FLUE GAS CLEANING

WE MAKE THE WORLD A CLEANER PLACE

Steinmüller Babcock Environment

SBEng

NIPPON STEEL & SUMIKIN ENGINEERING GROUP

Steinmüller Babcock Environment – innovative and global

WE MAKE THE WORLD A CLEANER PLACE

Steinmüller Babcock Environment (SBEng) – a name in leading technology for flue gas cleaning and thermal waste treatment. Our company develops, plans, builds and monitors complete plants as well as individual key components. Our products qualify for the trademark "Made in Germany". We have been developing solutions for environmental protection for over 50 years – five decades in which we have combined tradition and experience with research and innovation. Over 1,200 reference plants worldwide attest to our expertise. The company is based in Gummersbach in the heart of North Rhine-Westphalia, the most populated federal state in Germany. About 300 employees work here for SBEng or – as required – on site at our plants around the world. We develop plant concepts in close coordination with our clients, therefore the plants are customised. We are supported by our subsidiary in Shanghai, Steinmüller Babcock Engineering Consulting Co. Ltd.,

Our partnership: strength in numbers

Steinmüller Babcock Environment is part of the NSENGI GROUP (Nippon Steel & Sumikin Engineering Co., Ltd), one of the leading environmental technology companies in Asia. Being one of the most important subsidiaries of the Nippon Steel & Sumitomo Metal Corporation (NSSMC), the second-largest producer of steel in the world, NSENGI was originally founded in 1974 as the research & development department of NSSMC, until it was spun off in 2006 and became an independent business unit of NSSMC while remaining a 100% fully-owned subsidiary. NSENGI now employs over 4000 people and, with 42 reference plants (40 in Japan and 2 in South Korea), it is the world's leading supplier of waste gasification systems with integrated melting technology (Direct Melting System/DMS).

Our origins: historic growth

Our roots stretch back over 150 years. SBEng was created by pooling the environmental technology know-how of three companies rich in tradition: Deutsche Babcock Anlagen GmbH, Noell KRC Energie- und Umwelttechnik GmbH and L & C Steinmüller GmbH. These origins shaped what we are today and entail a sense of duty. For our customers, we are not only a competent partner, but also an innovative one when it comes to the construction of environmental technology systems. Now and in the future!

Flue Gas Cleaning

Our flue gas cleaning: prospective planning, act sustainably

One of the greatest contemporary challenges is to ensure air quality. Our flue gas cleaning plants for power stations and industrial facilities contribute a significant part to this process by complying with the most stringent environmental standards. New plants and retrofits from SBEng ensure high efficiency with maximum availability. As one of the market leaders, we are aware of our responsibility to act sustainably: for the benefit of our customers and for the benefit of the environment.

Our waste technologies: sound solutions, designed for the long run

We plan and install plants for the thermal treatment of different waste materials in close coordination with our customers. Our services are especially tailored to their specific requirements. Whether as a supplier of the entire process chain or of individual components – based on our experience of many years, we are constantly optimising our products and processes for long-term efficiency and cost-effective use.

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Energy from Waste

After Sales Service

Flue gas cleaning – turns incineration into clean matter

Hazardous emissions of acidic gases, dust, heavy metals or organic compounds have no longer been emitted from power plants, waste incineration facilities and most thermal industrial plants for many years. The air around these facilities is veritably clean – modern flue gas cleaning systems ensure it. In Germany and Europe as a whole, incineration plants are subject to very strict regulations with respect to permissible emissions, producing exhaust gases partly cleaner than the air around them. To remove the variety of harmful pollutants, SBEng has different technologies that can be seen in the pollutant matrix below:

Technologies for removal of different pollutants

	Electrostatic precipitators	Wet electrostatic precipitators	Fabric filters	Semi-dry FGD *	Limestone-gypsum FGD *	Dual-loop- limestone-gypsum FGD *	Seawater-FGD *	CIRCUSORB®	SCR-catalyst	SNCR
Dust	X	X	X	X	(X)	(X)	(X)	X		
HCl			X[1]	X	X	X	X	X		
HF			X[1]	X	X	X	X	X		
SO_2			X[1]	X	X	X	X	X		
SO_3		X	X[1]	X	(X)	(X)	(X)	X		
Droplets, aerosols		X								
Mercury / Hg			X[2]	X[2]	(X)	(X)	(X)	X[2]		
Other heavy metals	(X)	(X)	X	X	(X)	(X)	(X)	X		
NO_x									X	X
Dioxins / furans and aromatic hydrocarbons			X[2]	X[2]				X[2]	X	

(X) There is a moderate removal efficiency as a side effect | X[1] dosing alkaline absorbents | X[2] dosing carbon -based absorbents

* FGD = flue gas desulphurisation system

Products of leading technology

Steinmüller Babcock Environment feels highly obliged for the environment. Our flue gas cleaning systems are products of top technology, developed on the basis of decades of research and practical experience. We are aware that only when harmful combustion gases constituents are reliably removed, only when strict emissions standards are followed, do fossil-fuel power plants, waste incinerators and industrial facilities enjoy the requisite public acceptance.

Maximum flexibility

Our different technologies for flue gas cleaning and flue gas desulphurisation can also meet more stringent environmental directives even at very high content of pollutants. SBENG has a broad technology portfolio that can be used to select and combine the appropriate technologies for any fuel and any customer-specific requirements. With decades of experience in the design and installation of flue gas cleaning systems, Steinmüller Babcock Environment has relevant reference projects demonstrating effective, reliably working systems.

Designed for energy efficiency

Our systems are designed for energy efficiency. Depending on specific customer needs, flue gas cleaning can even contribute to increasing efficiency, for example with a flue gas condensation stage. An increase in efficiency is one of the great technical challenges in fossil-fuel power plants and thermal waste treatment. The increasing input of renewable energies into the power grids also results in stricter requirements for partial load capacity and flexibility for the still indispensable fossil-fuel power plants. With our technologies, we have the capability to meet the operational requirements of modern power plants.

Core technologies of our flue gas cleaning processes:

Dust removal

- Fabric filters
- Electrostatic precipitators
- Wet electrostatic precipitators

Separation of acidic pollutants

- Single- or multi-staged wet scrubbing based on limestone
- Seawater wet scrubbing
- Combined scrubbing systems based on limestone products or sodium hydroxide
- Spray absorption
- Conditioned dry absorption with calcium hydrate (CIRCUSORB®)
- Dry absorption with sodium bicarbonate
- Combined absorption processes

Separation of heavy metals and organic compounds

- Activated carbon dosing
- Activated carbon solid bed reactors
- Catalytic dioxin reduction

Denitrification

- SCR process for catalytic NO_x reduction both in a “High Dust” and a “Low Dust” arrangement
- SNCR process for non-catalytic NO_x reduction using ammonia or urea solutions

Energy recovery systems

- Downstream economisers
- Heat transfer systems for preheating of combustion air
- Flue gas condensation, for example for use in district heating (optionally with heat pump)
- Heat transfer systems within flue gas cleaning processes to optimise energy efficiency

Seawater FGD, 3 x 600 MWe (Shuaibah III / Saudi Arabia)

Dust removal – solids excluded

At Steinmüller Babcock Environment, we approach dust separation from gaseous media using the latest state of the art in electrostatic precipitators or fabric filters. Particle separation is based on different separation principles in these two types of filter.

Electrostatic precipitators

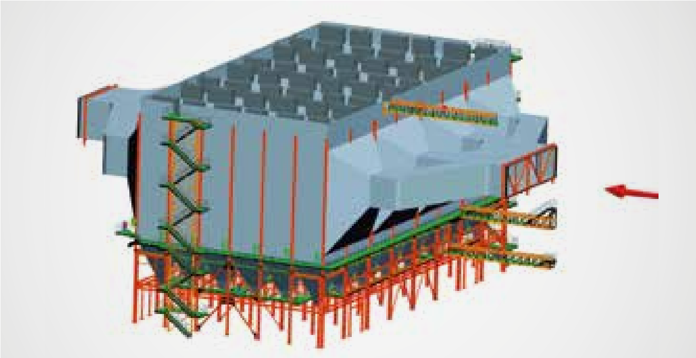
The function of dust separation in an electrostatic precipitator is based on an electrical field built up between the discharge electrodes, which is kept at a high voltage, and the earthed collecting electrodes. Numerous of such discharge and collecting electrodes are suspended alternately in a casing. As the exhaust gas flows through the electrostatic precipitator, the dust particles are electrically charged and consequently separated at the collecting electrodes due to the effect of the electrical field. This separation principle can remove even fine dust particles from gas very well in the electrostatic precipitator which is particularly protective of the environment.

Electrostatic precipitators are always designed on a custom basis, tailored to the specific application case. With decades of experience and over 400 reference systems around the world, SBEng can fulfill a wide variety of requirements.

Variety of applications

Electrostatic precipitators are primarily designed for a horizontal gas flow. For dust separation after large coal-fired power plants to emissions less than 10 mg/Nm³, an electrostatic precipitator with a width of 60 m and a length of 38 m can reach about half the size of a soccer field. Small electrostatic precipitators are also

Electrostatic precipitator steampower plant Rheinhafen Karlsruhe, unit 8



3D-model of an electrostatic precipitator for 820 MW power plant used, however, for example in biomass-fired boilers in the wood industry. When designing electrostatic precipitators for waste to energy plants, SBEng benefits from its experience as a general contractor and engineering service provider for the delivery and installation of waste incineration plants.

But electrostatic precipitators are also used in industrial sectors that do not involve the treatment of exhaust gas from combustion processes. Electrical dust separation is also positioned in different processes in the steel industry, for example in the area of sinter cooler systems, room and converter dust removal and electric arc and blast furnaces. Electrostatic precipitators are particularly important for product recovery, as they make a valuable contribution to resource conservation. Here, cement factories, coal refinement facilities and chemical as well as petrochemical plants are important industrial sectors.

Highest efficiency

For large quantities of dust, electrostatic precipitators can attain separation of well over 99.95% separation efficiencies, achieving a clean gas dust content of well below a level of 10 mg/Nm³. This is comfortably below the requirements of current regulations for emissions and thus is well-prepared for the future.

