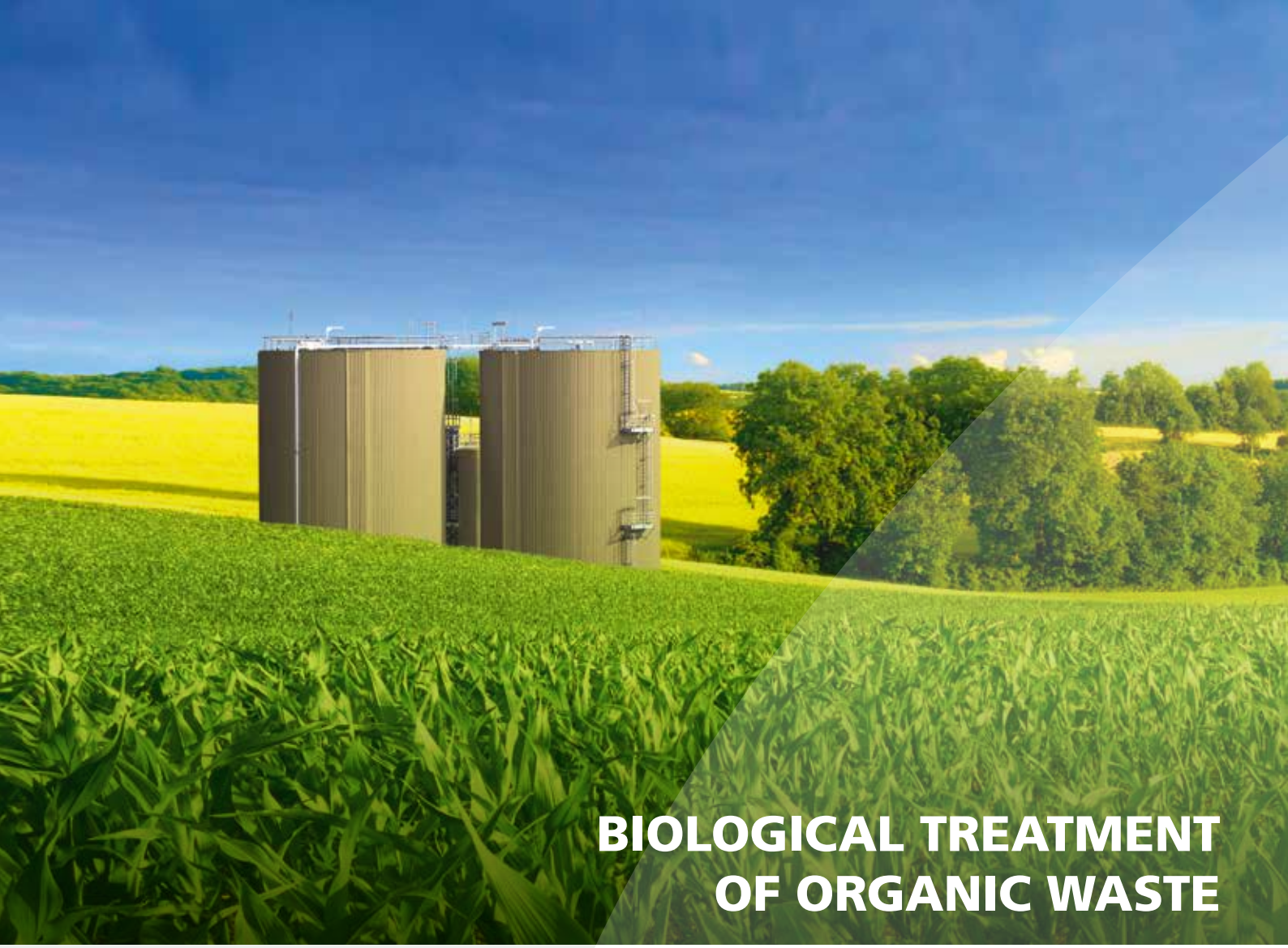


BIOLOGICAL TREATMENT OF ORGANIC WASTE

WE MAKE THE WORLD A CLEANER PLACE

Steinmüller Babcock Environment

SBENG

NIPPON STEEL & SUMIKIN ENGINEERING GROUP

Steinmüller Babcock Environment: innovative and global

Steinmüller Babcock Environment (SBEng) plans and erects plants for the treatment of a wide range of waste materials in close coordination with their customers. The spectrum of services comprises thermal and biological waste treatment, as well as processes for air and gas cleaning.

