

01

version

Proposal

Biogas plant using 231 tonnes brewery spent grains/day



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OVERVIEW

Zorg Biogas offers a plant for processing 231 tonnes of brewery spent grains per day. A vertical steel CSTR digester with a central agitator provides controlled mixing and temperature regulation. The calculated raw biogas production is approximately 27,360 m³/day, with a methane content of 60%. The treated biogas is supplied to the existing boiler plant to replace natural gas.

The gas treatment line combines biological scrubbing, cooling, compression and activated carbon filtration. A dedicated booster feeds the scrubber at 40 mbar. Process air is supplied to the scrubber at 10% of the raw biogas volume. The gas equipment is rated for 1,320 m³/h.

The specified H₂S concentration is 2,500 ppm before scrubbing, 100 ppm after scrubbing and 0 ppm after activated carbon polishing. A final gas pressure of 195 mbar is available downstream of the carbon filter. Digester microelements are dosed at 3 litres/day.

Digestate is separated into solid and liquid fractions. Automated controls and the laboratory support process monitoring, stable operation and maintenance. Zorg provides engineering, equipment supply, supervision, commissioning and operator training.

Raw material potential

Substrate	Quantity [tonnes/day]	Quantity [tonnes/year]	DM content: [%]	ODM content [%]	DM quantity (tonne s/ day)	ODM quantity (tonnes / day)	Biogas yield (m ³ / tonneODM)	Biogas (m ³ /day)	Methane content [%]	Biogas (m ³ /year)
Brewery spent grains	231	84 315	20	94	46,2	43,43	630	27 359	60	9 986 035

*-DM- Dry matter

**-ODM- organic dry matter

Biogas plant characteristics

Characteristics	Values	Figures
Number of reactors	units	1
Reactor (vCTR)	units	1
Volume:		
Work	m ³	6190
Overall		6526
Temperature	°C	55
Overall dimensions of the digester:		
diameter	m	22,20
height		16,87
Organic load	kgODM/m3	7,02
Hydraulic retention time (gross/net)	days	28/26
Number of gasholders	units	1
Volume:	m ³	800
Dimensions of the gasholder:		
diameter	m	12,6
height		9,7

Number of personnel

	Shift 1	Shift 2	Shift 3
Operator	1	1	1
Total	3		



Biogas plant working principle



The technology is based on the biochemical conversion of organic materials from high molecular weight compounds to low molecular weight compounds. The first stage of this process is hydrolysis. Hydrolysis produces organic acids and alcohols.

Organic compounds + $H_2O \rightarrow C_5H_7NO_2 + HCO_3$.

Further conversion of obtained dissolved compounds like organic acids and alcohols ($C_5H_7NO_2, HCO_3$) into gases - CH_4, CO_2 . $C_5H_7NO_2 + HCO_3 + H_2O \rightarrow CH_4 + CO_2 + NH_4$.

Biological process of consecutive (phasic) conversion of organic compounds take place in anaerobic environment i.e. in oxygen-free tank (biological reactor). At the first stage of fermentation, substrate hydrolysis take place under acidogenic bacteria influence. At the second stage, elementary organic compounds come through hydrolysis oxidation by means of hetero-acidogenic bacteria with production of acetate, carbon dioxide, and free hydrogen. The

other part of the organic compound including acetate forms C1 compounds (elementary organic acids). Produced substances are the feedstock for methanogenic bacteria of the third type. This stage flows in two processes of A and B type the character which depends on caused by different bacteria type. These two types of bacteria convert the compound obtained during the first and second stages into methane CH_4 , water H_2O and carbon dioxide CO_2 . Methanogenic bacteria are more sensitive to the living environment compared to acidogenic bacteria. They require a complete anaerobic environment and a longer reproduction period. The speed and scale of anaerobic fermentation depends on bacteria metabolic activity. That is why the biogas plant chemical process includes hydrolysis stage, oxidation, and methanization stage. For that kind of substrate, these processes take place in the same reactor

Technological process of biogas production

Brewery spent grains are fed to the reactor in controlled portions by the screw conveying system. The digester operates at 55°C under thermophilic conditions. A central vertical agitator mixes the substrate, while the heating system and dry cooler maintain the required temperature.

The reactor has a total volume of 6,526 m³ and a working volume of 6,190 m³. The stated hydraulic retention times are 28 days on total volume and 26 days on working volume.

Microelements are supplied to the digestion process at 3 litres/day.

Digestate is pumped to the decanter for separation into solid and liquid fractions. The solid fraction is discharged for storage; the liquid fraction is collected in the filtrate tank.

Produced biogas is collected in an external double-membrane gasholder. The outer membrane provides weather protection, while the inner membrane contains the biogas. Membrane support air remains separate from process air. Pressure protection devices safeguard gas storage.

The gas booster supplies the biological scrubber at 40 mbar. The scrubber receives process air at 10% of the raw biogas volume. Air is introduced into the scrubber, not the digester.

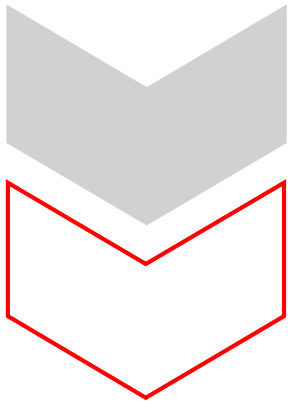
For equipment sizing, 27,360 m³/day of raw biogas and 2,736 m³/day of air give a combined flow of 30,096 m³/day, or 1,254 m³/h. The scrubber, cooling package, gas blowers, carbon filters and flare are specified for 1,320 m³/h.

The specified H₂S concentration decreases from 2,500 ppm to 100 ppm in the scrubber. Its pressure drop is 5 mbar, leaving 35 mbar for cooling and condensate removal.

The downstream compressor raises the gas pressure to 200 mbar. Activated carbon provides final polishing to a specified H₂S concentration of 0 ppm. A 5 mbar filter pressure drop leaves 195 mbar for the boiler gas supply.

The automation system monitors process measurements, alarms and equipment status. Local and remote controls support automatic and manual operation.

MAIN EQUIPMENT





Receiving tank (RT-01) and filtrate tank (FT-01)

Reservoir for reception of liquid kinds of raw materials. Tank is equipped with level sensors and side agitators for mixing raw materials. Tanks serve as a buffer for collection substrates and then to supply substrates to points of biogas plant according the technological process.

The receiving tank is used during biogas plant start-up to receive manure or inoculum.

