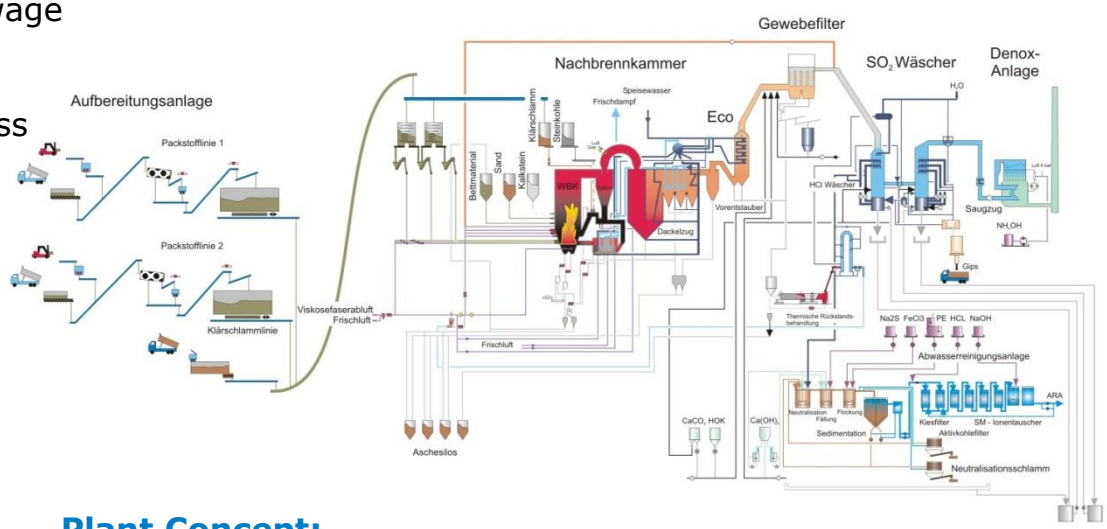
Circulating Fluidised Bed Incineration Lenzing (Austria 1993-2002)

Project Description:

- ✓ Fluidised bed incinerator for RDF and sewage sludge
- ✓ Production of electrical energy and process steam

Capacity:

- ✓ 110 MW fuel heat capacity
- ✓ Total capacity: 250.000 tons per year



Plant Concept:

- ✓ Mechanical treatment of RDF
- ✓ Circulating fluidised bed incinerator
- ✓ Waste heat boiler
- ✓ Dry, wet and catalytic flue gas cleaning plant
- ✓ Waste water treatment plant

TBU: concept engineering, tender engineering, supervision of basic engineering, detail engineering and start-up
Detail engineering of the fluidised bed bottom, combustion control system and scrubber

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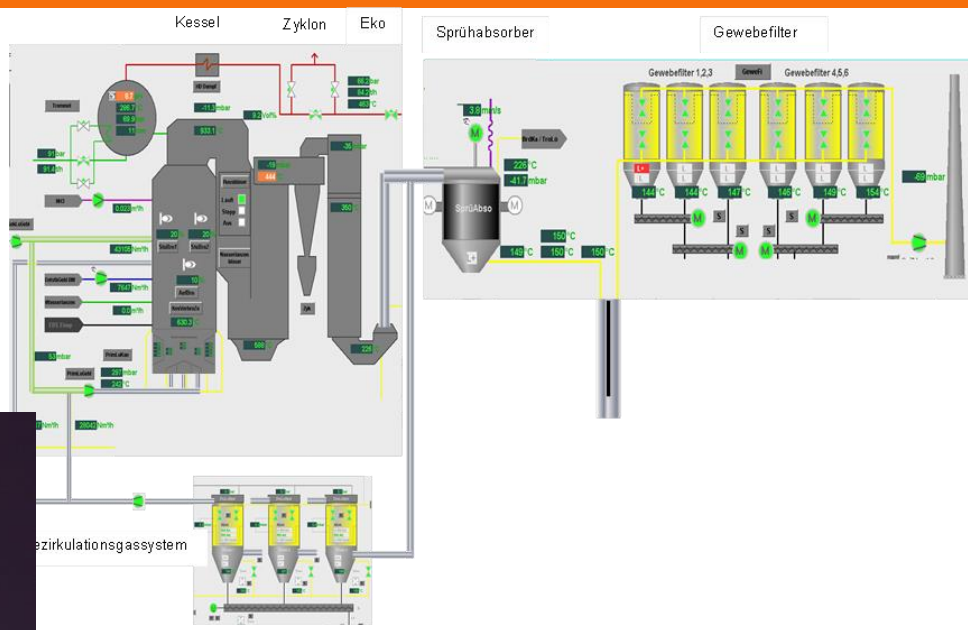
Fluidised Bed Incineration Plant Höchst for RDF (Germany 2011-2013)

Project Description:

- ✓ Fluidised bed incinerator for RDF
- ✓ Production of electrical energy and steam