Our services are specially tailored to the client's requirements. Whether as a supplier of the complete process chain or 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. In the field of biological processes, we back-up on experience gained in the construction of turnkey digestion plants since 1997.

With mesophilic and thermophilic process design, we are able to treat the entire spectrum of waste in mechanical-biological treatment plants (MBT), from separately collected biowaste right through to mixed municipal waste. With one digester, we cover a capacity range of 20,000 to 40,000 Mg/a, whilst the combination of multiple digesters allows throughputs of up to 200,000 Mg/a in a single dewatering line. As a result of decades of operational experience in anaerobic technology, SBEng utilises a digester system without movable internals. Agitator damage and wear are therefore no subject of concern.

Service and supply for biological waste treatment:

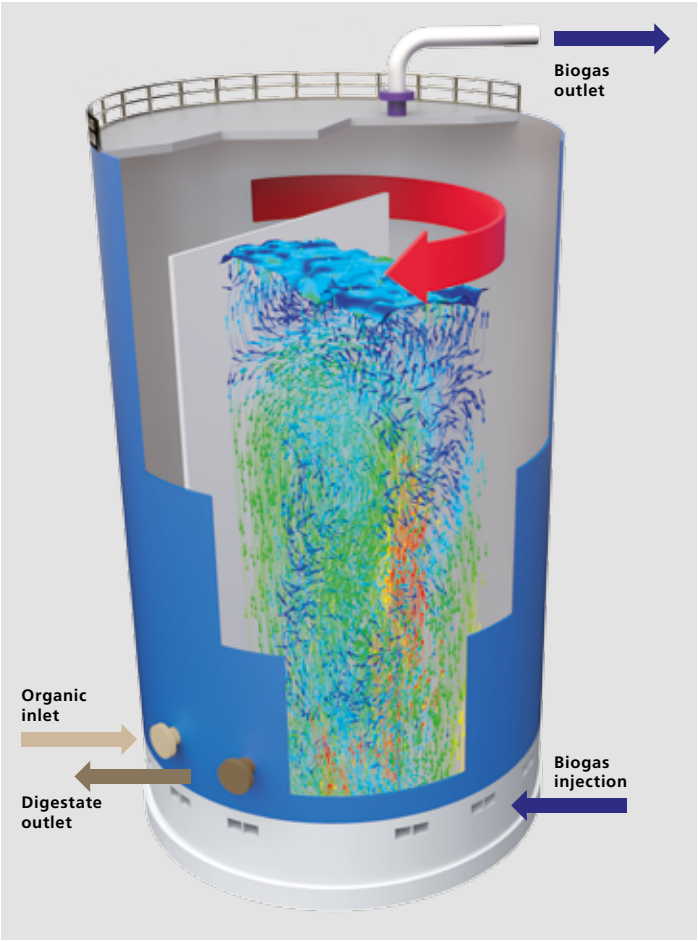
- Turnkey projects, from approval planning right through to commercial operation
- Plants for upgrade to biomethane, for feeding the grid or alternative use
- Energetic use of the biogas for generating electric power, heat or steam, e.g. with combined heat and power stations
- Digestion plants, from mechanical pre-treatment right through to aerobic post-treatment and contaminant removal, depending on the requirements
- Treatment of the process exhaust air through chemical, biological or thermal processes (scrubber, biofilter or regenerative-thermal oxidation)

Digestion reactor without moving components

Process dynamics

The SBEng digester stands out due to its specific process dynamics: To ensure a plug flow characteristic in the digester the digestate moves horizontally around an internal partition wall. This wall effectively prevents short circuiting of the flow. In the vertical, the digestate is thoroughly mixed in a loop flow („airlift pump effect“) in the respectively actuated sectors of the digestion reactor, thereby ensuring efficient renewal of the digestate's contact surface. This process characteristic is extremely effectively superposed by an effect that serves to enhance the performance with pulsed reactors: The ongoing process of the digestate rising and subsequently dropping again during the gas injection transfers a powerful mixing pulse, which leads to the early removal of the smallest gas bubbles from the digestate. The biochemical concentration gradient attained in this way encourages the direct resumption of the methanogenic metabolic process.