A particular advantage of this technology compared to other dust separators is their very low pressure loss. This reduces the energy consumption of the system and, for example, even increases overall efficiency for coal-fired power plants. The energy needed for dust separation is efficiently used in electrostatic precipitators, since the high voltage only affects the solids and not the gaseous medium. By installing intelligent power control, based on the dust content downstream of the electrostatic precipitator the power consumption can be significantly reduced. In particular during low-load operation and with dusts that separate well, the power consumption can be reduced by up to 80% – another important contribution to resource conservation.

Robust technology

Electrostatic precipitators are characterised by their high operational availability, since they are manufactured almost exclusively from steel components. The collecting electrodes are made of profiled steel plates and are suspended at a height of up to 16 m. The high-voltage discharge electrodes are welded together as pipe structures and are therefore extremely robust and unbreakable. Hence, filter malfunctions due to broken electrodes are a thing of the past. The electrodes are cleaned by a reliable tumbling-hammer rapping system so that adherent dust is loosened from the collecting electrodes and falls into the discharge hoppers placed below. All bearings for the internal rotating parts are specially protected. The low flow velocity in the electrostatic precipitator, of about 1 m/s, keeps erosion low. The robust, low-wear construction of our electrostatic precipitators also ensures long travel times as well as low maintenance and repair costs.

Your advantages at a glance

Electrical filters

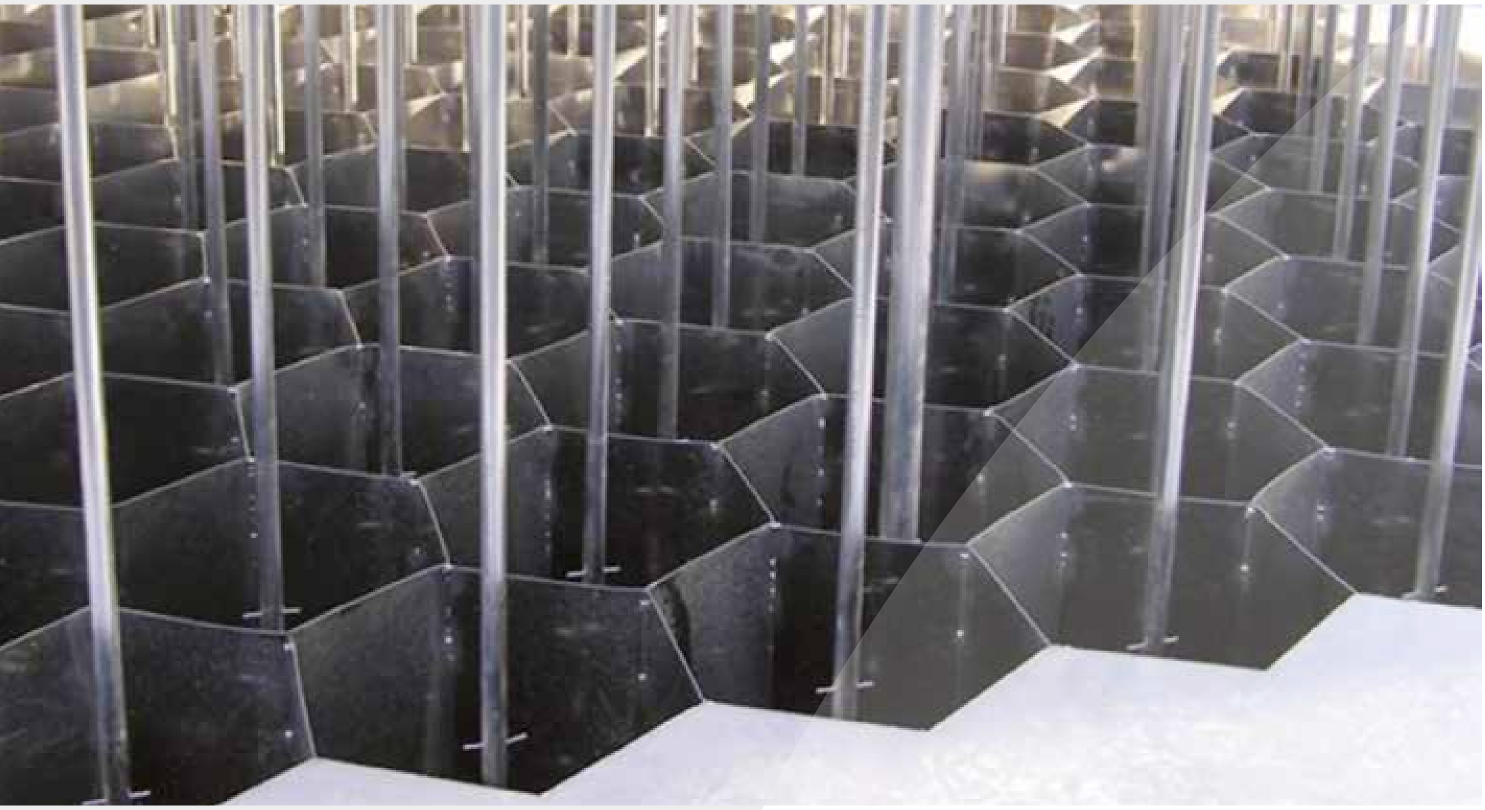
- High dust separation efficiencies of over 99.95 %
- Low clean gas dust content of < 10mg/Nm³
- Low pressure loss
- Energy-optimised plant operation controlled to the clean gas dust content
- Robust, reliable technology
- Usable at high temperatures up to 450°C
- High volume flows possible up to 4.5 million Nm³/h
- Long travel times
- Low service and maintenance cost
- Large variety of applications in all sectors of industry and power generation
- Reliable operation due to unbreakable discharge electrodes

2 x 1,100 MW power plant at Neurath BoA 2/3 (Germany)

Intelligent power control

The maximum total installed power of the transformer/rectifier sets of the electrostatic precipitators in units F and G in the most modern lignite-fired power plant in the world in Neurath is about 5,500 kW. Intelligent power control based on the clean gas dust content finally results in an actual power consumption at full load of only 750 kW. That corresponds to energy savings of over 85%.

Dust removal – solids excluded



Wet electrostatic precipitators

Wet electrostatic precipitators are generally used for the separation of very fine dusts, droplets and aerosols. The collecting electrodes are designed as honeycomb or pipes with gas flowing through them vertically. The discharge electrodes are located in the middle of the honeycomb.

High gas velocity, compact design

Unlike the dry electrostatic precipitator, deposited dust is not cleaned by rapping, but by flushing. This prevents dust from being re-introduced into the gas, the so-called "reentrainment". Due to these characteristics, the filter can be operated at much higher gas velocities, making a very compact design possible. Flushing is done using flushing lances arranged above the electrodes. They are controlled by a cyclical flushing program to minimise water consumption while maintaining high separation performance.

Ideal combination options

Another advantage of the wet electrostatic precipitators is the fact that it is perfect for combination with an upstream scrubber. Here, the wet electrostatic precipitator can be used as an additional stage downstream of the scrubber. Space can be used ideally while still obtaining excellent separation performance for dust, droplets and aerosols. SBEng wet electrostatic precipitators are already in use in many different applications, especially after combustion plants.

Your advantages at a glance

Wet electrical precipitators

- High aerosol separation efficiency of over 99.9 %
- Low clean gas dust content of < 1 mg/Nm³
- Low pressure loss
- Separation of adhesive and easily flammable dusts possible

Wet electrostatic precipitator for the separation of ash and activated carbon

Fabric filters

Fabric filter technology can be used for a variety of applications and represents a reliable technology for the separation of dusts. Even for difficult applications, dust removal efficiencies of up to 99.9% can be achieved. Fabric filters from SBEng have already been installed in a wide variety of industries. The bandwidth ranges from small to medium-sized filters used in industrial applications or waste incineration plants, to large filters with up to 10,000 filter bags downstream of coal-fired boilers. The robust and efficient design allows an operation under extreme conditions with low maintenance costs while still providing high availability. In addition to mere dust separation, SBEng fabric filters are also used as absorbers for the separation of gaseous pollutants downstream of a dry- or spray-absorption process, if necessary with a dosing system for activated carbon for the additional removal of mercury, dioxins and other hazardous organic components.

Efficient and controlled cleaning

A fabric filter consists of multiple filter compartments through which gas flows in parallel. This design offers the possibility to take individual compartments of the filter out of operation temporarily without having to interrupt the operation of the complete filter. The flue gas flows through filter bags suspended in the filter chambers. Thereby, the dust remains on the surface of the filter bag. A filter cake builds up and further enhances separation performance. At regular intervals, controlled by a cleaning program specially developed by SBEng, the filter cake is blown off the bags with a flush of compressed air. The compressed air is directed to the filter bags through a system of blowing lances. The individual components and the compressed air system are tuned specifically to one another to ensure the optimum, gentle cleaning of the bags. The dust cleaned off the bags falls into the hoppers located below the filter bags and is fed to the dust conveying system. When selecting a suitable dust conveying system, SBEng can also rely on long-time experience with different applications. Hence, critical interfaces can be avoided.

Your advantages at a glance

Fabric filters

- High dust separation efficiencies of over 99.95%
- Low clean gas dust content of < 5 mg/Nm^3
- Simultaneous separation of gaseous pollutants possible
- High volume flow supported
- Cleaning of filter bags during operation
- Replacement of defective filter bags possible during operation
- No limitations on the separation of dusts with high specific electrical resistance to the dust
- Large variety of applications in all sectors of industry and power generation

Even flow distribution with low pressure loss

The filtration behaviour, the cleanability of the bags, the pressure loss characteristics and the possible lifetime of the filter bags depend on the filter medium in use. Here, SBEng can draw on years of experience in the selection of the optimal bag material for particular applications. In addition to the selection of the filter medium, the flow through the filter and the distribution of the flue gas to the filter compartments plays an important role. The particular task is to distribute the flue gas flow evenly to all filter bags. A high velocity upwards flow along the bags must be avoided, since this may carry away the dust that has already been separated. The flow pattern developed by SBEng over a deflector plate located at the inlet of the compartments represents an optimal solution for the even distribution of gas flow while simultaneously minimising pressure loss.

Erection of fabric filters at MVA Krefeld (Germany)

Flue gas desulphurisation – a broad range of technologies

SBENG offers a wide variety of processes for the seperatipon of acidic pollutants to distinguish between dry, semi-dry and wet processes. Depending on the upstream plant, it should be individually determined which process is the right one for the particular application.