Capacity:

- ✓ 3 x 90 MW fuel heat capacity



Plant Concept:

- ✓ Fuel feeding
- ✓ Fluidised bed combustion with SCNR-system
- ✓ Steam boiler
- ✓ Baghouse filter, semi-dry adsorption

TBU: basic engineering for staged combustion and boiler reconstruction (retrofit of EBARA-process), combustion control system

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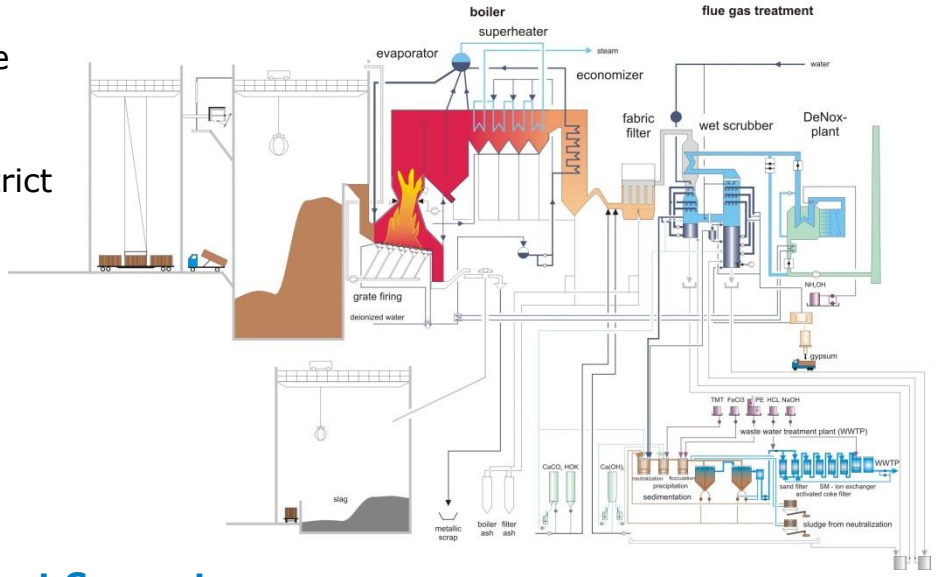
Waste Incineration Plant Dürnrohr (Austria 1994-2009)

Project Description:

- ✓ Grate combustion for domestic waste and sewage sludge in 3 lines
- ✓ Production of electrical energy and steam for district heating in power plant Dürnrohr

Capacity:

- ✓ 2 x 60 MW line 1 and 2
- ✓ 90 MW line 3
- ✓ Total capacity 525.000 tons per year



Plant Concept:

- ✓ Delivery, unloading and storage of waste fuels
- ✓ Boiler plant with integrated grate combustion
- ✓ Dry, wet and catalytic flue gas cleaning plant for 3 combustion lines
- ✓ Treatment plant for fast residues
- ✓ Waste water treatment plant

TBU: concept engineering, tender engineering and supervision of basic engineering, detail engineering and start-up of line 1, 2 (1994-2003) and line 3 (2005-2009)

Revamp of Fluidised Bed Incinerator WSO1 for Fernwärme Wien GmbH (Austria 2008-2009)

Project Description:

- ✓ Revamp of fluidised bed incinerator WSO1 for sewage sludge and solid fuels

Capacity:

- ✓ 16 MW fuel heat capacity

Revamp concept and project objectives:

- ✓ Modification of adiabatic combustion chamber geometry
- ✓ Additional high-pressure steam air pre-heater
- ✓ Combustion control concept

➔ Increased sewage sludge throughput

➔ Reduction of need for high calorific secondary fuel

TBU: basic engineering, detail engineering, supervision of start-up after revamp

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Biomass Power Plant Heiligenkreuz (Austria2008-2009)

Project Description:

- ✓ Fluidised bed incinerator for biomass
- ✓ Production of electrical energy and process steam

Capacity:

- ✓ 48 MW fuel heat capacity
- ✓ Emissions according to 17 BImSchV

Operating company: Bewag und Begas

Combustion: Babcock Wilcox

Boiler: Marcegaglia

TBU: simulation of combustion, improvement actions for combustion for prevention of depositions at the same time with capacity increase of 10 %