Service room beneath the digester vessel



Pinicple of the digester vessel

Advantages

Highest anaerobic decomposition capacities

Many years of statistics pertaining to gas production rates reveal high to very high specific gas formation rates in plants with gas injection, due to the process described above. The intensive contact surface renewal during the gas injection, and the associated pronounced shear forces, result in optimum digestion and good accessibility of the substrate for the microbial degradation of the available organic matter.

Compact footprint

Vertical digestion reactors without movable internals have proven themselves in long-term operation, and stand out due to their modest footprints. To date, volumes of up to 4,500 m³ have been realised per single digester.

High availability

Experience with plants that have been in operation in Germany since the end of the 90s shows that it may only be necessary to remove deposits after around 10 years or more. For example, a reference plant constructed in Freiburg in 1999 has been in uninterrupted operation ever since then. Downtimes do not arise due to damage or wear of movable internals.

Maintenance-friendliness

An easily accessible service room beneath the digestion reactor allows direct access to the gas injection system. As such, pipes, control valves and gas injectors are easy to access for maintenance and inspection purpose.

Flexibility

Combinations of up to 6 digesters in a single line facilitate an economical annual throughput of 20,000 to 200,000 Mg in the digestion process.

Durability

The digestion reactors are constructed in a durable, robust pre-stressed monolithic concrete design in slipforming for single volumes from approx. 1,500 to 4,500 m³.

Reference plants

Digestion plant Lindlar-Remshagen / Germany: separately collected organic waste (mesophilic)

Waste throughput:
35.000 Mg/a

Digester volume:
2 x 3.000 m³

Waste composition:
Biowaste 36 % TS, 70 % OTS

Retention time:
21 - 25 days

Biogas generation:
130 - 140 Nm³/Mg feedmaterial into digester

Specific methane yield:
240 - 260 Nm³/Mg ODS in feedmaterial

Biogas utilisation:
Heat and power generation (Output 940 kWel)

Commissioning:
1998

Digestion plant Freiburg / Germany: separately collected organic waste (thermophilic)

Waste throughput:
36.000 Mg/a

Digester volume:
1 x 4.000 m³

Waste composition:
Separately collected biowaste

Retention time:
21 - 25 days

Biogas generation:
125 - 130 Nm³/Mg feedmaterial into digester

Specific methane yield:
275 Nm³/Mg OTS ODS in feedmaterial

Biogas utilisation:
Heat and power generation

Speciality:
Located in industrial area
Liquid fertiliser production

Commissioning: 1999

Treatment plant for municipal waste La Coruña / Spain: mixed municipal waste (mesophilic)