Specifications

Receiving tank

Diameter:	5,12 m
Height:	4,27 m
Volume:	90 m ³
Quantity:	1 pcs.

Filtrate tank

Diameter:	5,12 m
Height:	4,27 m
Volume:	90 m ³
Quantity:	1 pcs.

Plates (tank wall enamelled, roof)
 Flange, nozzle, lap joint flanges outside
 Control glass
 Ex light
 Manhole
 Ladder, stair and walkway
 Brackets and clamps for pipe along tank edge
 (internal/external)



Reactor (RT-01)

Reactor is an important part of a biogas plant made of enameled sheet metal. The steel digester is installed on a concrete basis. A layer of enamel protects the surface of the entire metal structure. The enamel is vitreous and very resistant to aggressive pH and mechanical damage. Enameled digester assembled from steel segments. Such a digester is quickly and safely mounted. Steel panels are joined on bolted joints with a special sealant. The enamel coating is layered according to the PUESTA method. This is a special powder that is laid in layers by electrostatic attraction. Thus, uniformity of coating, density and smooth

Specifications

Height:	16,87 m
Diameter:	22,20 m
Total volume:	6526 m³
Substrate volume	6190 m³
Quantity:	1 pcs.

Plates (tank wall enameled, roof)
 Flange, nozzle, lap joint flanges outside
 2 off control glass 2 x DN 250 with water flush
 Ex light
 Manhole
 Ladder, stair and walkway
 Brackets and clamps for pipe along tank edge
 (internal/external)



Reactor central vertical agitator (AG-01)

The agitator is fixed to the center of the rigid overlap of the fermenter. Mixer blades are designed in different directions. This design of the blades helps to create a lifting force that lifts the substrate from the bottom of the digester to the top of the tank. The upper blades rotate distributing the substrate along the digester, directing the flow downward. The agitator works constantly, mixing the substrate in the digester all the time

Specifications

Engine power: 37 kW

Quantity per reactor: 1 pcs

Total quantity: 1 pcs



Side agitator (AG-02, AG-03)

Side mixers are used in biogas reactors and receiving tanks for mixing medium and low viscosity substrates. When installed on a metal tank, the stirrer is attached to a support column. The agitator drive is located outside, and a shaft with a screw goes into the reactor through a flange installed in the wall. Installation through a flange prevents the transfer of forces from the agitator to the tank walls. Suitable for use in aggressive environments with a dry matter content of up to 11 %. The special design of the shovel-like blades works good both with mixing different types of substrates and breaking up floating layers and crust.

Specifications

Receiving tank agitator

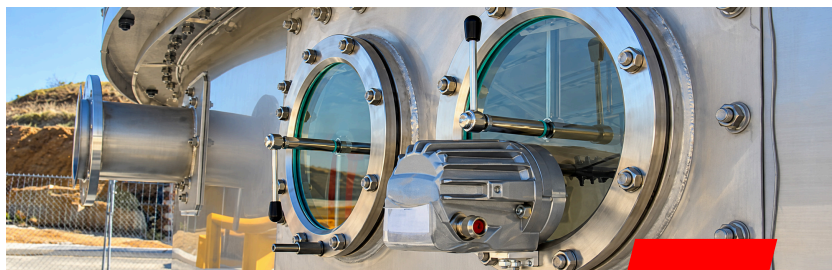
Engine power: 7,5 kW

Quantity per tank: 1 pcs

Filtrate tank agitator

Engine power: 3,0 kW

Quantity per tank: 1 pcs



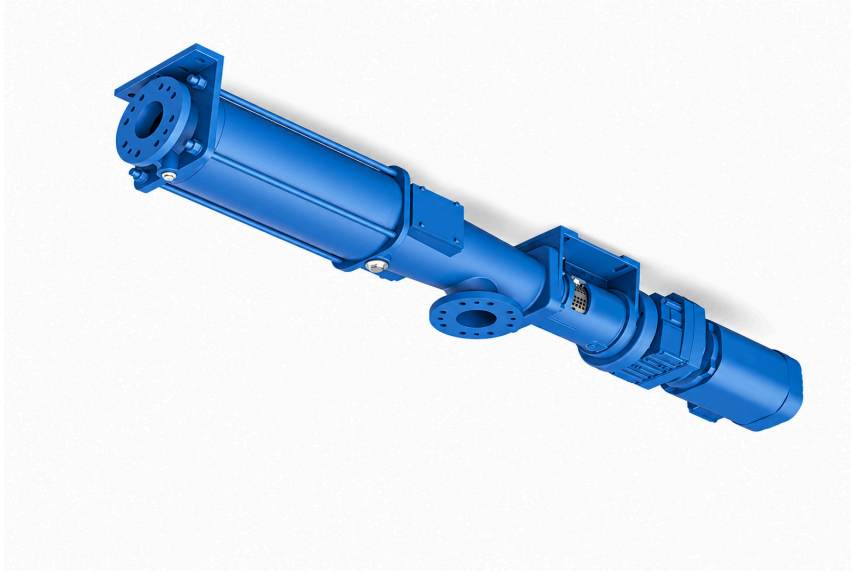
Window with spotlight (SG-01)

Inspection windows are designed for visual control of processes inside the fermenter. Spotlights were made in explosion-proof with automatic disconnection. Inspection windows are equipped with a cleaning washing system.

Specifications

Inspection windows: Ø300

Spotligh: 230V, 50W, IP65
VISULUX UL50 -G -H



Pump equipment (PU-01, PU-02)

Pumps are used to transport substrate to the equipment and facilities in the biogas plant and away. Biogas plant design allows to access easily to all pumps. Pumps are driven by helical geared motor. Stator has hopper inlet for optimum filling of the pumping chamber, wear-protected, robust universal joint with feeding screw, robust bearing pedestal with close-coupled drive and self-centering of the drive shaft. Pumps have modular design for high flexibility, low life-cycle-costs.