Processes for separation of harmful acidic gases:

Dry processes
- CIRCUSORB®

Semi-dry processes
- Rotary atomizer, nozzle atomizer

Wet processes
- Spray tower scrubber as single-loop absorber
- Spray tower scrubber as dual-loop absorber
- Spray tower scrubber as pass-through absorber (FGD with seawater)

Dry processes

The big advantage of the dry process is its low investment cost. However, a relatively large consumption of highly reactive absorbent material is required, and the reaction product is a residue that requires disposal. The material used and disposal of the residue result in relatively high operating costs, so the process is cost-effectively used rather for the purification of smaller flue gas flows or for systems with a short remaining operation time.

CIRCUSORB®-process

SBENG developed the CIRCUSORB® process specifically for flue gas cleaning in waste incineration plants. Dry calcium hydrate ($Ca(OH)_2$) is used to remove HCl, SO_2 and HF from the flue gas. The recirculation of a fraction of the residue as well as the moistening of that recirculate and fresh $Ca(OH)_2$ can minimise the consumption of calcium hydrate. The effectiveness of the process increases with decreasing temperature due to the evaporation of the additional moisture. Since the possible temperature reduction is limited due to the hygroscopic properties of calcium chloride ($CaCl_2$) in the reaction product, SBENG carefully tunes the operating parameters to the specific load point.

Static mixing elements (DIVA® = Dispersing Vane Element) are used to mix the solids with the flue gas. The formation of a highly turbulent flow ensures optimum distribution of the solids (see p. 23, Fig. 5).

Semi-dry processes

Semi-dry processes are characterised by the fact that a hydrous absorbent suspension is injected into the flue gas flow. A highly reactive calcium hydrate suspension is generally used.

The acidic pollutants react with the absorbent to form salts, while simultaneously the water evaporates and cools the flue gas before it leaves the absorber. A dry mixture of calcium salts and unreacted lime is obtained as a reaction product, which is usually separated from the flue gas flow in a downstream fabric filter. For better utilisation of the absorbent, a part of the dry product may be recirculated.

Spray absorption

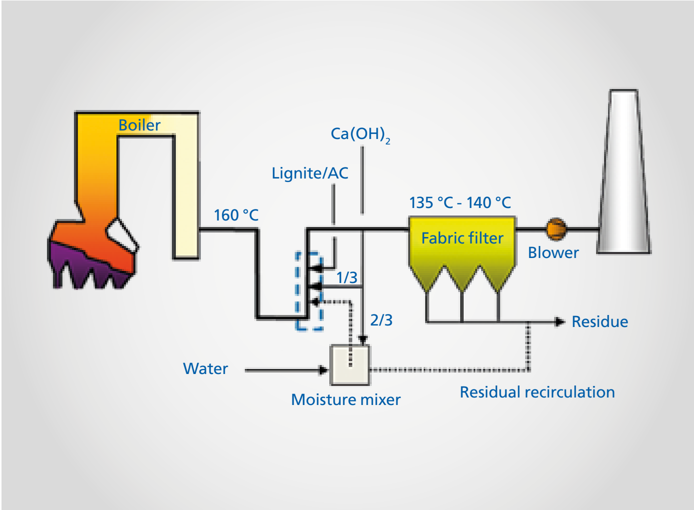
The spray absorber consists of a cylinder with a conical bottom. Located above the cylindrical part is the raw gas distributor with the rotary atomizer in its centre. The calcium hydrate suspension is fed to the rotary atomizer. The rapidly turning atomizer disc wheel generates a spray mist of very fine droplets, ensuring even distribution of the absorbent in the flue gas. The spray absorber is designed in a way that a sufficient reaction time between the flue gas and absorbent for SO_2 absorption and drying of the solids is provided. The rotary atomizer is used as a unit complete with drive motor. In the case of maintenance, the entire assembly can be replaced very quickly to resume operation of the separator without constraining or shutting down the upstream combustion process.

Wet processes

In contrast to the dry and semi-dry processes are the wet processes, since these work with a more favourable conversion stoichiometry. Using calcium-based absorbents they produce gypsum as a valuable product, which can be used for many purposes in the construction industry.

For every new plant, the right process must therefore be selected based on individual, location-specific requirements. If you aren't sure, talk to us – we will be happy to give you customised advice.

Sulphur dioxide (SO_2) is an acidic gas and can be bound to alkaline absorbents. Due to their wide availability, the alkalis calcium (Ca) and sodium (Na) – and in special applications, ammonia (NH_3), – are significant for large gas cleaning systems. Since limestone ($CaCO_3$) is available almost everywhere, processes that use calcium based absorbents ($CaCO_3$, CaO, $Ca(OH)_2$) - are preferred.



CIRCUSORB®- process

Your advantages at a glance

Dry processes

- Low investment costs
- Minimised absorbent consumption
- Optimised operating parameters
- DIVA® mixer for the best possible solid distribution

Semi-dry processes

- Suitable for plants up to about 1 million Nm³/hr
- Reduced investment costs
- Low absorbent stoichiometry
- Optimised system technology

Spray absorber, rotary atomizer

Wet flue gas desulphurisation – raw material supplier to the construction industry

Wet flue gas desulphurisation works with absorbents that form an alkaline solution in water. Calcium-based materials (limestone, quicklime, calcium hydrate) are specifically used as absorbents in order to produce gypsum as a valuable product of the reaction with the sulphur dioxide being removed from the gas. Gypsum is a raw material in widespread use in the construction industry, for example for the production of gypsum cardboards, as an additive in the production of cement and floating screed. Also, other alkaline solutions such as seawater are outstandingly well-suited as absorbents for the separation of acidic pollutants.

On this basis SBEng had already developed the SBEng seawater FGD by the end of the 90's. Customer-specific needs are incorporated on a tailor-made basis, so SBEng has a large number of process technology reference systems.

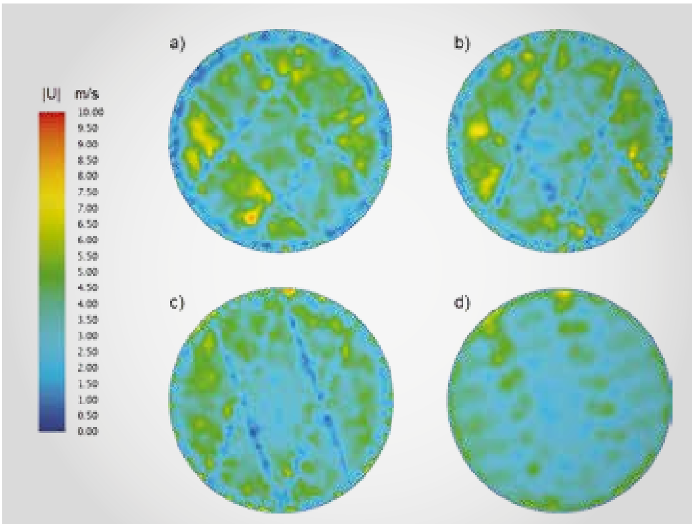
Limestone-gypsum process

The wet lime-gypsum process uses limestone as an absorbent for the desulphurisation of flue gases and produces gypsum that is suitable for industrial use as an end product. The flue gases coming from the firing are directed into the absorber, where the pollutants SO_2, HCl and HF and ash are removed before the flue gas is released into the atmosphere.

Single-loop absorber

In the absorber, constructed as a spray tower, the flue gases are brought into contact with a suspension containing calcium, removing pollutants from the gas. The absorber, has three main zones.

In the lower part of the absorber, the sump, the scrubbing suspension is stirred, supplied with fresh absorbent and aerated. The stirring supports the dissolution of the absorbent, ensures even gypsum crystallisation and prevents the solids from settling.



Velocity distributions of the gas phase in absorber cross-sections of different heights

To oxidise separated SO_2 into sulphate (gypsum), air is blown into the absorber sump in front of the side entry agitators and thereby finely dispersed in the liquid. The flue gases enter the absorber above the sump and flow upwards through the contact zone. There are multiple levels of spray nozzles in the upper area of this zone which disperse the scrubbing suspension out of the absorber sump in the form of fine droplets. The mass transfer of SO_2 from the flue gas into the scrubbing liquid takes place in this contact zone. In the absorber top, the flue gases pass the horizontally installed droplet separators which remove the liquid droplets from the gas. The cleaned gas has been cooled down to saturation temperature as it leaves the absorber.

Limestone is either delivered as a powder or it is ground in the plant with a wet ball mill and fed via a dosing station into the absorber sump. A part of the gypsum-containing suspension is removed from the scrubber and pumped to the gypsum dewatering, which preferably consists of a hydrocyclone station and a belt filter. The gypsum is rinsed there and dewatered to a residual moisture of < 10% by weight. A small part of the cyclone overflow is discharged as wastewater in order to remove chloride, which is very soluble in water, from the absorber cycle.

Dual-loop absorber

For special applications the absorber contact zone can be divided into two circuits. This is especially beneficial when particularly high separation efficiency is needed or for very high SO_2 concentration in the flue gas. For these cases, the limestone suspension and the flue gas are directed counter flow wise through a two-staged system. The gypsum product is removed from the suspension of the first loop, where the flue gas enters the absorber. This loop is operated in the same way as the suspension circulation of the single-loop absorber and has its reservoir in the sump of the absorber. In the second slurry loop, encountered by the flue gas the fresh absorbent is added. It has an external sump tank and it provides a significant excess of absorbent, which permits extremely high SO_2 removal efficiency. The additional cost of equipment for a dual loop absorber is compensated by the reduced energy consumption, so the choice between a single-loop and dual-loop absorber is normally made based on an evaluation of investment and operating costs.

A great advantage of the dual-loop absorber is its large excess of absorbent in the second loop, which makes the system very insensitive to fast changes in load or SO_2 concentration. This advantage becomes nowadays very significant in modern, flexible coal-fired power plants.