Waste throughput:
182.500 Mg/a

Digester volume:
4 x 4.500 m^3

Waste composition:
Municipal waste

Retention time:
16 - 20 days

Biogas generation:
130 - 150 Nm^3/Mg feedmaterial into digester

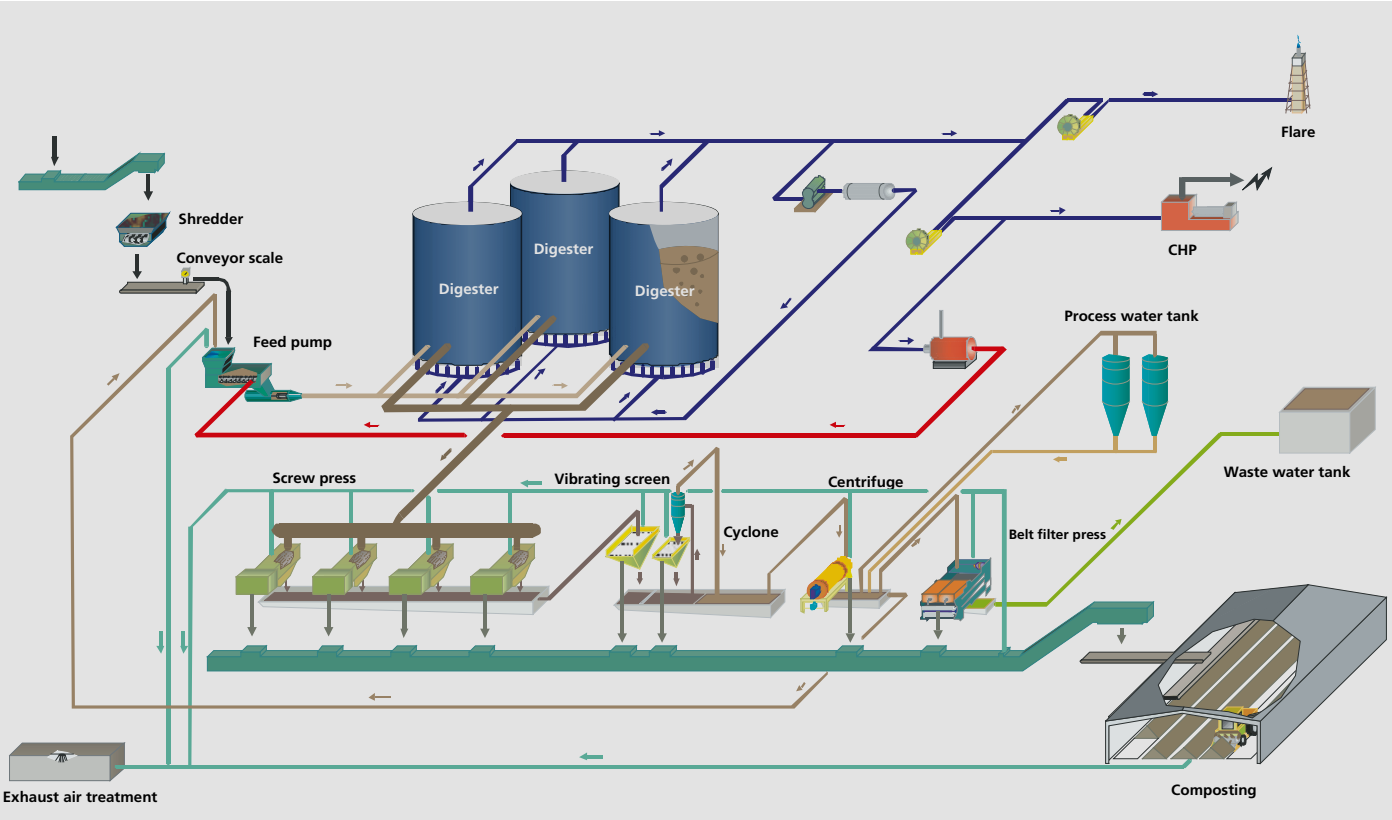
Specific methane yield:
250 - 270 Nm^3/Mg ODS in feedmaterial

Biogas utilisation:
Heat and power generation (5x 1250 kWel)

Speciality:
Recovery of resources

Commissioning:
2002

Exemplary plant scheme



Biological waste treatment with anaerobic digestion

The anaerobic degradation of the organic fraction, so-called „methanization", represents an increasing portion of sustainable waste treatment. These typically moist fractions with a low calorific value in mixed household waste are barely suitable for thermal waste treatment, although they are ideal for biological conversion into biogas. The digestion can take place under mesophilic (35° - 40° C) or thermophilic (55° - 60° C) conditions, specifically tailored to the specific requirements of the feed material, the post-treatment and the quality requirements of the end products (e.g. TASi-compliant landfilling). The resulting digestate can be mechanically separated into a solid fraction with approx. 50 % dry substance (DS) and a liquid fraction. This is partially recycled as dilution water for adjusting the DS concentration in the feed to the digestion process.

Typical operating values	
Hydraulic retention time	18 – 25 days
Average biogas formation	100 – 165 Nm³/h
Methane content	48 – 60 %

Energy balance (CHP related) per ton to waste input to digester	
Biogas	600 – 1.000 kWh/Mg
Electric (*)	240 – 420 kWh/Mg
Thermal (**)	270 – 450 kWh/Mg