Specifications

Substrate feed pump (PU-03)

Engine power:	11 kW
Flow rate:	35 m ³ /hour
Pressure:	4 bar
Quantity:	1 pcs

Substrate digested pump (PU-01)

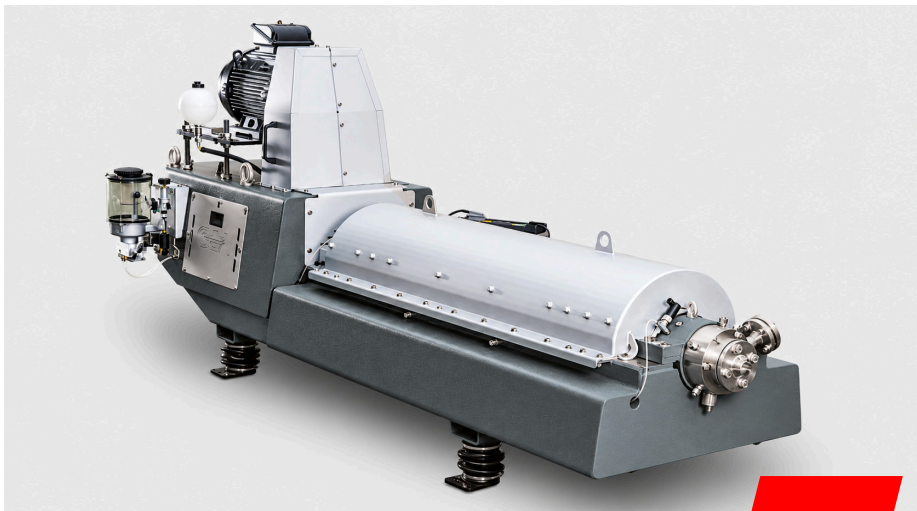
Engine power:	11 kW
Flow rate:	35 m ³ /hour
Pressure:	4 bar
Quantity:	1 pcs

Substrate circulation pump (PU-02)

Engine power:	11 kW
Flow rate:	35 m ³ /hour
Pressure:	4 bar
Quantity:	1 pcs

Filtrate pump (PU-04)

Engine power:	11 kW
Flow rate:	35 m ³ /hour
Pressure:	4 bar
Quantity:	1 pcs



Decanter (DR-01)

This deep-pond 3-phase decanter centrifuge has been customized for clear clarification, liquid separation and solids dewatering. The solid-wall bowl has a cylindrical section for efficient clarification of the liquids and a conical section for drying the solids. Due to the centrifugal forces, the solids are flung onto the inner bowl shell and are transported by the scroll to the solids discharge. On decanter the heavy or light liquid phase is discharged under pressure by use of a centripetal pump while the other liquid phase is discharged by drain tubes. The housing consists of a frame with supporting feet, protective plates and catchers for the discharged phases

Specifications

Engine power:	55 kW
Flow rate:	40 m3/hour
Quantity:	1 pcs



Gasholder (GH-01)

The gasholder provides for biogas storage and for equalizing pressure and biogas composition. The gasholder system has a two-layer construction. The external material consists of a weather-proof film of PVC-coated polyester fabrics with UV protection. Both sides are finished with an external N/5cm, internal membrane PELD (gasholder) membrane.

The gasholder has a methane permeation maximum of $260 \text{ cm}^3/\text{m}^2 \cdot 1 \text{ bar}$ biogas resistance. The gasholder film temperature range allows operation from -30°C to $+60^\circ\text{C}$.

The internal film is stretched under normal biogas pressure. Air is blown into the space between the external and internal membranes to pressurize the internal membrane and form the shape of the external membrane.

The biogas pressure in the gasholder is 2-5 mbar. The membranes are designed and cut out on NC machines. Welding is executed by high frequency currents. These steps yield substantial improvements for quality and service life compared to handmade membranes welded by standard welding equipment.

To prevent damage to the gasholder as a result of overpressure conditions, a safety valve is installed. To survey the internal membrane, an inspection window is installed on the external membrane.

Specifications

Height:	9,6 m
Diameter:	12,7 m
The total volume :	800 m³
Quantity:	1 pcs



Biological biogas scrubber (SC-01)

The biological scrubber removes hydrogen sulphide before biogas cooling and activated carbon polishing. Biogas contacts circulating liquid and an active biofilm, which support the biological conversion of sulphur compounds.

Controlled process air is supplied directly to the scrubber at 10% of the raw biogas volume. The specified H₂S concentration falls from 2,500 ppm at the inlet to 100 ppm at the outlet. Liquid circulation and process monitoring are integrated with the plant control system.

Specifications

Gas flow capacity	1,320 m ³ /h
Air supply	10% of raw biogas volume
Air flow	2,736 m ³ /day
H ₂ S inlet / outlet	2,500 / 100 ppm
Gas inlet / outlet pressure	40 / 35 mbar
Pressure drop	5 mbar
Quantity	1 unit



Biogas dryer and cooling (CHL-01)

Biogas dryer and cooling are provided with special equipment as GAS COOLER and AIR-COOLED LIQUID CHILLER. Biogas plants thanks to an extensive range of dedicated Biogas solutions, low pressure heat exchangers, a comprehensive range of water chillers and RWD Dry Coolers. Designed as one-way shell-and-tube heat exchanger. Process gas inside of the tubes; cooling water in the shell. All parts in contact with the process gas made of stainless steel 316Ti or 316L; heat exchanger shell made of stainless steel/ Designed with gas outlet chamber outlet connection radial; inspection opening axial Official acceptance according to PED 2014/68/EU in accordance with ADMerkblätter and factory pressure test.

Specifications

Gas flow capacity	1,320 m ³ /h
Gas inlet / outlet temperature	55°C / 20°C
Electrical load	50.6 kW
Gas outlet pressure	35 mbar
Quantity	1 unit



Biogas blowers (BC-01, BC-02, BC-03)

The first blower supplies biogas from the gasholder to the biological scrubber at 40 mbar. The downstream compressors deliver cooled gas to the activated carbon filters at 200 mbar. Two downstream units are retained, one operating and one on standby.

Variable-speed control matches delivery to process demand. Each unit has a design gas flow of 1,320 m³/h. The gas is ultimately supplied to the existing boiler plant.

Specifications

Design flow, each	1,320 m ³ /h
Booster discharge pressure	40 mbar
Booster quantity	1 unit
Compressor discharge pressure	200 mbar
Compressor motor, each	22 kW
Compressors	2 units: duty + standby



Activated Carbon Filter (CF-01, CF-02)

Activated carbon provides final gas polishing after biological scrubbing, cooling and compression. The media adsorb residual hydrogen sulphide before the gas is supplied to the boiler.

The specified H₂S concentration is 100 ppm at the inlet and 0 ppm at the outlet. A 5 mbar pressure drop reduces the gas pressure from 200 to 195 mbar. Outlet gas measurements determine when the carbon charge requires replacement.

Two filter vessels are provided in accordance with the equipment price list.