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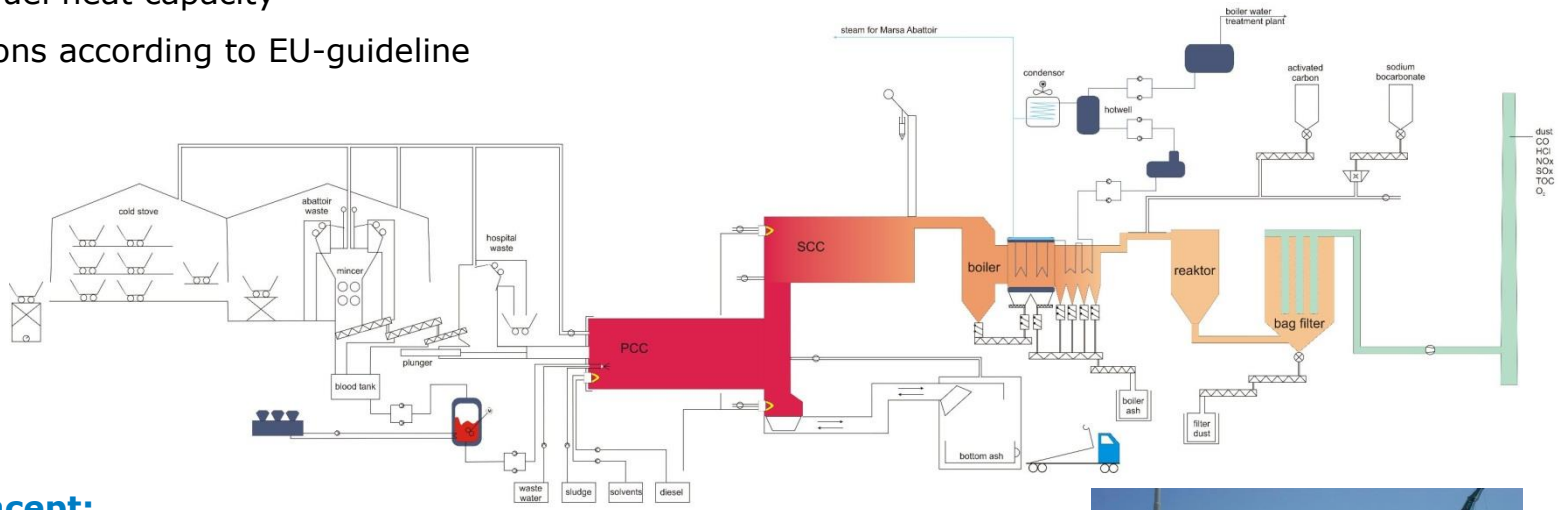
Waste Incineration Plant Marsa (Malta 2007-2009)

Project Description:

- ✓ Upgrade of an existing incinerator for abattoir
- ✓ Hospital waste, special hazardous and non-hazardous waste used as fuel

Capacity:

- ✓ 5 MW fuel heat capacity
- ✓ Emissions according to EU-guideline



Plant Concept:

- ✓ Rotary kiln, combustion chamber and afterburning chamber
- ✓ Dry adsorption with baghouse filter

TBU: basic engineering, supervision of detail engineering and start-up, supervision of performance tests

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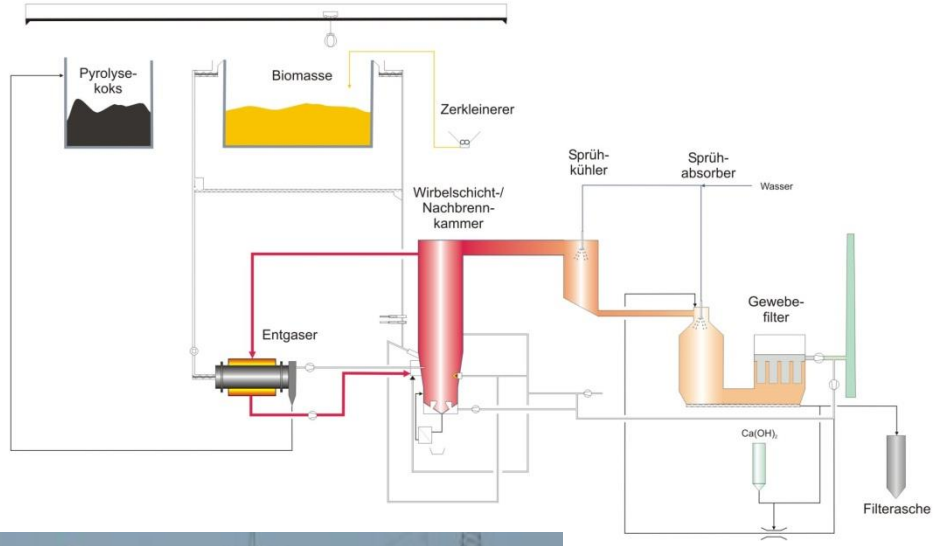
Pilot Plant for Straw Pyrolysis Dürnrohr (Austria 2006 - 2008)

Project Description:

- ✓ Pyrolysis of straw
- ✓ Combustion of pyrolysis gas
- ✓ Combustion of straw and pyrolysis coke in a fluidised bed combustion
- ✓ Project objective: Confirmation of design data and technology demonstration for use of straw in a large power plant



Capacity:

- ✓ 5 MW fuel heat capacity,
- ✓ Emission limits to Austrian law

Plant Concept:

- ✓ Indirect heated rotary kiln
- ✓ Fluidised bed incinerator
- ✓ Spray cooler
- ✓ Spray absorber
- ✓ Baghouse filter

TBU: approval procedure, basic engineering, detail engineering, supervision of production and commissioning , start-up

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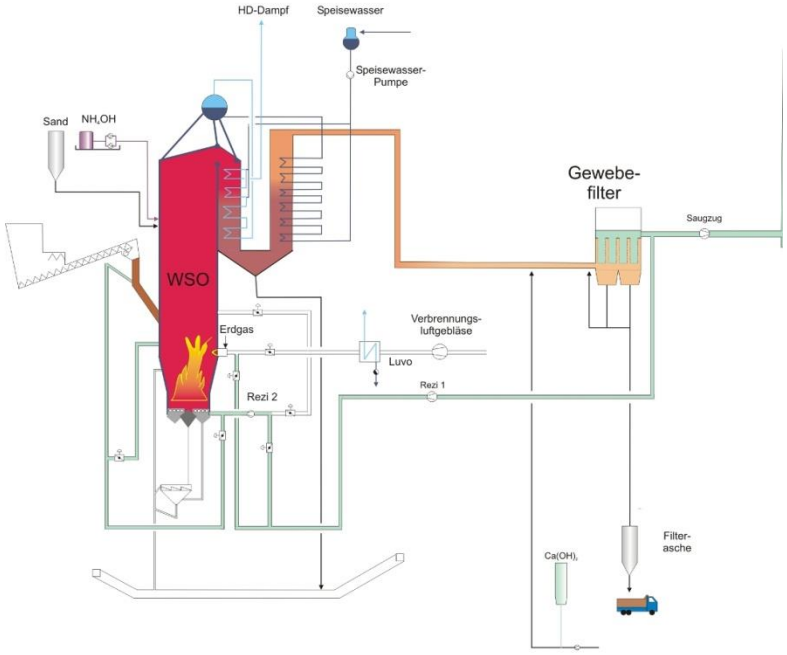
IWB Biomass Power Plant Basel (Switzerland 2006 - 2008)

Project Description:

- ✓ Fluidised bed incinerator for biomass
- ✓ Production of electrical energy and steam for district heating

Capacity:

- ✓ 30 MW fuel heat capacity
- ✓ Emissions according to Swiss law



Plant Concept:

- ✓ Storage of biomass
- ✓ Boiler with integrated fluidised bed incineration
- ✓ Dry flue gas cleaning plant
- ✓ Existing water steam cycle with turbine

TBU: basic engineering, detail engineering, supervision of production and assembly of combustion as well as start-up of the whole plant

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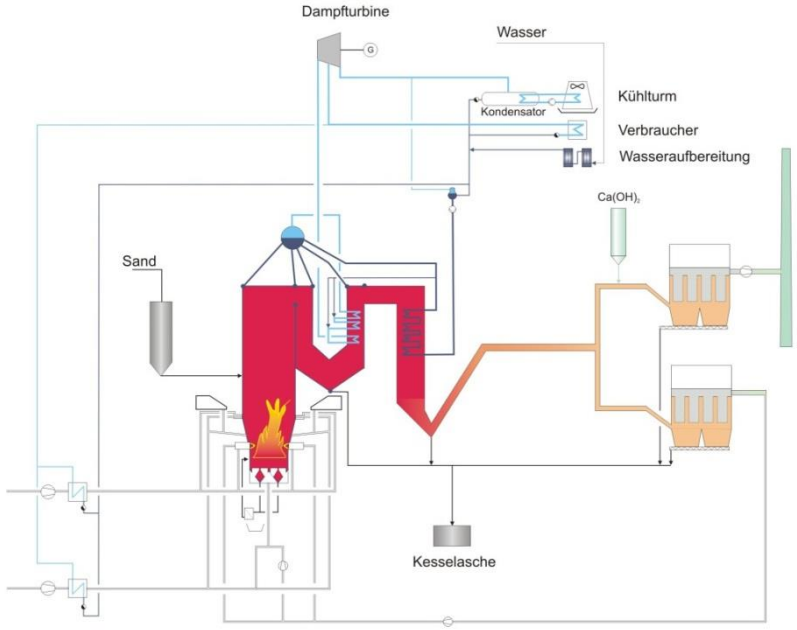
Waste Wood Fluidised Bed Incineration Plant ALTENSTADT-SCHONGAU (Germany 2004-2005)

Project Description:

- ✓ Upgrade of the existing fluidised bed incinerator
- ✓ Production of electrical energy and steam for district heating from biomass

Capacity:

- ✓ 40,4 MW fuel heat capacity
- ✓ Emissions according to 17 BimschV



Plant Concept:

- ✓ Storage of waste wood
- ✓ Boiler with integrated fluidised bed combustion
- ✓ Dry flue gas cleaning plant
- ✓ Water steam cycle with turbine