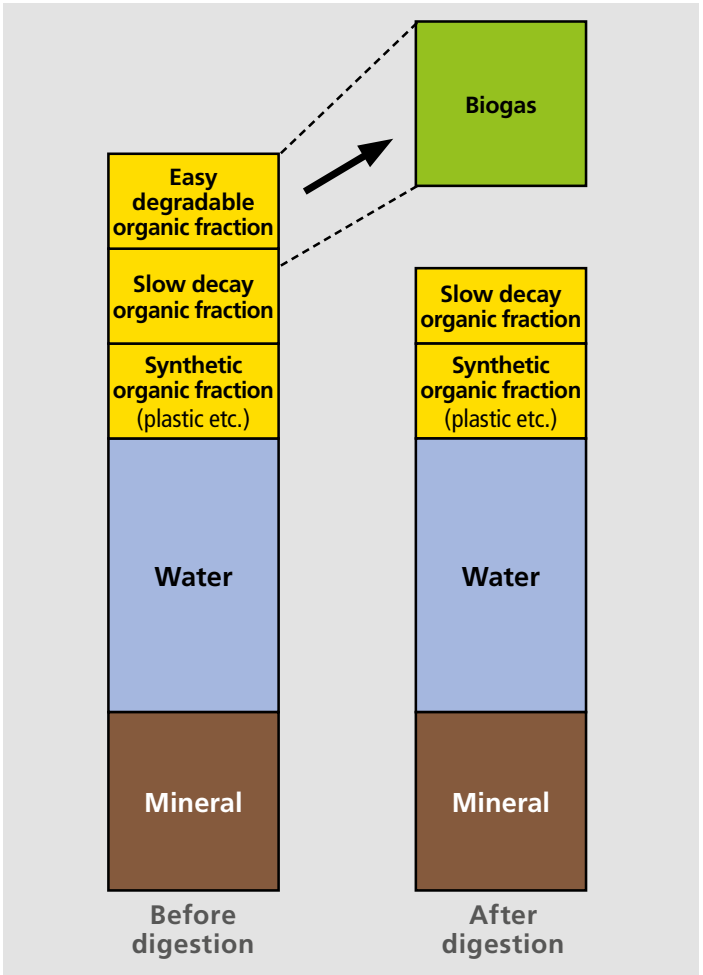
(*) 40 - 42 % electrical efficiency of the gas engine
(**) Hot water / steam recovery of exhaust gas heat exchanger

Separate collection of biowaste per German KrWG

The digestion technology is supported by the legislation: In implementation of EU waste regulations in national law, § 11 section 1 of the Closed Substance Cycle Waste Management Act (KrWG), passed in 2012, obligates waste generators and public disposal organisations to separately collect biowastes subject to mandatory transfer by no later than the 1st January 2015. According to the definition of the term „biowaste" in § 3 KrWG, this specification applies to garden, park and landscape conservation waste, as well as food and kitchen waste. For further development of the requirement formulated in KrWG regarding the separate collection of biowastes, the legislature intends to utilise the delegated legislation in § 11 section 2 KrWG and implement a new version of the biowaste ordinance.

Source: TEXT 84/2014 environmental research plan of the Federal Ministry for the Environment, Nature Conservation, Construction and Nuclear Safety

CHP Standard container unit connected to district heating system



Production of biogas with anaerobic decomposition of organic waste

Combined biological-thermal treatment of waste

As a leading manufacturer of thermal and biological waste treatment plants, SBEng also supplies plants that efficiently combine the advantages of biological waste treatment processes with those of thermal processes.

Through intelligent pre-treatment, unsorted household waste is separated into three fractions: one fraction with a high degree of moisture and large biomass portion that is treated in a digestion plant, a relatively dry fraction with a high calorific value that is treated in a combustion plant, and a third fraction that can be both incinerated and digested. The separation of the fractions results in a reduction in the moisture content of the fuel for the combustion plant, and therefore enhances the efficiency. Furthermore, the quantity of waste in the incineration plant is decreased, which significantly reduces the size of the plant.