Specifications

Gas flow capacity, each	1,320 m ³ /h
Carbon charge, each	300 kg
H ₂ S inlet / outlet	100 / 0 ppm
Filter pressure drop	5 mbar
Gas outlet pressure	195 mbar
Quantity	2 units



Gas analyzer (CH₄, CO₂, H₂S) (GA-01)

Gas analyzer - a measuring device to determine the qualitative and quantitative composition of the gas mixture. In a biogas plant's installed absorption gas analyzers, biogas mixture components are absorbed sequentially with various reagents. Automatic gas analyzers continuously measure any physical or physicochemical characteristics of the gas mixture or its individual components. Operation is based on physical methods of analysis, including auxiliary chemical reactions.

Specifications

Set includes
 Device for wall mounting
 LCD display menu
 Flow meter / control valve
 Sensors

Quantity:

1 pcs

Defined gases methane % (CH₄), carbon dioxide % (CO₂), hydrogen sulfide ppm (H₂S)



Flare (BF-01)

Flare is designed for the temporary or periodical complete combustion of the biogas produced by biogas plants without the possibility of its use as an energy source. The burn system consists of a burner and additional equipment. The burner is designed on the principle of injection and consists of a combustion nozzle with an injector with an air supply control system, flame protection tube, fitting and burner control system. The biogas combustion system is made of stainless steel.

The supporting structure holds the burner and vertically mounted socket. The burn control system is installed in a case, which is mounted on the supporting structure of the combustion system and contains all the elements for monitoring and controlling ignition and flame.

Specifications

Flow rate:	1320 m ³ /hour
Pressure:	min 10 mbar- max 60 mbar
Quantity:	1 pcs

Water supplying and sewerage system



Water supplying system provides biogas plant feed water, water for network circuits, the domestic water and fire safety systems. As used centrifugal single stage pumps as main pumping elements. These pumps are designed for pumping waste water, household / domestic water and sewage. Pressure Boosting Systems are designed for pure water pressure boosting in industrial plants. The booster comprises 2 to 3 (connected in parallel pumps) installed on a common base frame, and provided with all the necessary fittings.

Specifications

Drain pump
Pressure 4m
Flow 2-3 m³ / h
Engine 0,24 kW

Equipment
Pump case control
Stove-base
gauges
Check valves
Float switches
Brackets
Valves



Heating system

Heating equipment is used for biogas plant heating and for sustaining constant temperature in the fermenter. Heating equipment includes circulation pumps, heat exchanger, heating manifold and pipes. The heat from the boiler is transferred to the biogas plant by using heat exchanger, and then is pumped through of biogas plant by circulation pumps. A heat carrier prepares water with an additive of ethylene glycol. Inlet temperature in the fermenter is 60C, the outlet is 40C.

Specifications

Circulating pump feeding heat carrier

Engine power:	2,0 kW
Flow:	20 m ³ /hour
Pressure:	1 bar

Circulating pump feeding heat carrier

Engine power:	0,8 kW
Flow:	3 m ³ /hour
Pressure:	1 bar

The pumping station feeding propylene glycol

Engine power:	0,8 kW
Flow:	1 m ³ /hour
Pressure:	4 bar



Plate Heat Exchanger (HE-01)

As of today, the design of dismountable plate heat exchangers is the most advanced in the field of solving heat exchange problems. Dismountable plate heat exchangers with thermal capacities ranging from 5 kW to 30 MW can be implemented for various technological processes.

The collapsible plate heat exchanger consists of a frame and a set of heat transfer plates. The frame of the heat exchanger consists of movable and fixed plates, upper and lower guides and a rear stand. All heat exchanger plates in the package are identical in size, but are rotated 180 degrees relative to each other. This arrangement ensures alternating hot and cold channels. During the heat exchange process, the working fluids move towards each other (counter currently). The hot medium transfers heat through the plate wall. There are dozens of plate sizes available for the collapsible heat exchanger. And for each plate size, there are several corrugations. The combination of plates with different reliefs (corrugations) increases the number of possible combinations of heat exchange channels. All of this makes it possible to model a plate heat exchanger that is as close as possible to the specified power and losses.

Specifications

Volumetric capacity
Temperature
Working pressure

5 to 100 m³/h
up to 90°C
at 4 bar

Capacity of the heat exchanger for substrate
Quantity:

400 kW
1 pcs

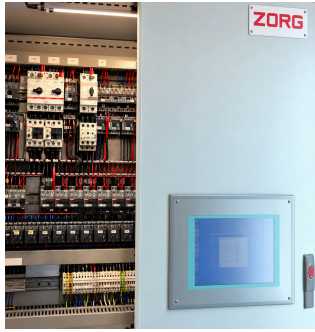


Dry cooler (cooling substrate system)

Device is designed to cool the substrate to working temperature according to technological regime. When use high temperature substrate, there is a chance of uncontrolled heating. The cooler is connected to the heating pipes, heat exchangers and it will be activated if it is need.

Specifications

Heat power:	80 kW
Electric power:	3 kW
Quantity:	1 pcs



Automation and electrical equipment

Process control equipment is used for supervision and regulation operation of the plant and for the limitation of damage. In case of emergency (for example, breakdown of the electrical power supply) the biogas plant is automatically transferred to safe operating conditions by the process instrumentation. Critical electrically driven devices are supplied with emergency power. An automatic system allows the supervision of the plant in real time and to recognize and correct aberrations immediately; to run the plant at its optimum saving resources and costs; and to record for the electronic database operation parameters. The automatic system consists of a control cabinet and sensors for parameter control of technological processes and execution devices.

The control cabinet is designed based on the industrial controller Siemens CPU315-DP2, using periphery distributing system Simatic ET200S, and operator panel OP277 Touch with touch-sensitive controls. Communications is executed by PROFIBUS and MPI with physical interface RS-485. The control program is designed based on the Simatic Step7. The control cabinet is a modular design. The upper part has a power box with central and front-end processor. The periphery distributing system, Simatic ET200S, is installed with input - output units. The lower part with interface relay and clips is installed for connecting execution devices. The entire plant is controlled by a single operator.

