ZORG BIOGAS

01

version

# Proposal

Biogas plant
9.2 MW el.brutto/8,7MW netto
using Napier grass

Date: 01/07/2025

Validity: 12 months

# CONTENT

# OVERVIEW

We offer a solution to process Napier grass into biogas and power in the high-load reactors (HLR). The proposed HLR technology is superior to the conventional CSTR. HLR is 3 times smaller and cheaper than CSTR. For 9.2 MW brutto / 8,7MW netto electrical power just 4 HLRreactors x 3925m3 are enough. The plant will produce 73 million kWh electric energy netto for sale annually. 8400 motor-hours annually.

Zorg makes the detailed engineering, supplies equipment and provides supervision during construction as well as training and start-up.

The construction and installation are done by Client under Zorg' supervision.

## 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** ($m^3$ / | Biogas ($m^3$ /day) | **Methane content** (%) | Biogas ($m^3$ /year) |
|---|---|---|---|---|---|---|---|---|---|---|
| Napier grass | 447 | 163 137 | 33 | 96 | 147,49 | 141,59 | 690 | 97 700 | 52 | 35 660 500 |

***-DM-** Dry matter

****-oDM-** organic dry matter

# Biogas plant characteristics

| Characteristics | Values | Figures |
|---|---|---|
| Number of reactors | units | 4 |
| a) volume: | | |
| Work | $m^3$ | 3680 |
| Overall | $m^3$ | 3925 |
| b) Organic load | kgODM/ $m^3$ | 9.02 |
| c) Hydraulic retention time (gross) | days | 35/33 |
| d) Overall dimensions of the reactor (diameter / height) | m | 26.0/8.0 |
| e) Temperature | $^0C$ | +52 |
| Gasholder (external) | | |
| a) Volume | $m^3$ | 870 |
| b) Number of gasholders | units | 1 |
| c) Dimensions of the gasholder (diameter / height) | m | 13.0/9.8 |

## Number of personnel

| | Shift 1 | Shift 2 | Shift 3 |
|---|---|---|---|
| Director | 1 | - | - |
| Operator | 1 | 1 | 1 |
| Driver | 1 | - | - |
| Electrician | 1 | - | - |
| Mechanic | 2 | - | - |
| Total | 7 | | |

# 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 + H2O→ C5H7NO2+HCO3.
Further conversion of obtained dissolved compounds like organic acids and alcohols (C5H7NO2,HCO3) into gases - CH4, CO2.
C5H7NO2 + HCO3 + H2O → CH4+CO2+NH4.
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 CH4, water H20 and carbon dioxide CO2. 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

Napier grass is transported to a biogas plant area and discharged into loaders. The loaders input substrates by portion to reactors using augers. In the reactors the substrate is brought up to a temperature of +52°C. Constant temperature is sustained for the entire digesting period. To prevent a rise in temperature (for example, in summer), the biogas station is equipped with a coolers (dry cooling). The reactors operating regime is thermophilic. The heated substrate in the reactors is blended periodically. Mixing is performed by vertical agitators. The average time of processing in the reactors is 35 days. After the reactors, the substrate is fed by pump to a separator area where it is separated into solid and liquid bio-fertilizer. Solid bio-fertilizer is discharged to the separation area and transported for storage; liquid filtrate is directed to a liquid residue storage tank. Biogas goes up under overlap and delivered into an external gas holder through pipeline.

The gas holder's weather protective film protects the gasholder from precipitation and damage by foreign objects. The weather protective film is fixed firmly by a special system. To protect the gasholder from overpressure, digesters are equipped with safety valves, which start working at a pressure of 5 mbars and bleeds biogas to the atmosphere.

Then accumulated in gasholders biogs goes through a gas pipeline to a biogas cooler with a condensate discharge unit and then to a compressor, where the pressure is raised up to 80-150 mbar to meet engine requirements. After the compressor, biogas is fed to activated coal filters to remove hydrogen sulfide (H2S). After filters (the final purification) the biogas goes to the co-generators to produce electric and heat energy.

All technological processes are controlled and operated by an automatic system. Biogas plant work is monitored at the central control room monitor. The control room is equipped with a central control unit, which allows the switching of any biogas plant module into automatic or manual mode with local or remote control.

# MAIN EQUIPMENT

# Solid feeder (SF-01, SF-02, SF-03 , SF-04)

Solid feeder machines have been proven in various situations. Solid feeder has the solid design, which guarantees a maximum functionality and less maintenance, combined to a low energy consumption. Because of the vertically oriented walls, there is no change for the material to get stuck or build bridges. The conveyor chains and the milling-unit allow continuous dosing by various types of materials. Furthermore, the material is loosened by this dosing process. The user is able to control the material flow up to 20m³/h or more, regarding to the own consumption of electrical power by the machine. In addition, the corrosion protection, wear resistance and high quality allow customers to use our product for a long period of time.