Your advantages at a glance

Wet processes

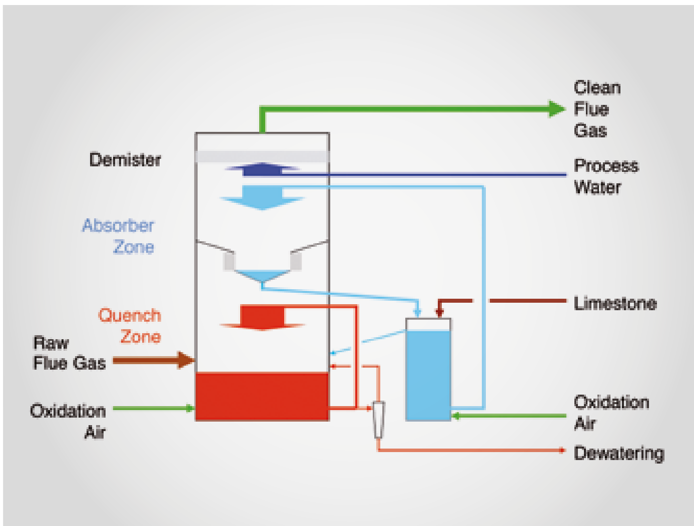
Limestone-gypsum process (single-loop absorber)

- Minimum absorbent costs
- Marketable end product (gypsum)
- Maximum system availability
- Optimised material and system concepts
- Global references for all power plant sizes and fuels

Dual-loop absorber

- Best SO_2 separation performance
- Suitable for extremely high sulphur content in fuel
- Lowest energy requirements thanks to counter current flow principle
- Insensitive to fast changes in SO_2 concentration and load

Clean gas duct



Principle of the dual-loop absorber

Flue gas desulphurisation with seawater – ideal for coastal locations

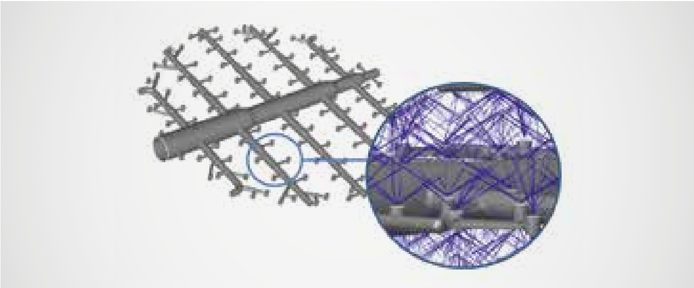
Flue gas desulphurisation systems based on seawater are a mature, cost-effective technology and an ideal solution for coastal locations. In this wet scrubbing process, seawater is used as the exclusive absorbent instead of the limestone typically used. The pollutant, sulphur dioxide (SO_2), dissolves in the seawater, forming sulphite and hydrogen sulphite. These compounds are neutralised by carbonates and bicarbonates, which are natural components of seawater. The air introduced into the oxidation basin oxidises the sulphur compounds into sulphate, which is a natural component of seawater too. The seawater used in this process is usually taken from the cooling water circulation of the power plant, and is directed back into the sea after its use as an absorbent in the seawater flue gas cleaning system.

Seawater outlet (Seawater FGD Alba, Bahrain)

Earthquake-resistant design (Seawater FGD Puerto Coronel I, Chile)

Optimum SO_2 separation

Optimum SO_2 separation is achieved due to homogeneous gas and seawater distribution in the scrubber. The optimised spray levels are designed using advanced CFD tools. Unlike other systems with packings, the spray tower scrubber has no internals that can be contaminated by biological growth.



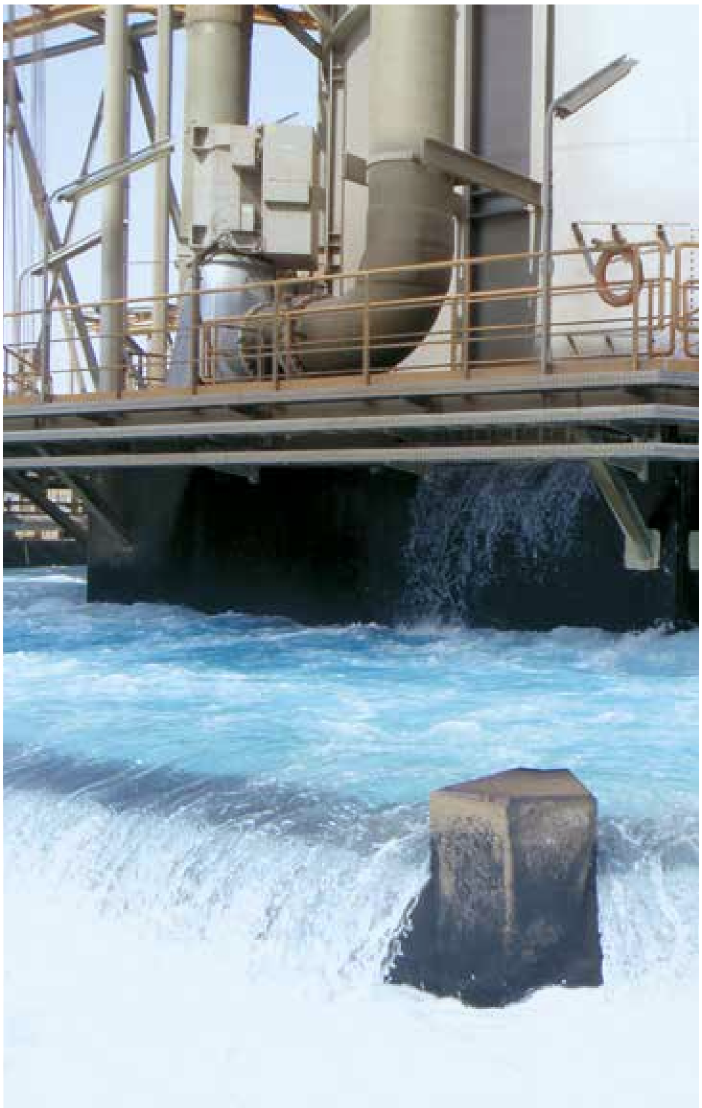
CFD simulation of a spray bank

High operational flexibility

The use of a variable number and combination of spray levels with individually assigned pumps allows a high degree of operational flexibility and optimum adaptation to the boiler load and sulphur content of the fuel.

Oxidation and effective CO_2 stripping

The special concentric SBENG design of the oxidation basins allows a space-saving setup with controlled water intake and staged, controlled injection of oxidation air. The optimised oxidation and effective CO_2 stripping makes it possible to comply reliably with the required oxygen concentration and pH value for the discharged seawater while making the best possible use of the alkalinity of the water.



Oxidation zone (Seawater FGD Shuaibah III, Saudi Arabia)

Desulphurisation system based on seawater (Shuaibah III, Saudi Arabia)

Your advantages at a glance

Seawater FGD

- Ideal solution for locations near the coast
- Can be used for any fuel
- SO_2 removal efficiency up to 99 percent
- Maximum plant availability with optimum total system costs
- Energy-optimised system operation thanks to flexible adaptation to boiler operation
- Space-saving installation concept due to concentric basin geometry
- Short construction time based on optimised installation concept
- Worldwide references for spray tower absorbers for all sizes of power plant

Denitrification - last exit for greenhouse gases

Anthropogenic nitrogen oxide emissions from combustion processes are one factor responsible for ozone destruction in the stratosphere. In 1984, the introduction of large-scale denitrification technology in Germany downstream of steam generators established the first steps towards countering this problem. Steinmüller Babcock Environment is a pioneer in this technology and provides a high level of innovation and reliability in this field up to date.

SCR process

Of all the processes for the denitrification of exhaust gases, the SCR process (Selective Catalytic Reduction) has proven the most effective, and has won recognition throughout the world. As the most cost-effective process with NO_x removal efficiencies of over 90% required today, SBEng has implemented SCR reactors directly after combustion (high-dust arrangement) or downstream of the flue gas absorber (tail-end arrangement). The required operating temperatures are 180-430 °C, depending on the type of system and the sulphur content of the flue gas. SBEng has effectively implemented the technology of the SCR process in steam generators fired with coal, oil, biofuels, and waste fuels. Further applications, for example at cement kilns, are currently in progress.

Turn-key solutions have been implemented for the retrofit of existing large-scale steam generators that also include the adaptation of the economiser outlet temperature to the required operating temperature of the catalytic converter at low load. We can provide successful references for all process options to adjust the optimum flue gas temperature – modification of the existing economiser, retrofit of new eco-bundles downstream of the catalyst, or water- or flue gas-side Eco-Bypass.

Make use of competitive advantages

The performance package from SBEng includes the renovation of the flue gas path needed for an SCR retrofit, from rebuilding of the regenerative air preheater with SCR-compatible heating surfaces to the modification of the electrostatic precipitator and replacement or adaptation of the induced draft fans. Our SCR reactors can be equipped with any catalyst available on the market, giving our customers a competitive advantage in the later replacement of catalyst elements. For flexible catalyst management, we also offer our customers reactors with spare layers.

Suitable design of the SCR reactors and catalyst not only supports NO_x removal and the destruction of dioxins and furans, but also makes a significant contribution to the removal of mercury. At the catalyst, metallic mercury can be oxidised at rates of over 90% depending on the specific conditions, allowing it to be removed in that state in a downstream wet scrubbing process. That is a significant advantage, because mercury emissions limits will become an ever more important topic in the future in Europe as well.

Pioneer in innovation

Our know-how is based on our many years of experience and the pioneering role we have taken in the field of environmental technology. For example, SBEng brought Europe's first commercial High-Dust SCR system in operation (at the Altbach power plant in 1985, 460 MW), as well as the world's first tail-end SCR system (at the Hafen Power Plant in Hamburg in 1987, 150 MW). This long-term experience has allowed valuable knowledge to be integrated into the further development of the technology. To continue to meet the strict requirements on removal efficiency when using a wide variety of fuels while simultaneously achieving the longest possible service life of the catalyst, SBEng optimises the offered SCR systems, using flow model tests (at a 1:15 scale) and CFD simulations. This ensures the best possible homogenising of velocities and the NO_x profile, as well as the optimum distribution of the injected reagent. SBEng uses the patented DIVA® mixers to homogenise the gas flow and to dispense either the gaseous NH_3 or solutions of NH_4OH or urea. This allows us to achieve the best possible removal efficiency and best possible utilisation of catalyst activity, while still minimising dust deposits in the flue gas ducts and on the catalyst. Especially under the toughest arrangement requirements, SBEng is the right partner for retrofits of SCR systems.

Your advantages at a glance

SCR process

- Turn-key systems including renovation of the entire flue gas path
- Highest possible NO_x removal efficiencies with the lowest possible ammonia slip
- Can be used downstream of steam generators fired with coal, oil, gas, refinery by-products, biofuels, or waste fuels
- Destruction of dioxins and furans as well as oxidation of metallic mercury
- Customised design with respect to layout and back up of low-load temperatures

SCR high-dust system at a 650 MW steam generator

Catalyst management

The SBEng service also includes catalyst management. Due to the build-up of dust and degradation by certain flue gas constituents, the catalyst slowly loses activity during operating time. It is necessary to increase the activity of the catalyst at least after the maximum permitted NH_3 slip is achieved. This is generally done using regeneration, adding an additional layer of catalyst in the spare layer, or replacing catalyst layers.