Specifications

Incoming control case with automatic set ASE-1, 2, 3

Base Siemens CPU315-DP2 controller

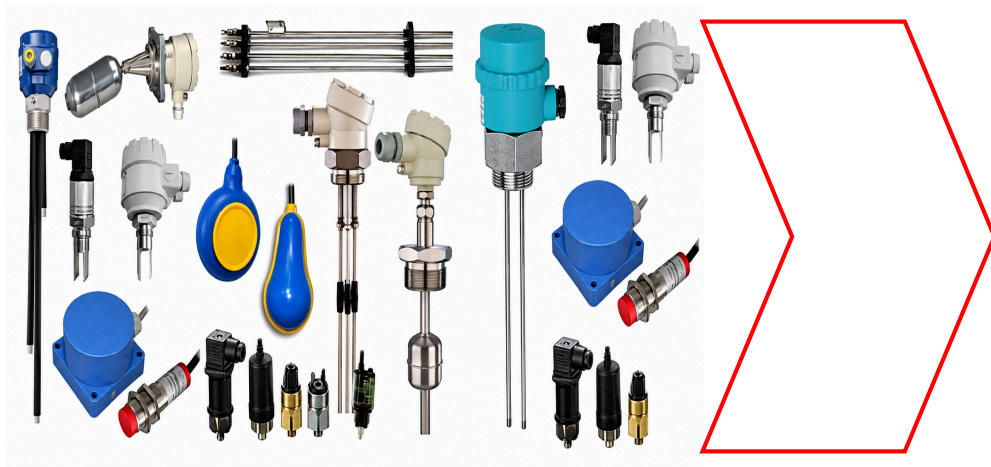
Peripherals Simatic ET200S

Control panel OP277 touchscreen

Communication PROFIBUS and MPI

Interface RS-485

Control system Simatic Step7



Sensors set

Sensors are used to measure physical quantities (temperature, pressure, level of moisture) data collection.
installation kits

Specifications

Conductometric sensor

Pressure Sensor / level

Ultrasonic sensor

Gas Pressure Sensor

Temperature converters with protective sleeves

The moisture sensor and the gas temperature



Laboratory

Monitoring and control of parameters of raw materials and fermentation processes is important for the efficient operation of a biogas plant. The laboratory allows you to assess the content of dry matter in the input raw materials, fermented mass, determine the ratio of volatile organic acids to total inorganic carbon (FOS/TAC parameter), determine the degree of substrate fermentation in fermenters, the level of biogas output, and evaluate the efficiency of separator.

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Equipment

Analytical scales

Moisture analyzer

Automatic titrator

Laboratory pH meter

Centrifuge

A set of flasks

Equipment specification list



Nº	Equipment	Characteristic	Quantity
1	Submersible mixer	N=3,0kW	1
1.1	Airtight motor gearbox		1
1.2	Hydraulic screw (wear-resistant steel)		1
1.3	Mixer control mechanism		1
1.4	Electric motor mount		1
1.5	Set of fasteners		1
2	Reactor central vertical agitator	N=37 kW	1
2.1	Airtight motor gearbox		1
2.2	Hydraulic screw (wear-resistant steel)		1
2.3	Shaft (adapted to the height of the fermenter)		1
2.4	Blade		1
2.5	Frequency converter		1
2.6	Mounting bracket to bottom of the mixer		1
3	Safety valve of digesters		1
4	Window with a searchlight	set	1
4.1	Inspection window RD300 (mounts and sealant included)	Ø300	2
4.2	Spotlight (mount system bundled) VISULUX UL50 -G -H	230V, 50W, IP65	1
5	Substrate feed pump	35 m3/hour N=11.0 kW	1
6	Substrate digested pump	35 m3/hour N=11.0 kW	1
7	Substrate circulation pump	35 m3/hour N=11.0 kW	1

Nº	Equipment	Characteristic	Quantity
8	Decanter	N=55 kW	1
9	Filtrate pump	45 m3/hour N=11,0 kW	1
10	PVC gas holder	800 m3	1
10.1	Weather protection film	Ø12,6 m	1
10.2	Gasholder film PELD methane permeation max.260 cm3/m2*d*1 bar, 650 N/5cm biogas resistant		1
10.3	Air blower	16A, 0,5kW	
10.4	Excess and minimum pressure valve		1
10.5	Dome level sensor		1
10.6	Mounting system		1
10.7	Accessories		1
10.8	Safety valve		1
11	Biogas cooling package	1,320 m³/h; 50.6 kW	1
11.1	Chiller		1
11.2	Gas heat exchanger		1
11.3	Propylene glycol tank		1
12	Activated carbon filter	1,320 m³/h; 300 kg	2
13	Biogas compressors BC-01 / BC-02	1,320 m³/h; 200 mbar; 22 kW	2
14	Electromagnetic flow meter	1,320 m³/h	1
15	Biogas flare	1,320 m³/h	1
16	Gas analyser	set	1
17	Gas piping and accessories	set	1
17.1	Drainage pumps	DN50; 1 m³/h; 13 m	2

Nº	Equipment	Characteristic	Quantity
18	The heat supply system	set	1
18.1	Diaphragm expansion tank	V=1000 l,P=6Bar T=120°C	1
18.2	Circulating pump for supplying heat carrier	Q=30 m3/h,H=1bar	1
18.3	Propylene glycol feed pump station heating systems	Q=1,0 m3/h, H=4 bar	1
18.4	Circulation pump for supplying heat carrier to the digester	Q=18 m3/h, H=1.1 bar	1
19	Water supply and sewerage system, complete, disassembled	set	1
20	Automation with electrical equipment	set	1
20.1	Incoming distribution cabinet with a set of automation DB-1		1
20.2	Incoming distribution cabinet with a set of automation DB-2		1
21	Sensors, set		1
21.1	Gas pressure sensor 0,025Bar		2
21.2	Gas pressure sensor 0,4Bar		2
21.3	Pressure sensor(substrate level) 1,0Bar		4
21.4	Pressure sensor (substrate pressure) 2,5bar		4
21.5	Resistive thermometer (gas temperature)		3
21.6	Resistive thermometer with thermo well (fermenter substrate temperature)		3
21.7	Resistive thermometer with thermo-well (digester tank substrate temperature)		3
21.8	Resistive thermometer (heat conductor temperature)		3
21.9	Conductometric sensor of maximum level		3