## Specifications

| | |
|---|---|
| **Length:** | 6.7 m |
| **Width:** | 3.6 m |
| **Height** | 3.4 m |
| **Volume:** | 30 m³ |
| **Quantity:** | 4 pcs. |

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

Reinforced concrete reservoir for reception of liquid kinds of raw materials. The reservoirs are equipped with level sensors and submersible agitators for mixing substrate.

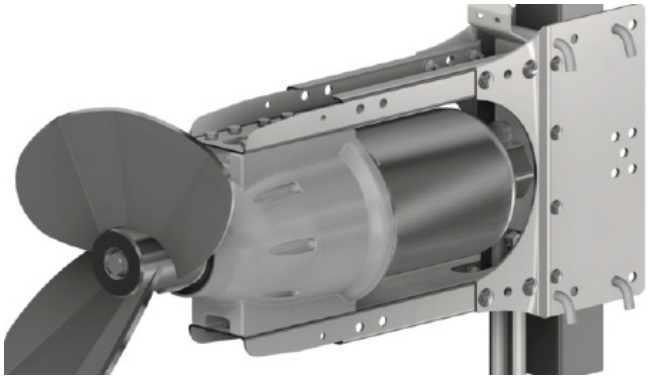
## Specifications

### Receiving tank (RT-01)

| | |
|---|---|
| **Diameter:** | 10.0 m |
| **Height** | 2.5 m |
| **Total volume:** | 196 m³ |
| **Quantity:** | 1 pcs |

### Filtrate tank (FT-01)

| | |
|---|---|
| **Diameter:** | 10.0 m |
| **Height** | 2.5 m |
| **Total volume:** | 196 m³ |
| **Quantity:** | 1 pcs |



# Submersible agitator (AG-21, AG-22)

The submersible motor agitator serves for mixing renewable raw materials (RRM), liquid substrate as manure and similar substrates. The electro-motor driven submersible agitator is designed for submersion operations in potentially explosive environments of Ex zone 2 and complies with Directive 94/9 EC. The submersible agitator can be attached to most sliding masts by means of the motor support. A mounting option for a hauling cable is provided on the motor support for height adjustment purposes.

Due to the 4-roller guidance of the motor support, the agitator can be lifted and lowered without friction and the square mast, even if the pull of the hauling cable is slightly angular. The motor support is designed for a 100 x 100 mm square sliding mast as standard, but can also be used for an 80 x 80 mm sliding mast by changing the rollers. The strain relief of the connecting cable can be positioned in the extension of the motor or towards the top on the motor support, depending on the requirements. This enables universal utilization with the most various installation kits.

The geared motor is made of spheroidal graphite iron(GGG40) and painted, the propeller is galvanized and the motor support is made of stainless steel. The submersible motor agitator is designed as a water pressure-tight monoblock unit for driving the three-vane propeller. The submersible agitator is of modular design, submersible electro-motor with flange-mounted planetary gear and bearing flange for holding the propeller. The conical shaft in the bearing flange is mounted in the oil bath by two angular roller bearings and sealed off from the agitating substrate with a mechanical seal.

## Specifications

**Submersible agitator of the receiving tank (AG-15)**

| | |
|---|---|
| **Nominal power** | N=3.0 kW |
| **Quantity:** | 1 pcs |

**Submersible agitator of the filtrate tank (AG-16)**

| | |
|---|---|
| **Nominal power** | N=3.0 kW |
| **Quantity:** | 1 pcs |

# Reactor (R-01, R-02, R-03, R-04)

Reactor is a tank of cylindrical form (for better mixing during the fermentation). It is built of cast-in-situ reinforced concrete based on sulphate-resistant cement with thickness of walls and bottom - 0,25m. In the center of the reactor there is a column with chapiter. Overlap of digester is reinforce concrete plate. On the tank's wall and in the bottom there is to be installed pipelines for heating, intended for assurance and maintenance of the optimal fermentation process temperature at thermophilic conditions. For heat conservation and reduction of heat energy consumption, the reactor walls, overlap and bottom are insulated outside with 100 mm slabs of extruded polystyrene foam. Over the heater, the substructure walls and bottom are insulated with roll damp proofing. Superstructure and substructure heat insulation is protected by shaped sheet from the outside mechanical damages and rodents. The reactor bottom has a slope 1%.