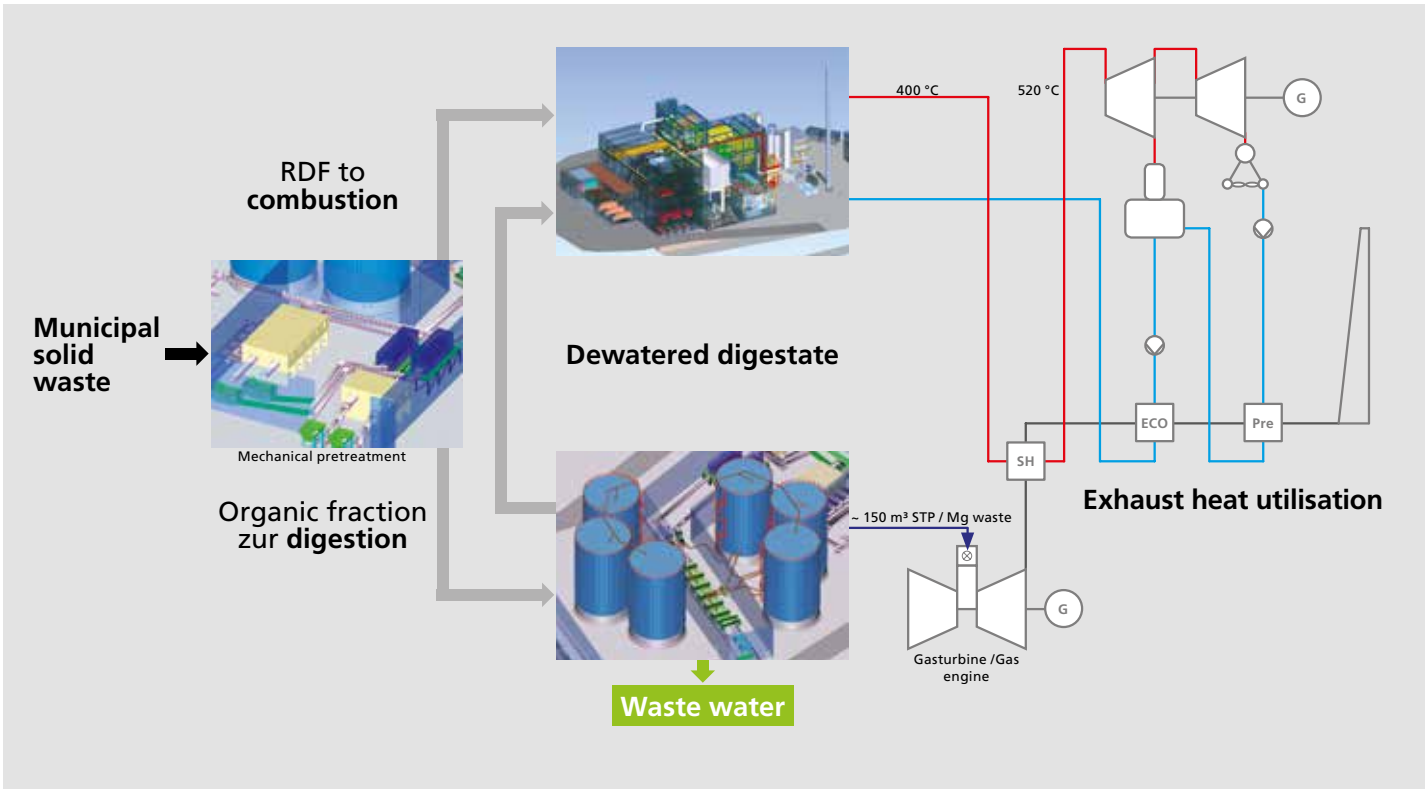
The possibility of optionally incinerating or digesting the third fraction also facilitates increasing the flexibility of the overall plant: due to the possibility of diverting the waste into the digestion plant, the incineration plant is able to react flexibly to load requirements from the grid, without the entire system experiencing a change in capacity. The complete plant therefore exhibits a constantly high disposal capacity at all times.

During digestion, biogas is obtained from the organic matter, which can be converted into electricity with a gas motor or gas turbine. The exhaust gas heat is used to superheat the steam from the incineration plant to very high steam temperatures. The 400° C fresh steam can be superheated up to 520° C in this way. Despite the very high steam temperatures with the technology offered by Steinmüller Babcock, the plant is not subject to an increased risk of corrosion. In addition to the steam superheating, condensate and feed water are pre-heated by the exhaust gas of the gas turbine or gas motor. Low-calorific process heat is therefore also optimally utilised here. During periods with a low power demand, the biogas can also be used to produce biomethane, and fed into the public gas grid depending on requirements.

The digestate from the digestion plant is mechanically dewatered and subsequently treated according to regulations. It can either be directly treated in the incineration plant, or used as covering material on a landfill site after composting.

Both plants can be combined with each other at any time, or operated fully independently. This is particularly relevant if one of the two plant sections is undergoing a revision, or if specific output requirements arisising from the connected electricity, gas or district heating networks. Due to an intelligent control system, the combination plant supplied by SBEng optimally adjusts to the respective requirements and guarantees safe handling of the waste volumes arising at all times.

As a result of comprehensive experience, Steinmüller Babcock is also capable of technical integration of new digestion plants in existing incineration plants.



Example of combination plant

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