TBU: basic and detail engineering, supervision of production and assembly of combustion as well as the start-up of the whole plant

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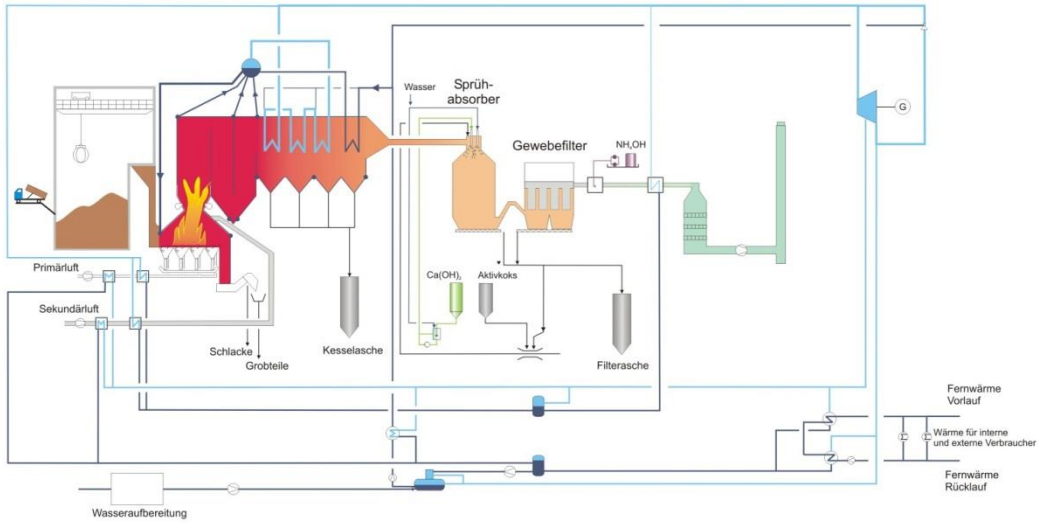
Waste Incineration Plant MSZ 3 Moscow (Russia 2003-2008)

Project Description:

- ✓ Grate combustion for domestic waste
- ✓ Production of electrical energy and steam for district heating

Capacity:

- ✓ 90 MW fuel heat capacity
- ✓ Total capacity 360.000 tons per year



Plant Concept:

- ✓ Delivery, unloading and storage of waste
- ✓ Grate integrated into the boiler
- ✓ Semi-dry and catalytic flue gas cleaning plant
- ✓ Water-steam cycle with counter pressure turbine

TBU: concept engineering, tender engineering, supervision of basic engineering, detail engineering for water steam cycle and semi-dry gas cleaning plant and start-up

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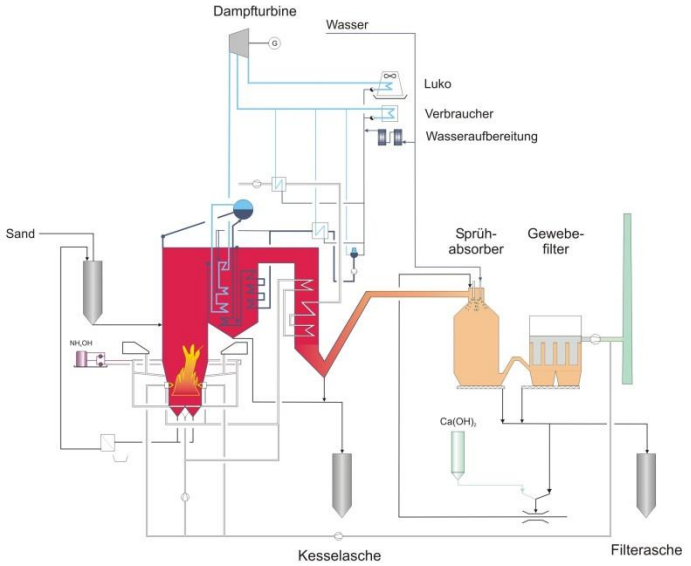
Waste Wood Fluidised Bed Incineration Plant OIE Neubrücke (Germany 2002-2003)

Project Description:

- ✓ Fluidised bed incinerator for biomass and waste wood
- ✓ Production of electrical energy and steam for district heating

Capacity:

- ✓ 30 MW fuel heat capacity
- ✓ Total capacity 60.000 tons per year



Plant Concept:

- ✓ Storage of waste wood
- ✓ Boiler with integrated fluidised bed combustion
- ✓ Selective non-catalytic NOx-reduction
- ✓ Semi-dry flue gas cleaning plant
- ✓ Water steam cycle with turbine

TBU: basic engineering, detail engineering, supervision of production and assembly of combustion and flue gas cleaning and start-up of the whole plant