## Specifications

| | |
|---|---|
| **Height :** | 8,0 m |
| **Diameter :** | 25,0 m |
| **The total volume :** | 3925 $m^3$ |
| **The substrate volume :** | 3680 $m^3$ |
| **Quantity:** | 4 pcs |

# Reactor vertical agitator (AG-01 ... AG-20)

Mixers are designed and engineered to guarantee high energy efficiency. We use gear units and motors from respected European manufacturers. This guarantees the long life of our mixers. All motors and gear units are available with ATEX certifications.
Agitators are designed for mixing substrates with a high solids content of 13-18%. The blades of the mixers are set at an optimum angle, and the external motor of the mixer is mounted on a special support.

## Specifications

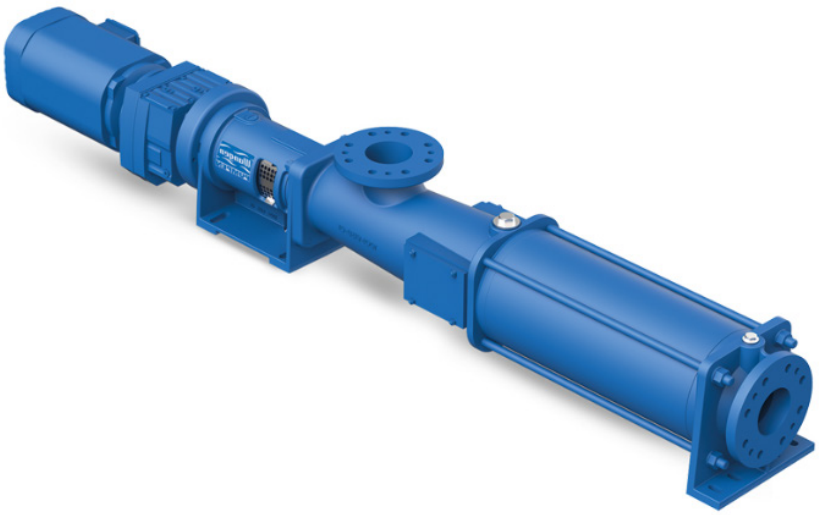
| | |
|---|---|
| **Engine power:** | N=15 kW |
| **Quantity per digester:** | 5 pcs |
| **Quantity total:** | 20 pcs |

# Window with spotlight (SG-01, SG-02, SG-03, SG-04)

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**
**Spotlight VISULUX UL50 -G -H**
**230V, 50W, IP65**



# Pump equipment (PU-01, PU-02, PU-03, PU-04, PU-05, PU-06 )

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 pump to separator (PU-01, PU-02, PU-03, PU-04)** | |
| **Flow rate:** | 10-25 m3/hour |
| **Engine power:** | 11.0 kW |
| **Pressure:** | 4 bar |
| **Quantity:** | 4 pcs |
| **Liquid substrate pump (PU-05)** | |
| **Flow rate:** | 45 m3/hour |
| **Engine power:** | 11.0 kW |
| **Pressure:** | 4 bar |
| **Quantity:** | 1 pcs |
| **Filtrate pump (PU-06)** | |
| **Flow rate:** | 50 m3/hour |
| **Engine power:** | 11.0 kW |
| **Pressure:** | 4 bar |
| **Quantity:** | 1 pcs |


# Separator (SR-01, SR-02, SR-03, SR-04)

The Press Screw Separator covers a broad spectrum of applications, from agriculture to biogas and bioethanol plants. The innovative technology separates substrates in its solid and liquid elements. The secret of the versatility of the press screw separator is that it can adjust to different dry matter contents and Thick liquids (20% dry matter content). Slotted screens have different assortment and width of table cells and give possibility work with small solids and fiber contents. In the slotted screen, the solids are screened out from the liquid. The solids build up a layer which also acts as a filter to separate finer particles from the liquid. The auger flights convey this layer to the solids outlet. The screen surface is cleaned and a new filter layer is formed. The design of the screens is not conducive to plugging. The pressure in the first part of the screen is low but increases with the solid consistency to the solid output. The consistence of the gained solid can be varied with the help of a output regulator by the amount and position of counter weights. This way the required consistency of the final product for either further storage, use as fertilizer or the basis for compost can be reached. The liquid phase can easily be drained through a pipe or hose system.

## Specifications

| | |
|---|---|
| **Engine power** | **5.5 kW** |
| **Flow rate** | **5-12 m3 / h** |
| **Quantity** | **4 pcs** |
| **Equipment** | |
| **Frame** | |
| **Screw** | |
| **Sieve for the filtration** | |
| **Counterweights** | |
| **The design of the protective room** | |

# 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 cm3/m2 * 1 bar biogas resistance. The gasholder film temperature range allows operation from -30°C to +60°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 :** | 9.8 m |
| **Diameter :** | 13.0 m |
| **The total/working volume :** | 870 $m^3$ |
| **Quantity:** | 1 pcs |

# Biogas dryer and cooling (CHL-01, CHL-02)

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 volume flow** | 2100 $m^3$/ h |
| **Gas inlet temperature** | +50 C |
| **Gas outlet temperature** | +20 C |
| **Cooling power** | 200 kW |
| **Engine power** | 48.5 kW |


# Biogas compressor (BC-01, BC-02)

Biogas blower is a device used to move gas and increase pressure thanks to a rotating impeller within a toroidal channel, so there is a progressive increase of energy.
Blower is used to transporting biogas from gasholder storage to consumer (biogas upgrading plant in our case).