SBEng can handle the evaluation of service life and planning of the optimum time to replenish catalyst volume or to replace the catalyst. To do this, we monitor the activity of the catalyst used depending on the planned downtimes of the plant. With SBEng expertise, you're always in safe hands.

SCR high-dust system at three 660 MW steam generators

Wet scrubbing and activated carbon filter – a high-end combination

Semi-dry processes are very often used in waste incineration plants. Whenever very low emission values are required, these processes reach their limitations – if only due to the high disposal cost of the residues. For these cases, SBENG also offers "high-end" flue gas cleaning processes.

Wet scrubbing

Wet scrubbing for exhaust gas treatment after waste incineration is generally done using a combination of an acid scrubber (HCl scrubber) and an alkaline scrubber (SO_2 scrubber). This process is usually installed downstream of a dust removal system (fabric filter or electrostatic precipitator).

Your advantages at a glance

Wet scrubbing

- Nearly stoichiometric use of absorbents
- Option of producing valuable materials such as gypsum, hydrochloric acid, and industrial salt
- Low amount of residues
- Can also be used with high concentrations of pollutants or strongly fluctuating raw gas values

HCl scrubbers

The HCl scrubber is generally a parallel flow scrubber, with the exhaust gas flowing through it from top to bottom. Located in the inlet area is a nozzle level, through which the scrubbing liquid is sprayed into the exhaust gas stream using redundant circulation pumps. The liquid is collected in the sump of the scrubber. Due to evaporation of a small part of the scrubbing liquid, the exhaust gas becomes saturated with water vapour and cools down. At the same time, the scrubbing liquid absorbs the largest part of the HCl present in the exhaust gas.

The HCl scrubber is generally operated without the addition of caustic reagents. As a result, the scrubbing liquid forms a dilute hydrochloric acid with a pH < 0. No SO_2 is separated in this acidic medium, but it is outstanding for the separation even of large amounts of ionic mercury. Part of the hydrochloric acid is continuously removed from the scrubber sump and taken for wastewater neutralisation. Powderised limestone is used to neutralise it there. The exhaust gas including a small residual HCl content flows into the SO_2 scrubber.

The HCl scrubber is made of acid-resistant fibreglass-reinforced plastic (FRP). A temperature-resistant teflon coating is applied in the gas inlet area. Depending on the process chain downstream of the wet scrubber, the hot raw gas upstream the HCl scrubber can be used to reheat the clean gas emerging from the last scrubber stage in a heat exchanger.

SO_2 scrubber

Flue gas passes the SO_2 scrubber in counterflow to the circulating suspension, from bottom to top. In the upper part of the scrubber, there are multiple levels of nozzles through which the scrubbing suspension is intensively sprayed into the exhaust gas in large quantities using redundant pumps. Depending on the process desired, the scrubbing suspension can be neutralised by the addition of limestone powder, milk of lime, or sodium hydroxide. Due to the high quantities of suspension circulated, the SO_2 is almost completely removed. Residual HCl and HF are also separated from the exhaust gas in this scrubber. If the upstream HCl scrubber fails, this scrubber can also separate all the HCl and HF present in the exhaust gas. Depending on the type of absorbent, the discharge brine is taken for gypsum dewatering or directly to wastewater treatment. In smaller gas cleaning units, the scrubber is preferably made of chemical-resistant FRP. Fabrication in steel with soft rubber corrosion protection is also possible.

Activated carbon filters

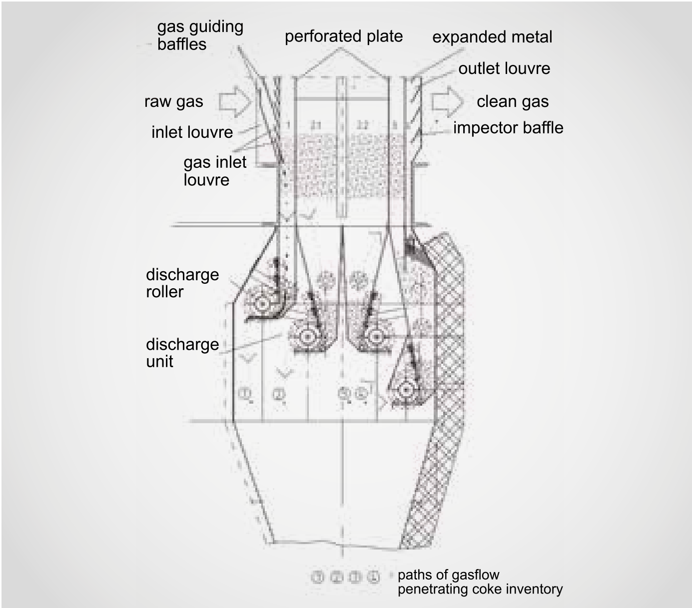
The activated carbon filter is used for precision cleaning and it is a safety system should one of the upstream flue gas cleaning stages fail. The activated carbon filter is a universal separation stage for nearly all pollutants to be separated from the exhaust gas, with the exception of nitrous oxides. The pollutants are almost completely removed. However, for the large pollutant quantities of dust, SO_2 and HCl in the raw gas, carbon consumption would not be cost effective. As a result, upstream use of effective cleaning stages for these components is the economically viable solution.

The activated carbon filter consists of multiple parallel carbon beds through which the flue gas flows horizontally. Each carbon bed consists of three layers, from which the carbon can be removed individually. The first layer absorbs the main part of the pollutants still present in the flue gas. In the middle layer, most of the rest of the remaining SO_2 and HCl is separated. The third layer is only for safety, and should capture any residual hazardous components. Due to the effective separation of the pollutants in the earlier cleaning stages, the hazardous material load in the activated carbon is low. The criterion for the removal of activated carbon from the filter at intervals is therefore generally not the capacity of the carbon, but rather prevention of solidification of the carbon layers. The coarse-grained carbon removed is subsequently placed into the residue silo. Carbon filters can heat up due to intrinsic oxidation of the carbon if there is insufficient local gas flow. Reliable automated monitoring measures, however, do ensure that the filter does not enter a critical operating condition.

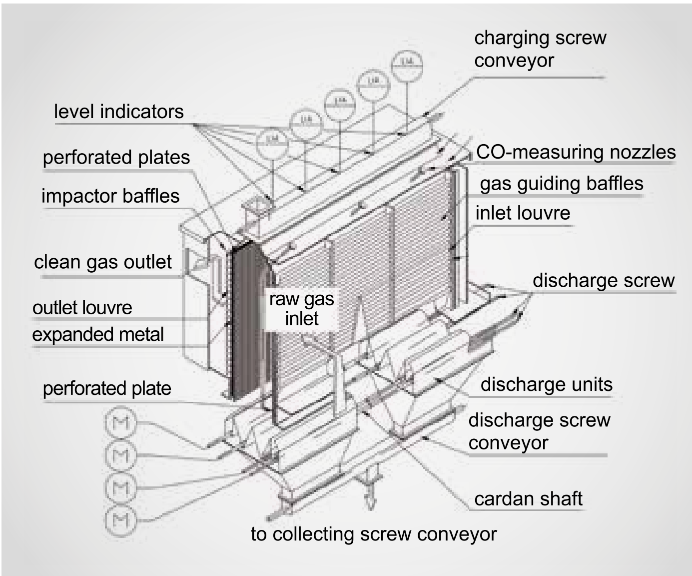
Your advantages at a glance

Activated carbon filters

- Purification gas emissions well under the requirements of 17.BImSchV or EN 2010/75
- Can be used as a tail end and safety stage downstream of wet scrubbing systems
- Reliable separation even if raw gas conditions fluctuate sharply
- Reliable compliance even with future, stricter limit values
- Best preparation for the use of a downstream low-temperature SCR



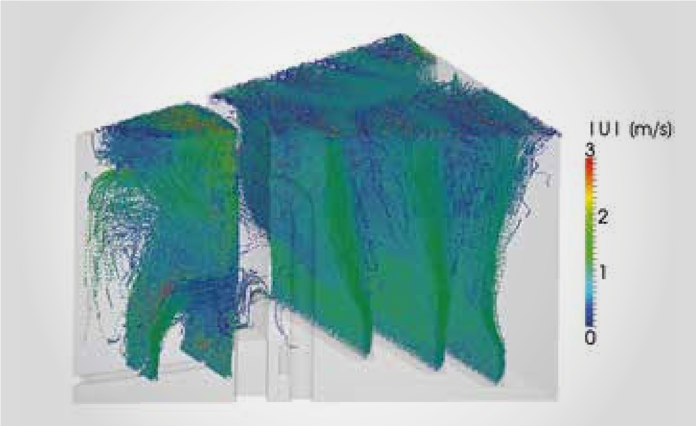
Sketch showing the filter layers and removal units



Sketch of one of four carbon beds

Research and development – always at the latest state of the art

Steinmüller Babcock Environment is an innovative company in environmental technology with comprehensive research and development activities. In the area of gas cleaning, processes for cleaning flue gases from power plants, waste incineration and industrial exhaust gases are investigated and refined. Each process of the gas cleaning – whether denitrification, dust removal, desulphurisation or fine cleaning – is continuously on the test bench in order to exploit every potential for optimisation. Process steps are integrated into the overall process taking every option for economical energy optimisation into account (such as heat recovery and minimisation of pressure loss).



CFD model of an oxidation basin

From idea to optimised product

The overall view from a component detail to the system as a whole is made possible by a dedicated technology centre, the latest in computer-supported tools and operational data coming back from installed plants. In the technology centre, experimental investigations are performed on physical models using the principle of similarity. Reliable metrology systems allow us to measure all process-relevant data with high accuracy. In combination with numerical tools like AspenPlus, ANSYS-Fluent, OpenFOAM, Scilab, Xcos and our own design- and layout software developed in-house, ideas become reality in an optimised product or process. Numerous patents attest to the innovative capacity of SBENG.