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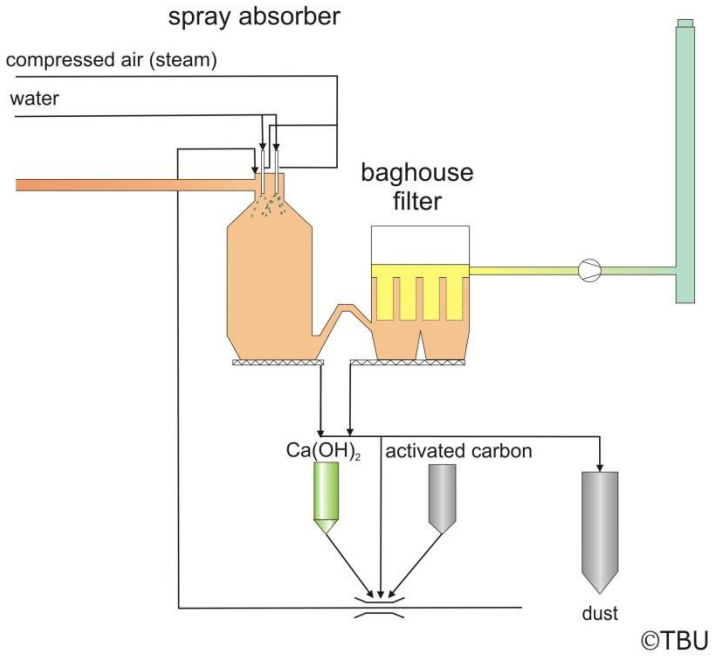
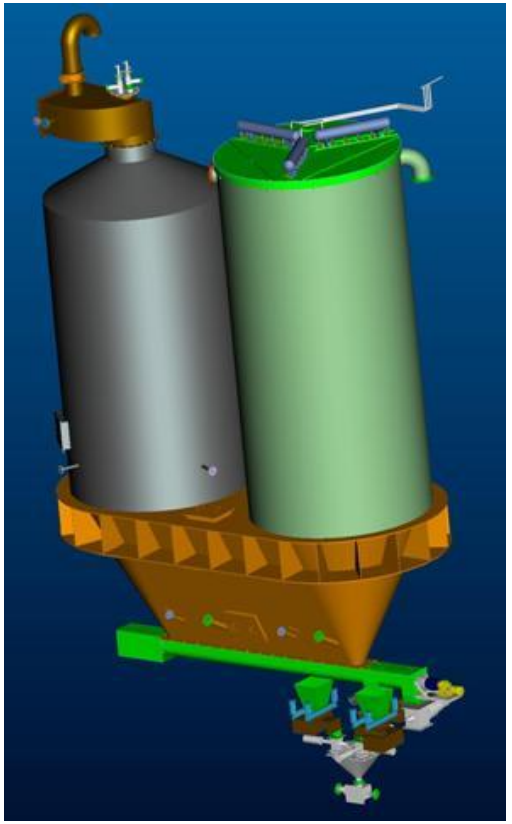
Dry and Semy-dry System

This system is used for waste and hazardous waste incinerators to remove following flue gas components:

- ✓ Dust
- ✓ HCl, HF, SO2
- ✓ Mercury
- ✓ Dioxins und Furans





Optimised gas adsorption and dedusting system for low concentrations of gaseous pollutants

- ✓ Low pressure drop
- ✓ High availability of nozzles
- ✓ Simple combined system

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Assembly - Spray Absorber with Baghouse Filter

Advantages - Dry and Semy-dry System

Advantages

- ✓ Optimised gas adsorption and dedusting system for low concentrations of gaseous pollutants
- ✓ Low investment- and energy costs
- ✓ Simple combined system