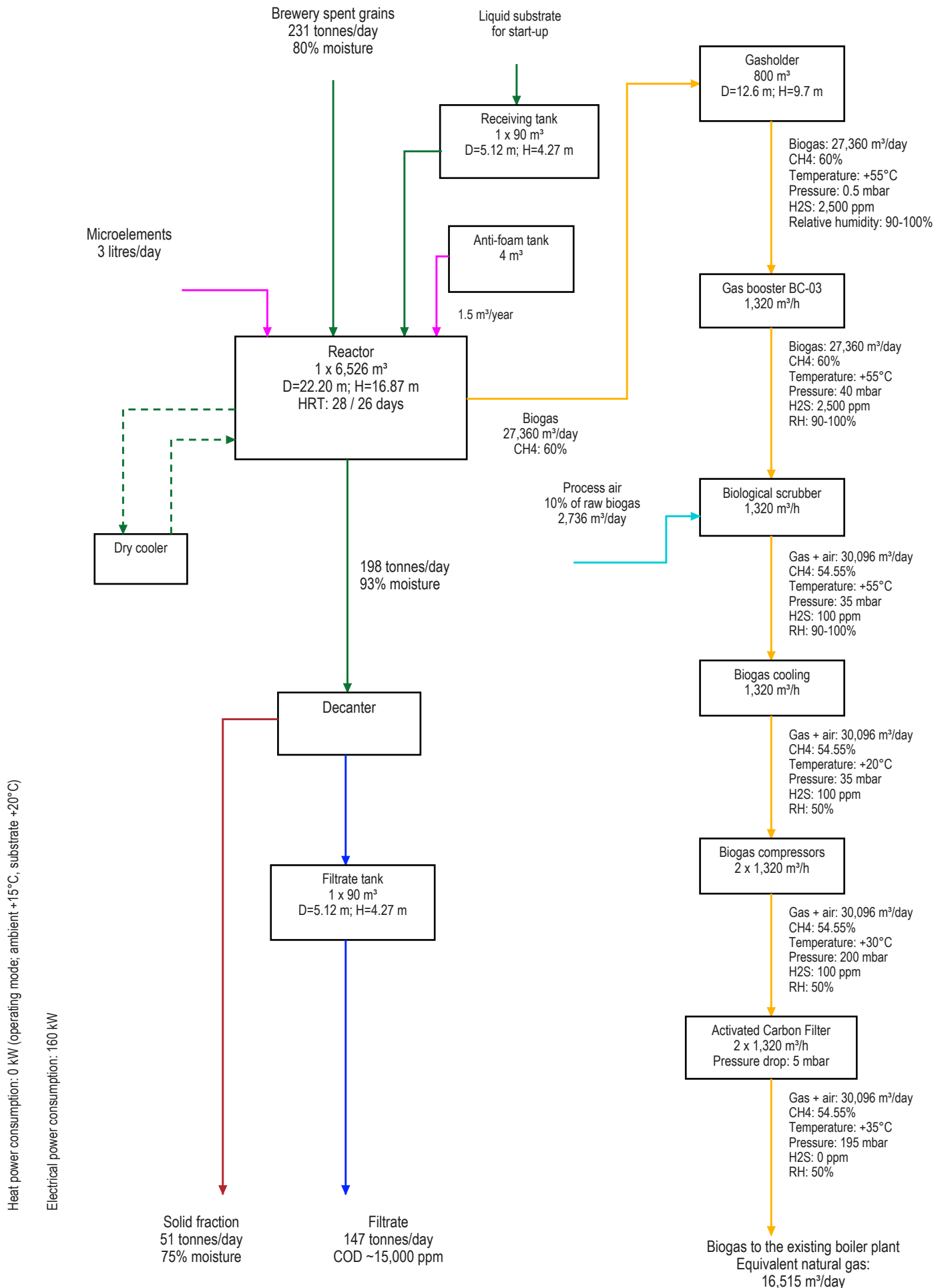
Nº	Equipment	Characteristic	Quantity
21.10	Conductometric sensor of water level		3
21.11	Dome position sensor		1
21.12	Coolant pressure sensor	SEN 3276 B065 G1/2 6Bar	2
22	Dry cooler 80 kW heat pow.		1
23	Laboratory	set	1
24	Steel enamel tank	90 m3	2
25	Steel enamel tank	6526 m3	1
26	Submersible mixer	7,5kW	1
27	Biological biogas scrubber SC-01	1,320 m³/h	1
28	Gas booster BC-03	1,320 m³/h; 40 mbar	1