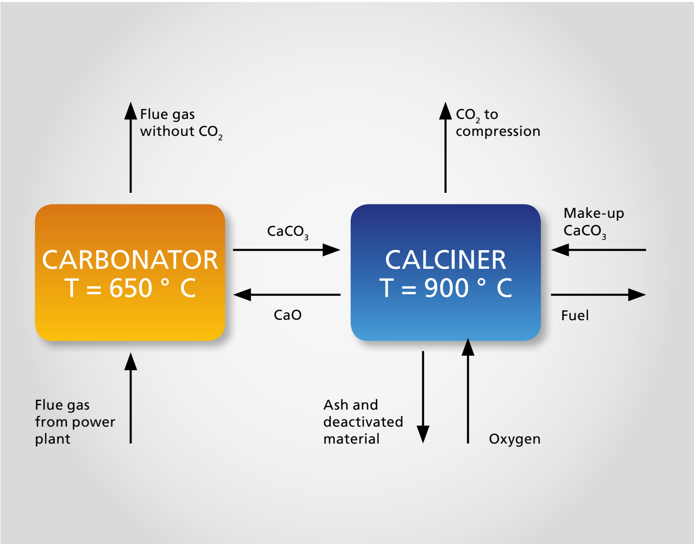
Physical model of an oxidation basin

Strategic research activities

In addition to the continuous improvement of existing technologies, the development of new products and processes is also a focus of our activities.

For example, we are working in an interdisciplinary research project on a carbonate looping process for the separation of environmentally harmful carbon dioxide from flue gases. These developments are being pursued in close collaboration with our customers, suppliers and industry partners, as well as with well-known German universities and technical universities.

In the carbonate looping process, the CO_2 is removed from the power plant's flue gas in an initial cyclone reactor (carbonator) by allowing it to bind to calcium. In a second cyclone reactor (calcinator), the CO_2 is separated from the limestone again, condensed and removed for use or storage. The calcium is taken through the "loop" multiple times in the process, and only small quantities need to be removed from the process and replaced with fresh limestone. With our participation in this and other research projects, SBEng is supporting the climate policy goal of a CO_2-free power plant.



Carbonate looping process

Carbonate looping test plant / EST TU Darmstadt

CFD – from product development to plant optimisation

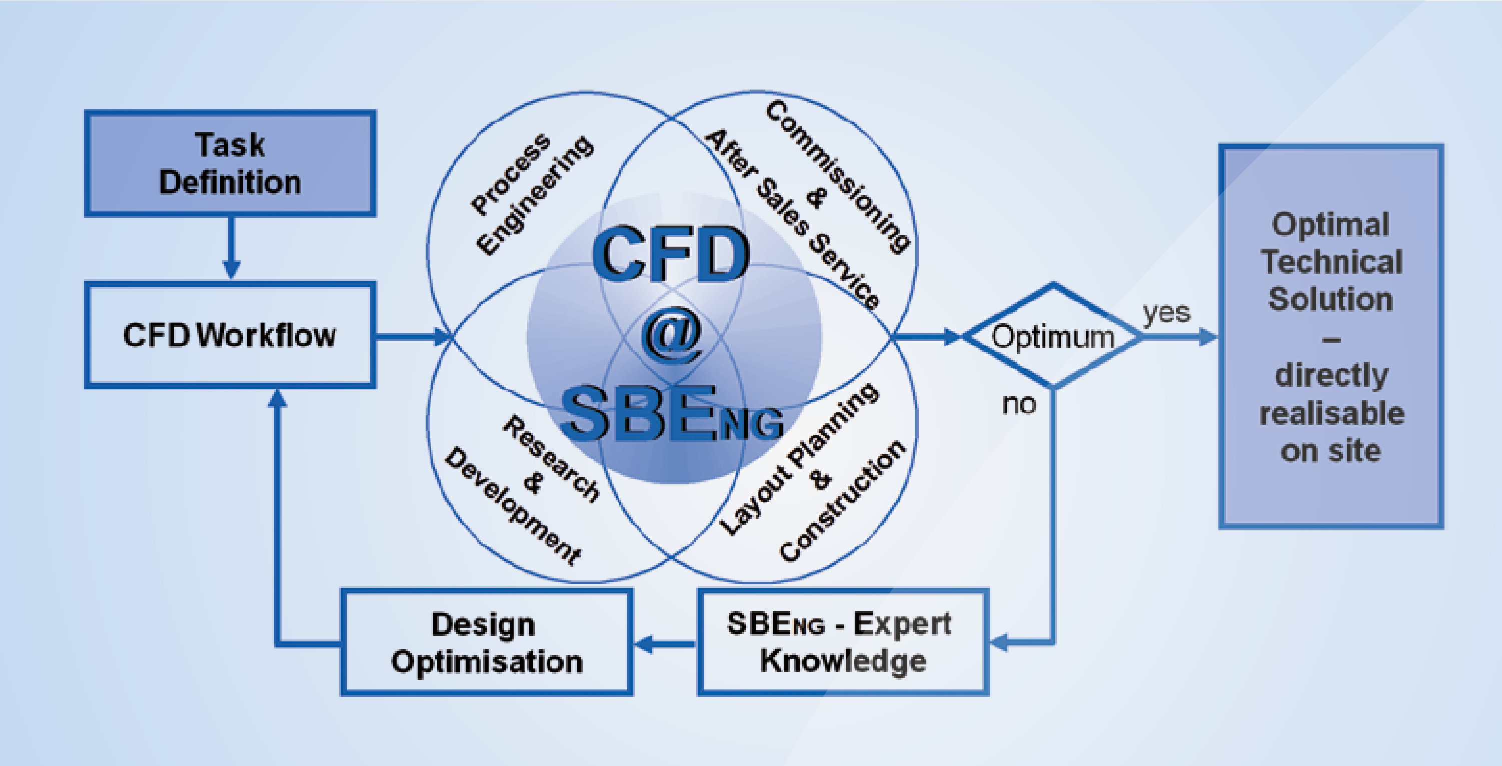


Fig. 1: CFD-supported optimisation process

In plant engineering and construction more stringent emission limits and increasing requirements in terms of efficiency, availability and safety are the driving forces for development and optimisation of products and processes. One prerequisite for product and process optimisation is a detailed knowledge of flow coupled transport phenomena within plant components and ducts. The magic words for investigation of these processes are "Computational Fluid Dynamics" (CFD): a computational method for the simulation and analysis of coupled momentum, heat and mass transfer in single- and multiphase reactive fluid systems. As an innovative company in environmental technology, SBENG uses this method to determine these relevant field values with high precision at every point in a flow domain.

SBENG primarily uses CFD to homogenise the flow-through and incoming flow of plants and system components, to minimise pressure loss, to optimise particle and droplet distributions and to obtain the desired distributions for temperatures and species concentrations. The typical work flow for a CFD-based flow optimisation is shown schematically in Figure 1. After the task is defined, the CFD workflow is subdivided into the following steps: First, the geometry of the relevant flow domain is modelled in a CAD tool (see Figure 2a). The next step is to generate the calculation grid by meshing the CAD model with the smallest possible, predominantly tetrahedral and hexahedral cells (see Figure 2b). Then a mathematical model is set up which describes the transport phenomena (see Figure 2c). By means of the associated initial, boundary and volume conditions, the resulting system of equations is solved. In the post-processing step the numerical solution is visualised and can be analysed at each point in the flow domain (see Figure 2d).

Fig. 2a: Geometry of the flow domain

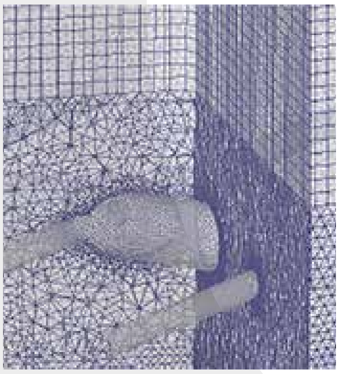


Fig. 2b: Meshing the flow domain

$$\frac{\partial}{\partial t}(\rho\psi)+\underbrace{\nabla(\rho\underline{u}\psi)}_{F_\psi}=\underbrace{\nabla\cdot(\Gamma\nabla\psi)}_{D_\psi}+Q_\psi$$

conserved quantity	ψ	D_ψ	Q_ψ
mass	1	0	0
momentum	$\underline{u}$	$\nabla\cdot\underline{\underline{\tau}}$	$-\nabla p+\rho\underline{g}$
energy	h	$-\nabla\cdot\dot{\underline{q}}$	$\frac{\partial p}{\partial t}+\nabla\cdot(\underline{\underline{\tau}}\cdot\underline{u})$

Fig. 2c: Mathematical modelling
(as described in „CFD-Modellierung", R. Schwarze, Springer-Verlag, 2013)

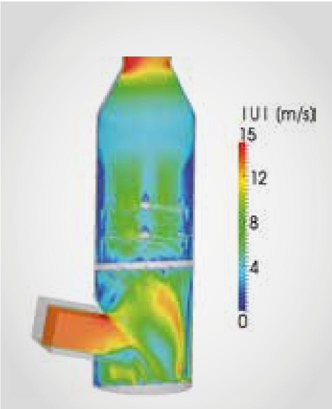


Fig. 2d: Velocity distribution in a flow domain

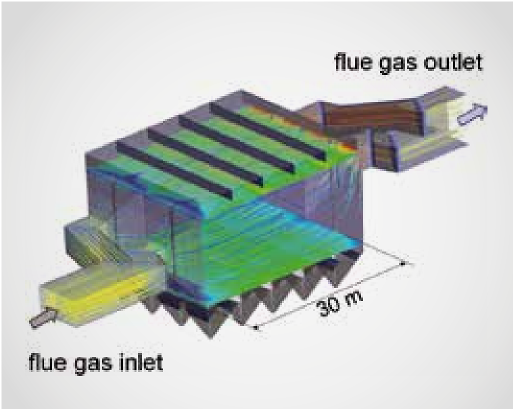


Fig. 3: CFD model of an electrostatic precipitator (left part subject to symmetry plane)

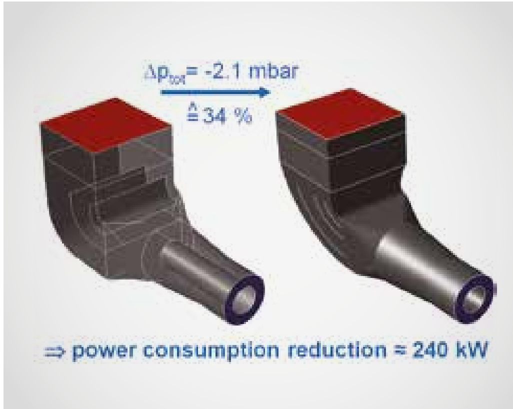


Fig. 4: 90 degree deflection downstream an axial fan

SBEng uses the latest CFD software such as ANSYS-Fluent® and OpenFOAM® for the numerical solution of the mathematical model. Areas within the flow domain, where insufficient transport conditions exist, can be identified by analysing the simulation results. Based on this knowledge, possibilities of flow enhancements and optimisations can be derived. CFD is embedded in every technical department at SBEng, such as Process Technology, Research and Development, Layout Planning, Design and in After Sales Service. Hence all the expert knowledge from these departments is incorporated into the optimisation of a product or process. The great advantage is that the optimal solution identified is not only reliable, but can also be implemented directly into the product or in the plant on-site. To carry out complex CFD simulations, SBEng has a high-performance IBM BladeCenter available in our own computer centre. CFD models with a very large number finite volume cells, currently up to 100 million cells, can therefore be calculated robustly and efficiently. These numerical simulations are validated both with measured data from technical centre experiments, and based on measurements obtained during commissioning and operation of plants erected by SBEng.