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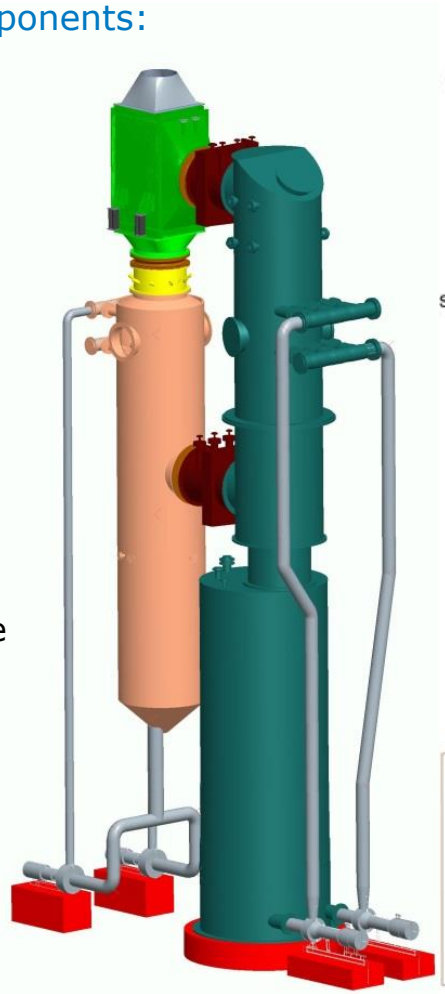
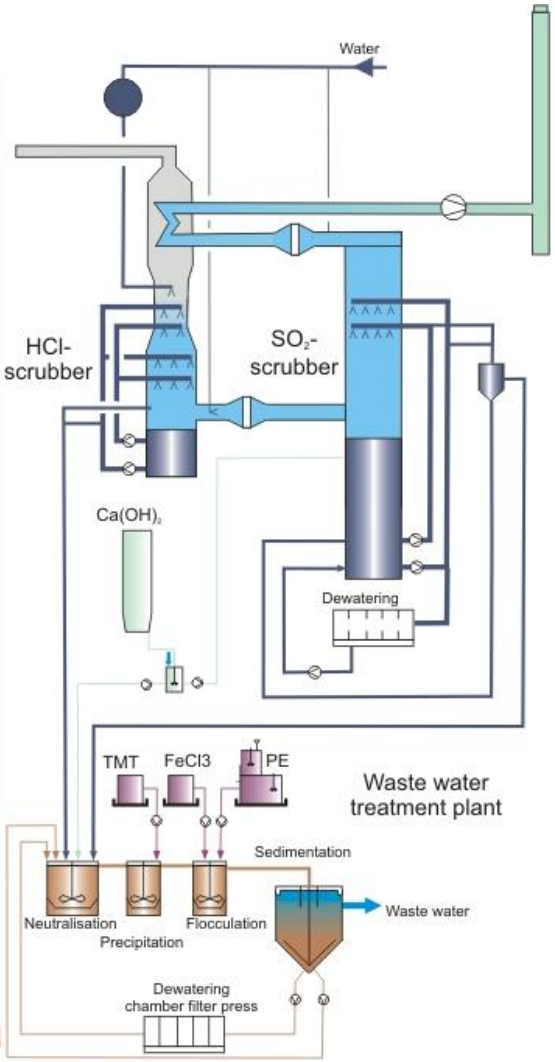
Wet Flue Gas Cleaning System

This system is used for waste and hazardous waste incinerators to remove following flue gas components:

- ✓ HCl, HF, SO2
- ✓ Mercury
- ✓ Heavy metals
- ✓ PCDD/F





The wet flue gas cleaning plant consists of:

- ✓ Bag house filter
- ✓ Storage and dosing devices for hydrated lime and activated coke (additives)
- ✓ Wet gas cleaning system with 2 scrubbers
- ✓ Waste water treatment plant and dewatering system for gypsum

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Wet Flue Gas Cleaning System

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Advantages Wet Flue Gas Cleaning System

- ✓ Low pressure drop
- ✓ Low water pressure
- ✓ Low energy consumption
- ✓ Low emissions of HCl, HF, SO2
- ✓ Optimised residues → gypsum from the SO2 scrubber
- ✓ Neutralisation medium CaCO3 and Ca(OH)2