APPENDICES



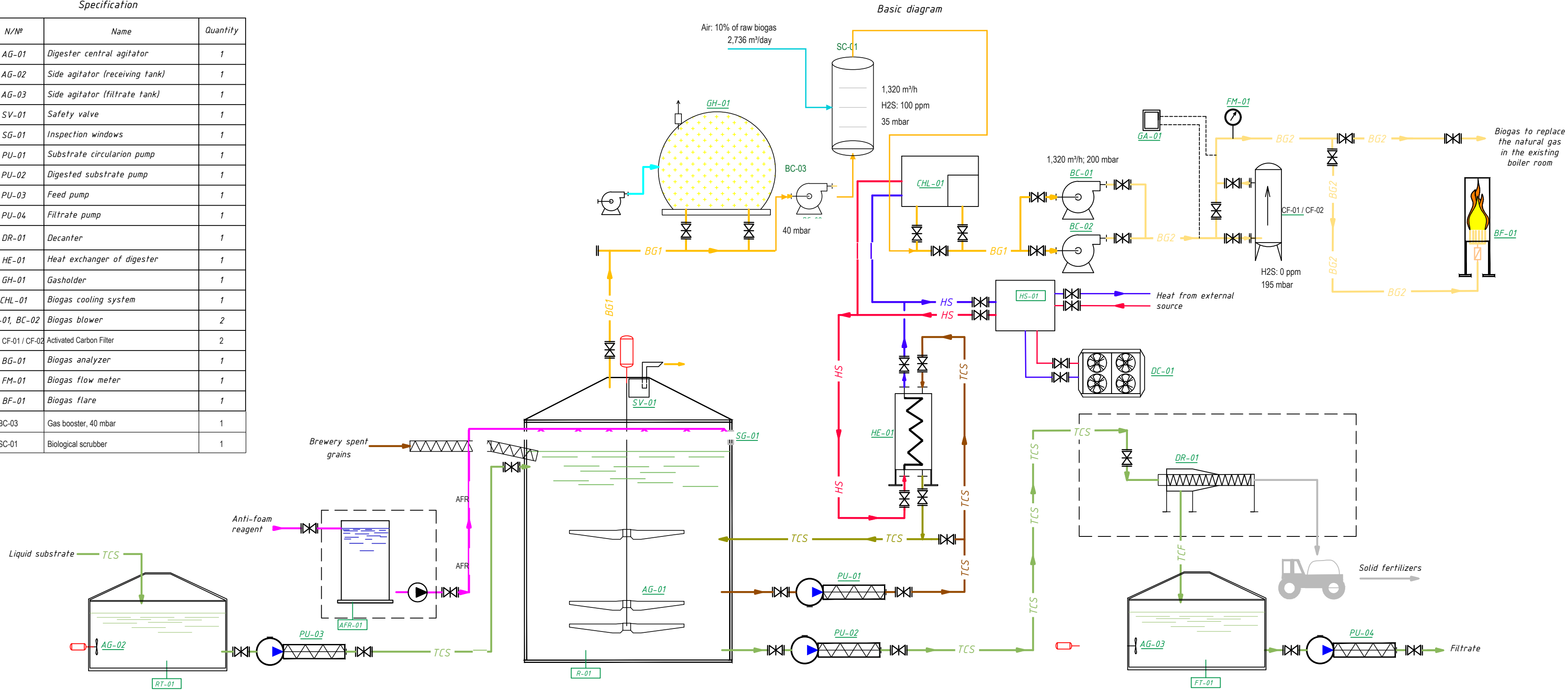
Material flow diagram

Appendix 1



Specification

N/Nº	Name	Quantity
AG-01	Digester central agitator	1
AG-02	Side agitator (receiving tank)	1
AG-03	Side agitator (filtrate tank)	1
SV-01	Safety valve	1
SG-01	Inspection windows	1
PU-01	Substrate circularion pump	1
PU-02	Digested substrate pump	1
PU-03	Feed pump	1
PU-04	Filtrate pump	1
DR-01	Decanter	1
HE-01	Heat exchanger of digester	1
GH-01	Gasholder	1
CHL-01	Biogas cooling system	1
BC-01, BC-02	Biogas blower	2
CF-01 / CF-02	Activated Carbon Filter	2
BG-01	Biogas analyzer	1
FM-01	Biogas flow meter	1
BF-01	Biogas flare	1
BC-03	Gas booster, 40 mbar	1
SC-01	Biological scrubber	1



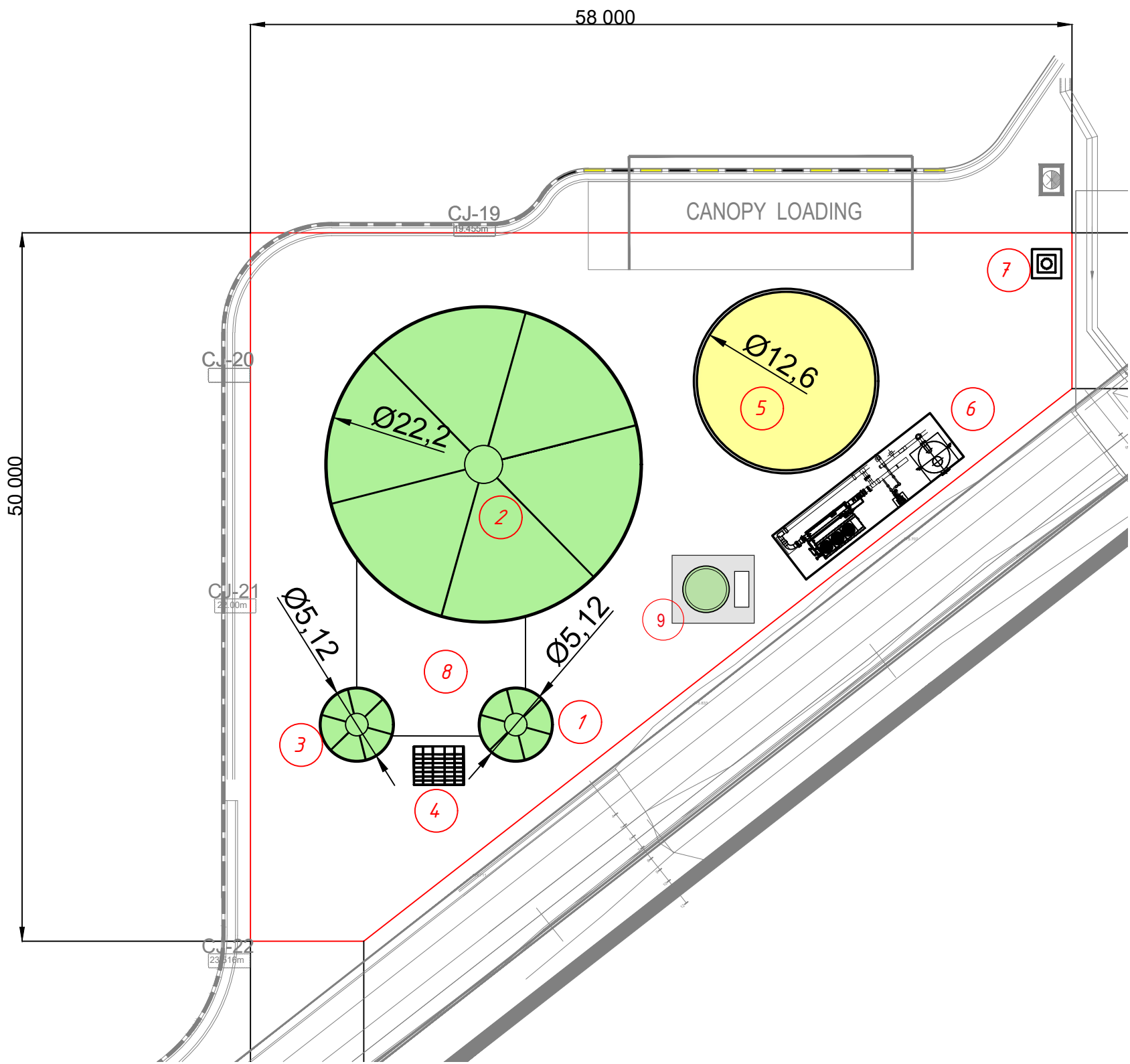
Structure

N/Nº	Name	Quantity
R-01	Reactor	1
FT-01	Filtrate tank	1
HS-01	Heat sub-station	1
AFR-01	Anti-foam reagent tank	1

Legend main pipelines

TCS	Substrate
TCF	Filtrate
BG1	Biogas
BG2	Biogas
HS	Heat system pipeline
HS	Heat system pipeline
AFR	Anti-foam reagent

Plan-scheme of biogas plant



Explication

N/Nº	Name	Note
1	Receiving tank	
2	Reactor	
3	Filtrate tank	
4	Decanter	
5	External gasholder	
6	Biogas cooling system	
7	Biogas equipment area	
8	Equipment room	
9	Biological biogas scrubber	