Your advantages at a glance

Computational Fluid Dynamics

- Provides detailed insights into flow phenomena
- CFD analyses help during trouble-shooting
- Identification of optimisation potentials
- Enhancement of system efficiency
- Reduction in costs of investment, operation and maintenance
- CFD@SBEng leads to the "optimal solution – directly realised on site"

CFD – much more than coloured figures

The specific advantages of flow investigations with CFD are best understood by presenting some examples:
Figure 3 shows the left part subject to the symmetry plane of an electrostatic precipitator used to remove dust particles from the flue gas. The objective is to ensure the optimal flue gas flow through the separation zones. This is achieved by optimising the inlet flow into the first field. Additionally, the flow above and below the separation zone as well as reentrainment of the dust into the passing gas are minimised.
A 90-degree deflection in the duct downstream an axial fan is shown in Figure 4. By optimising the duct geometry and ensuring optimal positioning of the guiding vanes, it was possible to reduce pressure loss by 35%. This corresponds to a reduction in electrical energy consumption of about 240 kW.
Figure 5: Based on transient simulation of the coupled transport of a continuous gas and dispersed particle phase, the optimum positions are determined for a DIVA® mixer and particle injection lances. This makes it possible to obtain the necessary homogeneous distribution of particles needed at the outlet of the mixing zone.
The knowledge gained during CFD-based optimisation process is applied in product development continually. This approach ensures ongoing minimisation of investment, operation and maintenance costs. Therefore CFD at SBEng contributes significantly to the enhancement of system efficiency.

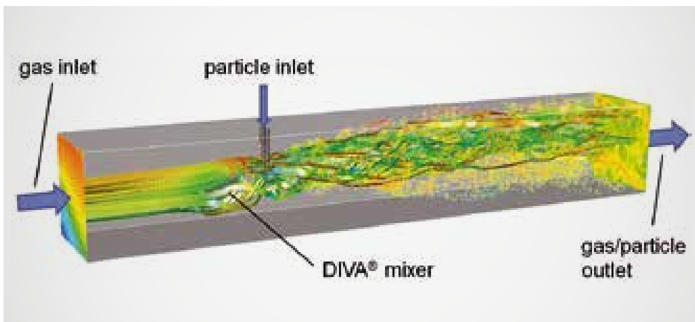


Fig. 5: Mixing zone with particle injection downstream of a DIVA® mixer

One company – many roles

Environmental technology is top technology, highly complex, a perfectly matched interplay between individual components. Steinmüller Babcock Environment can handle a wide variety of tasks in this area. We work as a general contractor for turn-key systems, but also develop and deliver individual components. Regardless of the capacity in which we work, one thing is always true. From planning to material logistics, from the first shovelful of dirt to plant commissioning – individual departments of our company work perfectly together.

To fulfil our many roles, we have a team of the best qualified engineers available, who use the latest tools to ensure high quality in both plant engineering and later implementation. In addition to the engineering area, we also offer professional project management – also equipped with the latest project management tools to ensure high quality execution. Processing of an order in a project team guarantees that every project member is always up-to-date on the current progress. That is the pre-requisite to ensure the seamless handling of every customer order. This transparency in operational processes guarantees on-time delivery – at a technical standard that meets the strictest of expectations.

Our technology: trailblazing

Anyone who wants to stay ahead of the game has to keep thinking. So we engage in the development of future technologies and work closely with technical universities and research institutions. We work today to set the direction for tomorrow.

Our advantage: many years of experience

Whether as a supplier of the entire process chain or of individual components – based on our many years of experience, we are always optimising our products and processes for long-term efficiency and economical use.

Reliability and quality

Quality and reliability are top priorities for us. We are certified in management systems for Health, Safety and Environmental Protection. As a supplier of pressure equipment, we are also qualified as a manufacturer under the applicable EU Directive. This includes DIN EN 13480 for self-designed pipelines. With certification for ASME S-Stamp (new construction) and ASME R-Stamp (repairs/redesign), we have also made it possible to market our products in the United States, Canada and 90 other countries. Borders are no barrier to the use of our products.

We also guarantee the outstanding quality of our products for the long term. That’s why we have our own welding and test equipment with certified process testing compliant with EN ISO 15614 and certified ZfP personnel compliant with EN ISO 9712.

Our service profile

- **General contractor for turn-key plants and individual lots**
- **Supplier of key components**
- **After Sales Service partner**
- **Engineering provider**

Our After Sales Service – always at your side

Even after completion and commissioning of our plants, we are there for our customers. With us, you have access to all our services, from engineering to erection and from inspection to repair. All our services are provided to you comprehensively, flexibly and reliably from a single source to ensure high availability of your plant and increase its performance.

As a part of a plant engineering and construction company, our After Sales Service has access to the entire accumulated knowledge of our development, engineering and design departments. Our comprehensive expertise is at your disposal, for example for studies, the optimisation of system designs, plant updates and even as the basis for maintenance work at the highest possible level of quality.

Steinmüller Babcock Environment has every technical speciality necessary to offer you engineering, fabrication, delivery, installation and documentation for flue gas cleaning systems from a single source. Our After Sales Service department is a competent contact for any flue gas cleaning technology throughout the entire process chain, and is at your side with advice and support at any time – and not only for systems we erect.

Inspection, maintenance and repairs

Prevention is better than downtime. Planned maintenance is the basic foundation of a cost-effective maintenance strategy. Our After Sales Service is always happy to advise you on preventive measures and can offer either special or comprehensive inspection services. That lets you shorten downtime and increase system availability.

The organisation and performance of maintenance work is oriented on the timeframes you specify, and tailored to the needs of your system. Our experienced staff knows how to match scheduling needs with the required scope of measures.

Our range of services

Inspection, maintenance, and repairs

- Revision and maintenance
- Inspection and repair
- Spare- and wear parts management
- Service contracts (incl. on-call service / operational management)
- Service contracts for wear parts

Plant operation and optimisation

The service life of flue gas cleaning systems generally streches over 20 years and more. During operation, new requirements often arise, such as changes in legal regulations for environmental protection or changes in fuel compositions and pollutant contents. All of this has consequences on the operation, sometimes even on the technical design needed for the plant.

With our engineering-based services, you get the support you need to take on any challenges from ongoing operations, such as the optimisation of energy and fuel consumption. We have the latest tools available, for example thermography, industrial machine diagnostics and video endoscopy – and of course the experience we have gained from many reference plants.

To support you in system management, we can also train your operations staff, optimise operation sequences or handle the complete technical and plant operations management.

Service agreements

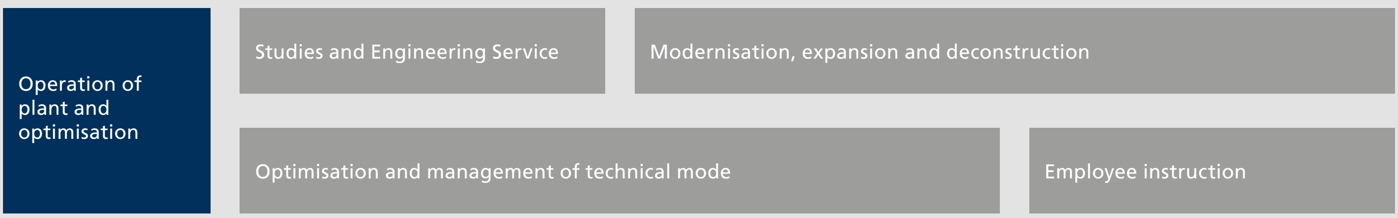
Steinmüller Babcock Environment can offer service agreements for inspection and ongoing maintenance of systems for flue gas cleaning in waste incineration plants and gas cleaning systems in power plants. These are adapted to customer needs via four service areas:

- Contract duration
- Technical scope – e.g., individual components such as electric filters (wet or dry), fabric filters, DeNOx systems or the entire flue gas cleaning system
- Scope of service – e.g., inspections or maintenance/repair work during planned inspection shutdowns and/or during ongoing operation, optional on-call service for disturbances during ongoing operations
- Depth of service – e.g., staffing for routine preventive maintenance measures and/or for malfunction repair in the case of a (partial) plant shutdown, or provision of a complete intervention team for inspection shutdowns or individual experts as supervisors

Your advantages

A customised service contract offers you:

- Projectable maintenance costs for the long term
- Fast, non-bureaucratic support by our service team
- Additional services such as on-call support
- Fast, reliable supply and replacement of wear parts
- Price advantages during the period of validity of the contract
- Engineering support as operational problems arise, optimisation and retrofit measures



Worldwide active – a selection of our 1,200 reference plants

Flue gas cleaning

Desulphurisation plants (lime-based)

Austria
Linz
Retznei
Salzburg
Timmelkam

Belgium
Langerlo

Canada
Belledune

China
a total of over 15 plants
Banshan
Bejing
Chongqing
Jiangsu
Nanton
Shandong
Shi Jing Shan

Czech Republic
Tisova
Tusimice
Usti

Denmark
Amager
Asnaes

Finland
Inkoo
Meri Pori

Germany
a total of over 50 plants
Berlin Charlottenburg
Boxberg
Braunschweig
Bremen
Datteln
Hamburg Hafen
Hamburg Wedel
Heilbronn
Höchst
Janschwälde
Lünen
Mainz/Wiesbaden
Mannheim
Munich
Neurath
Niederaußem
Schkopau
Spremberg (Schwarze Pumpe)
Staudinger
Walsum
Weisweiler