counter current scrubber

open quench

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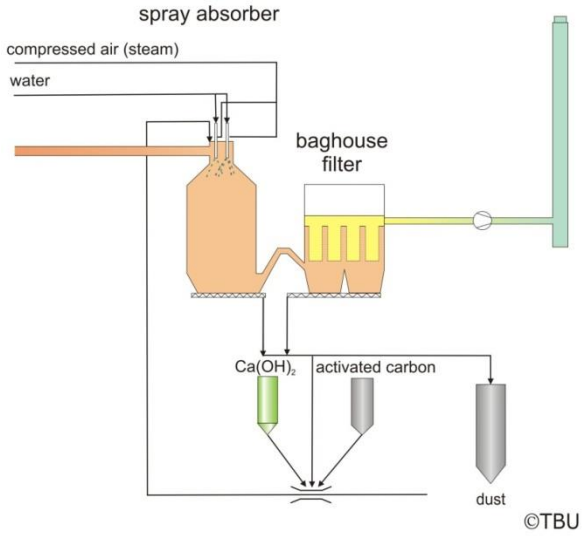
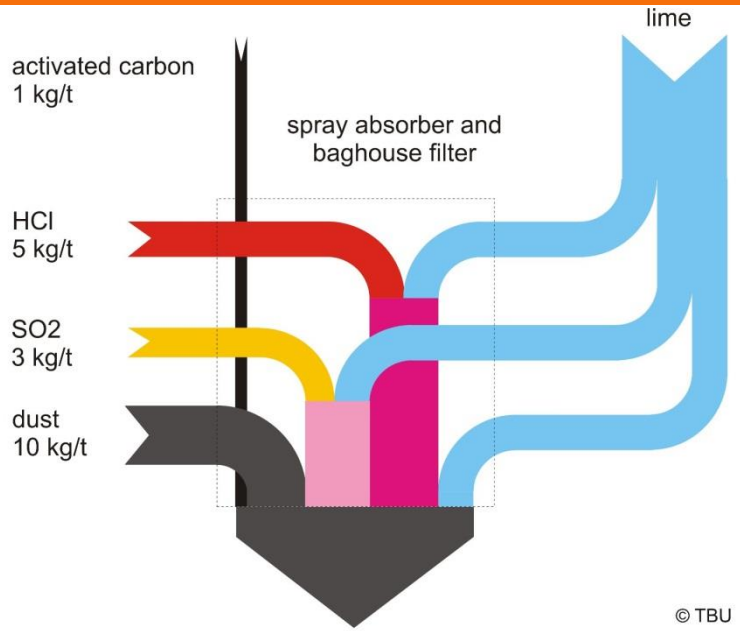
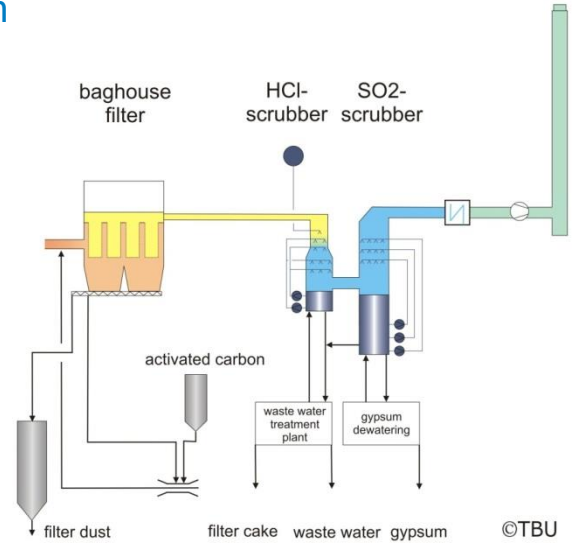
Comparison - Gas Cleaning Systems for muicipal waste

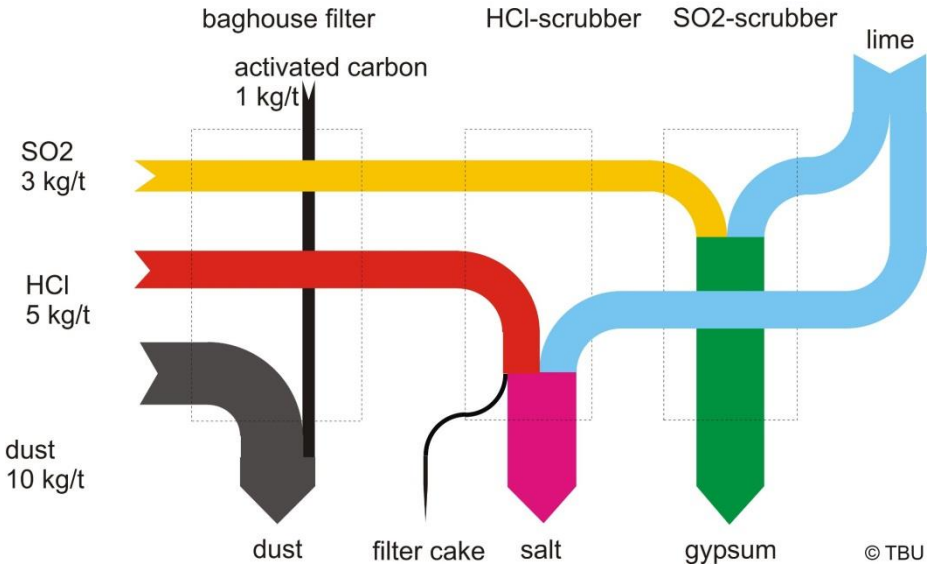
Semy-dry system





Wet system





Comparison - Gas Cleaning Systems

	Semy-dry system (Spray adsorption)	Wet System
Filtration efficiency	✓ Dust and gaseous heavy metals ✓ Increased use of activated carbon	✓ Dust and gaseous heavy metals ✓ No increased use of activated carbon
Costs	✓ Low energy costs ✓ Higher cost adsorbents and residues ✓ Low investment costs	✓ Higher energy costs ✓ Low costs for absorbents and residues ✓ Higher investment costs
Main field of application	✓ Smaller plants with low pollutant loads	✓ Bigger plants with high pollutant loads
Neutralisation medium	✓ Sodiumbicarbonate, high quality quicklime or hydrated lime ✓	✓ Grinded limestone, hydrated lime
Residues	✓ Mixture of ash, chlorides, fluorides, sulphites, sulphates, surplus lime and activated carbon ✓ High proportion of water-soluble components, difficult to solidify	✓ Baghouse filter→ ash and activated carbon ✓ HCl-scrubber→ neutral salts in waste water ✓ SO2-scrubber→ usable gypsum ✓ Low proportion of water-soluble components, easy to solidify

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