Biogas plant - electrical power consumption

Equipment	Unit power (kW)	Quantity	Installed power (kW)	Hours/day	Energy (kWh/day)
Feeding screw set	15	1	15.0	8	120.00
Reactor central vertical agitator	37	1	37.0	16	592.00
Receiving tank agitator	7.5	1	7.5	8	60.00
Filtrate tank agitator	3	1	3.0	8	24.00
Feed pump	4	1	4.0	1	4.00
Substrate pump to decanter	11	1	11.0	8	88.00
Substrate circulation pump	11	1	11.0	12	132.00
Filtrate pump	11	1	11.0	4	44.00
Decanter	55	1	55.0	8	440.00
Anti-foam pump	1.5	1	1.5	1	1.50
Biogas cooling system	50.6	1	50.6	24	1214.40
Gas booster BC-03, 40 mbar	5.5	1	5.5	24	132.00
Biogas compressors, duty + standby	22	2	44.0	12	528.00
Biological scrubber package	3.6	1	3.6	24	86.40
Dry cooler: digester	4	1	4.0	24	96.00
Dry cooler: spent grains	4	1	4.0	24	96.00
Heating circulation pump	3.5	1	3.5	24	84.00
Gasholder membrane support air blower	1	1	1.0	24	24.00
Digester heating circulation pump	0.8	1	0.8	24	19.20
Technical building heating pump	0.1	1	0.1	24	2.40
Digester cooling circulation pump	2	1	2.0	24	48.00
Propylene glycol pump	0.8	1	0.8	0.5	0.40
Drainage pumps	1	2	2.0	0.5	1.00
Outdoor lighting	1	1	1.0	8	8.00
Inspection window lighting	0.1	1	0.1	0.5	0.05
Switchboard lighting	0.1	1	0.1	0.5	0.05

Total installed power, kW

279.1

Daily electrical consumption, kWh/day

3,845.4

Average electrical power, kW

160.2

Operating basis: ambient temperature +15°C. Booster and scrubber auxiliary loads are design allowances. Standby compressor operation is shared between the two units.

Prices: biogas plant, 231 tonnes/day of brewery spent grains

Pos	Name	Number of units	Unit price, EUR	Price sub-total, EUR	
1	Project documentation	1	58.100	58.100	
2	Supervision	1	40.000	40.000	
3	Startup and training	1	40.000	40.000	
4	Living and travel expences	1	40.000	40.000	
5	Delivery of the equipment	13	8.000	104.000	
6	Laboratory	1	18.900	18.900	
7	Digester central vertical agitator 37kW	1	103.350	103.350	
8	Receiving tank agitator 3 kW	1	8.400	8.400	
9	Filtrate tank agitator 3,0kW	1	7.000	7.000	
10	Substrate feed pump 11kW	1	14.700	14.700	
11	Digested substrate pump 11kW	1	14.700	14.700	
12	Circulation substrate pump 11kW	1	14.700	14.700	
13	Filtrate supply pump 11kW	1	14.700	14.700	
14	Decanter	1	122.500	122.500	
15	Gasholder 800m3	1	45.500	45.500	
16	Biogas cooling system 1,320 m³/h	1	42.500	42.500	
17	Biogas compressor 1,320 m³/h, 200 mbar	2	11.200	22.400	
18	Activated carbon filter 1,320 m³/h, 300 kg	2	20.000	40.000	
19	Biogas flare 1,320 m³/h	1	41.300	41.300	
20	Gas analyzer	1	18.900	18.900	
21	Gas conditioning unit	1	25.200	25.200	
22	Over- and under pressure safeguard	1	5.600	5.600	
23	Water supply and canalization system	1	18.900	18.900	
24	Heat supply station	1	25.900	25.900	
25	External heat exchanger	2	10.500	21.000	
26	Dry-cooler	2	18.900	37.800	
27	Automation and electric cabinet	1	135.000	135.000	
28	Sensors (set)	3	25.000	75.000	
29	Receiving Enameled steel tank V=90 m³	1	56.800	56.800	
30	Filtrate Enameled steel tank V=90 m³	1	56.800	56.800	
31	Digester Enameled steel tank V=6526 m³	1	760.000	760.000	
32	Screw set	1	120.000	120.000	
33	Biological scrubber 1,320 m³/h including gas booster, 40 mbar	1	250.000	250.000	
34	Construction, erection and installation. Includes excavation, concrete foundations, gas pipes, substrate pipes, air pipes, cables, montage of all equipment with labor as well as montage machinery and instrumetns lease. The price is thumb up from our previous experience. Can be confirmed only after teh detailed project design.	1	500.000	500.000	by Client
ZORG, EUR				2.399.650	
TOTAL Zorg + Client, EUR				2.899.650	

Implementation terms and payment

Months	1	2	3	4	5	6	7	8	9	10	10	11	12
Project documentation	50%		50%										
Approvals and permits													
Equipment				30%		25%	25%	20%					
Delivery						25%	25%	25%	25%				
Construction													
Supervision				50%			50%						
Biogas plant start-up											50%	50%	

Contracts

Project implementation is executed simultaneously under several contracts

- Engineering contract
- Equipment supply contract
- Supervision contract
- Start-up and training contract

List of exclusions for biogas plant:

- 1) Project report, civil permits and authorizations, adaptation of the project documentation by a licensed local engineering organization for the permit purposes. Namely the organization puts their stamp, and acts act the face of the project. The design documentation is not changed in fact. 10 000 – 15 000 EUR
- 2) Topographic and geological surveys 3000-7000 EUR
- 3) Electric transformer for start-up, for construction period for normal operation.
- 4) External roads.
- 5) Temporary water supply during the construction and the hydraulic test of the reactor 6526 m3. It can be a technical quality water from a river, lake, well. Not salty.
- 6) Bacterial seed for the start-up. It can be biomass from another biogas plant. Possibly also, cow manure, any kind of manure, sludge from city sewage treatment plant. Customer needs to bring the seed one-time during a 1–2-week period and to fill with it at least 15-20% of the reactor volume 980-1200 m3. The rest is filled with the water item above.
- 7) Machinery to transport filtrate and the digested mass from the biogas plant to the agricultural fields (a truck, a frontal loader, a tractor)
- 8) Impregnated activated carbon 0,3 tonne per year x 1800 EUR/tonne
- 9) Microelements 1,095 l/year x 25 EUR/l (3 litres/day)
- 10) Anti-foam reagent 1 tonne annually (all kinds of vegetable oil, for example, palm oil or rapeseed oil)
- 11) Demineralized water to the heating system 1,0 tonnes,
- 12) Spare parts for 2 years 110 000 EUR



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