Greece
Megalopolis

Hungary
Matra

Italy
Fiume Santo
Fusina
La Spezia

Netherlands
Rotterdam

Poland
Belchatow
Jaworzno
Laziska
Ostroleka
Patnow
Plock
Siersza

Slovenia
Sostanj

Spain
Alcudia

Thailand
Mae Moh

Turkey
Orhaneli

U.S.A.
a total of over 10 plants
Cross
Culley
Henderson
Huntington, West Virginia
Warrick County

Desulphurisation plants (seawater based)

Bahrain
Bahrain

Chile
Puerto Coronel

Panama
Paco

Saudi Arabia
Shuaibah

United Arab Emirates
Abu Dhabi
Takreer

SCR technology

Belgium
Langerlo

China
Yang Shu Pu, Shanghai

Denmark
Amager
Enstedt
Esbjerg
Odense
Vodskov

Germany
a total of over 45 plants
Altbach / Deizisau
Berlin
Braunschweig
Cologne-Godorf
Dormagen
Elverlingsen
Frankfurt-Höchst
Friedrichshafen
Heilbronn
Hüls
Ingolstadt
Karlsruhe
Mannheim
Munich
Scholven
Schwedt
Uerdingen (Krefeld)
Voerde
Walheim
Werne
Wiesbaden

Italy
a total of 5 plants
Civatavecchia
Montalto di Castro
Torre Valdaliga
Turbigo
Vado Ligure

Korea
Youngnam

Netherlands
a total of 5 plants
Amer
Amsterdam
Nijmegen
Rotterdam

U.S.A.
a total of over 30 plants
Alamitos
Albany, New York
Big Sandy, Texas
Kentucky
Mill Creek
Orlando
Pasadena

Electrostatic precipitators

Austria
Lenzing
Linz
Salzburg
Timelkam

Bosnia
Tuzlar

Czech Republic
Litvinov
Usti

Germany
10 other plants
Boxberg
Hamburg Moorburg
Karlsruhe
Kiel
Mannheim
Neurath
Oberhausen
Salzgitter
Wesel
Wuppertal

Netherlands
Rotterdam

Slovenia
Sostanj

Spain
Velilla

Sweden
Uddevalla

Switzerland
Basel

Turkey
Afsin Elbistan
Iskenderum

Fabric filters

Bahrain
Bahrain

Belgium
Brügge
Lüttich

China
Majialou
Xiaowuji

Denmark
Aarhus
Avedöre
Glostrup

Germany
a total of over 45 plants
Berlin-Rüdersdorf
Berlin-Ruhleben
Burgkirchen
Cologne
Düsseldorf
Frankfurt
Hamburg
Herten
Krefeld
Lausward (Düsseldorf)
Mainz
Mannheim
Munich
Neumünster
Nuremberg
Salzgitter
Schweinfurt
Ulm
Werne
Würzburg

Italy
Milan
Naples

Japan
Hokusats
Ohta City
Takefu City

Netherlands
Maastricht
Nijmegen
Roermond
Venlo

Norway
Oslo-Brobekk
Oslo-Klemetsrud

Poland
Siekierki
Siersza

Spain
Alcudia

Switzerland
Cottendart
Horgen
Utzenstorf

Energy from Waste

Austria
Wels

China
Haidian
Hefei
Ningbo
Shanghai

Czech Republic
Brno

Denmark
Århus
Fünen
Glostrup

Finland
Riihimäki
Tampere

France
Bellegarde
Bordeaux
Bourgen Bresse
Carrieres sur Seine
Chateau Roux
Clermont Ferrand
Dunkerque
Fort-de-France / Martinique
Grenoble
Lagny / Marne-la-Vallée
Le Havre
Lyon
Rambervillers
Reims
Toulouse

Germany
Berlin-Ruhleben
Böblingen
Bremen
Burgkirchen
Cologne
Damm
Düsseldorf-Flingern
Essen-Karnap
Göppingen
Göttingen
Hagen
Hamburg Borsigstraße
Hamburg Rugenberger
Hamburg Stapelfeld
Hameln
Hamm
Heringen
Herten
Kamp-Lintfort
Kassel
Kiel
Krefeld
Leverkusen
Ludwigshafen
Munich
Oberhausen
Pinneberg
Rüdersdorf
Ruhleben
Schwandorf
Schweinfurt
Stuttgart-Münster
Weissenhorn
Weisweiler
Wuppertal
Würzburg

Great Britain
Birmingham-Tyseley
Edmonton
Isle of Man

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Italy
Bolzano
Cremona
Dalmine
Fenice Melfi
Macerata
Messina
Naples
Reggio di Calabria

Japan
Akashi, Hyogo
Funabashi, Chiba
Iwaki, Fukushima
Kadoma, Osaka
Kawaguchi, Saitama
Kawasaki, Kanagawa
Kishiwada, Osaka
Kobe, Hyogo
Kyoto
Matsue, Shimane
Moriguchi, Osaka
Ohta, Gunma
Ritto
Sennan, Osaka
Shijonawate, Osaka
Shimodate
Tokushima
Tokyo
Utsunomiya, Tochigi
Yashimata

Korea
Ansan
Anyang Pyongchon
Gyeongju
Icheon
Jung-Ku, Ulsan
Jungwon-Ku, Sung Nam
Kwang Myung
Myung-Ji, Pusan
Nowon-Ku, Sang-Gae

Lithuania
Klaipeda

Netherlands
Arnheim
Eindhoven
Joure
Moerdijk
Nijmegen
Rotterdam / Botlek
Rozenburg

Norway
Kristiansand

Russia
Kuibyshev
Moscow
Murmansk
Omsk
Pjatigorsk
Rostov
Saratow
Soci

Singapur
Ulu Pandan

Slovakia
Bratislava
Kosice

Spain
Palma de Mallorca
Tarragona

Sweden
Borlänge
Halmstad
Jönköping
Södertälje
Stockholm
Uddevalla

Switzerland
Affoltern
Biel
Buchs
Cottendart
Gamsen
Horgen
Muttenz
Oberwallis
Oftringen

Taiwan
Kaohsiung

Ukraine
Dnepropetrowsk
Donezk
Jalta
Kiev

U.S.A.
Essex County
Hempstead
Long Beach California
Montgomery Pennsylvania
Niagara Falls
Portland
Southeastern County

After Sales Service

Austria
Dürnrohr
Pfaffenau

China
Shanghai

Denmark
Aarhus
Glostrup
Odense

Finland
Riihimäki

Germany
Berlin-Ruhleben
Böblingen
Bonn
Damm
Düsseldorf – Flingern
Hamburg – Borsigstraße
Hamburg – Rugenberger
Hamburg – Stapelfeld
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Wuppertal

Great Britain
Isle of Man
Tyseley

Italy
Naples

Lithuania
Klaipeda

Netherlands
Arnheim
Delfzijl
Hemweg
Moerdijk

Norway
Kristiansand
Oslo

Spain
Alcudia
Palma de Mallorca
Tarragon

Sweden
Borlänge
Halmstad
Jönköping
Uddevalla

U.S.A.
Montgomery Pennsylvania

Alcudia 1&2 power plants, Mallorca/Spain
Technology: Semi-dry FGD
Fuel: Bituminous coal
Power plant capacity: 250 MWe
Flue gas volume: 2 x 0,5 million Nm^3/h
Commissioning: 2007

Shuabaih III power plant, Jeddah/Saudi Arabia
Technology: Seawater scrubber
Fuel: Crude oil
Power plant capacity: 1800 MWe
Flue gas volume: 3 x 2 million Nm^3/h
Commissioning: 2008

GKM 6 power plant, Mannheim/Germany
Technology: Limestone-gypsum FGD
Fuel: Bituminous coal
Power plant capacity: 280 MWe
Flue gas volume: 1 x 1 million Nm^3/h
Commissioning: 2005

RDK 8 power plant, Karlsruhe/Germany
Technology: Electrical precipitators
Fuel: Bituminous coal
Power plant capacity: 912 MWe
Flue gas volume: 1 x 2,5 million Nm^3/h
Commissioning: 2013

Neurath F & G power plant, Grevenbroich/Germany
Technology: Electrical precipitators
Fuel: Lignite
Power plant capacity: 2200 MWe
Flue gas volume: 4 x 2,3 million Nm^3/h
Commissioning: 2012

Hemweg 8 power plant, Amsterdam/Netherlands
Technology: SCR
Fuel: Anthracite coal + biomass
Power plant capacity: 659 MWe
Flue gas volume: 2 x 1 million Nm^3/h
Commissioning: 2006

FGD = Flue Gas Desulphurisation system | SCR = Selective Catalytic Reduction

Amercentrale 9 power plant, Geertruidenberg/Netherlands
Technology: SCR
Fuel: Anthracite coal + biomass
Power plant capacity: 600 MWe
Flue gas volume: 2 x 1,1 million Nm³/h
Commissioning: 2008

Boxberg IV power plant, Weißwasser/Germany
Technology: Limestone-gypsum FGD
Fuel: Lignite
Power plant capacity: 1600 MWe
Flue gas volume: 2 x 1,8 million Nm³/h
Commissioning: 1999

Maasvlakte 1&2 power plants, Rotterdam/Netherlands
Technology: Limestone-gypsum FGD
Fuel: Bituminous coal
Power plant capacity: 1080 MWe
Flue gas volume: 4 x 0,9 million Nm³/h
Commissioning: 2006/2007

Maasvlakte 3 power plant, Rotterdam/Netherlands
Technology: Limestone-gypsum FGD
Fuel: Bituminous coal
Power plant capacity: 1100 MWe
Flue gas volume: 1 x 3,2 million Nm³/h
Commissioning: 2014

Matra 3-5 power plant, Visonta/Hungary
Technology: Limestone-gypsum FGD
Fuel: Lignite
Power plant capacity: 600 MWe
Flue gas volume: 2 x 2 million Nm³/h
Commissioning: 2000

Santa Maria 1 power plant, Puerto Coronel/Chile
Technology: Seawater scrubber
Fuel: Bituminous coal
Power plant capacity: 35 MWe
Flue gas volume: 1 x 1,2 million Nm³/h
Commissioning: 2011

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