## Specifications

| | |
|---|---|
| **Flow rate:** | 4100 $m^3/h$ |
| **Pressure:** | 150 mbar |
| **Engine power:** | 35 kW |
| **Quantity:** | 2 pcs |

# Desulphurization system

The desulphurization system is a 3-step system. Stage 1 is adding Ferrum Hydrooxide. Stage 2 - biological. Adding a certain portion of air to the fermenter. Air by special bacteria, converting H2S into S. After 1 and 2 steps the sulphur contcentration is 80 ppm. Stage 3 - activated charcoal filtration, as activated charcoal has the capability to absorb sulfur. After passing through activated charcoal filters, the sulfur concentration is re-duced to 0 ppm.

## Specifications

| | |
|---|---|
| **Air compressor** | 5 m3/h |
| **The volume of charcoal (CF-01, CF02)** | 500 kg |
| **Numbers of charcoal columns** | 2 pcs |

# Cogeneration Power Plant (CHP-01)

A cogeneration power plant (CHP) is used for producing electricity and heat. CHP is a very efficient technology for generating electricity and heat together. A CHP plant is an installation where there is simultaneous generation of usable electric power and heat in a single process, and it can provide a secure and highly efficient method of generating electricity and heat at the point of use. Due to the utilization of heat from electricity generation and the avoidance of transmission losses, due to electricity being generated on site, CHP typically achieves a 35 per cent reduction in primary energy usage compared with power stations and heat only boilers. This allows for economic savings where there is a suitable balance between heat and power loads. Another important factor, showing the benefits of cogeneration and CHP, is its low environmental impact. CHP produces lower quantities of pollutant emissions and heat pollution of the atmosphere. The current mix of CHP installations achieves a reduction of over 10 per cent in CO2 emissions in comparison with combined-cycle gas turbines.

## Specifications

| | |
|---|---|
| Produced electric power | 2300 kW |
| Produced heat power | 2254 kW |
| Emissions | NOx < 500 mg/Nm³ (5% O2) |
| Generator | 400V, 50Hz |
| | |
| Quantity: | 4 pcs |

# Flare

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** | 4100 m³/h |
| **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 using 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

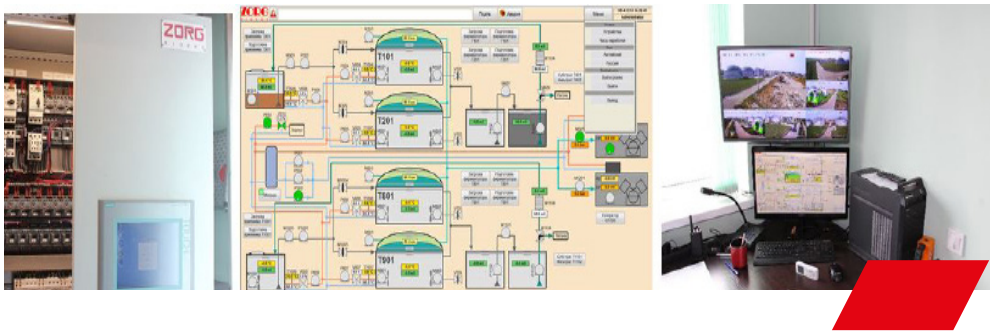
| | |
|---|---|
| Circulating pump feeding heat carrier heating | |
| Flow | 30 m3 / h; |
| Pressure | 1 bar |
| | |
| Circulating pump feeding heat carrier to the digester | |
| Flow | 18 m3 / h; |
| Pressure | 1.1 bar |
| | |
| The pumping station feeding propylene glycol | |
| Flow | 0.8 m3 / h; |
| Pressure | 4 bar |

# 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

| | |
|---|---|
| **Power  (cooling)** | 100 kW |
| **Length:** | 3,0 m |
| **Width:** | 2,5 m |
| **Height:** | 1,5 m |
| **Power electrical** | 4  kW |
| **Quantity:** | 4 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 ET2005, 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

**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.

## Equipment

**Analytical scales**
**Moisture analyzer**
**Automatic titrator**
**Laboratory pH meter**
**Centrifuge**
**A set of flasks**

# EQUIPMENT SPECIFICATION LIST

| № | Equipment | Characteristic | Quantity |
|---|---|---|---|
| **1** | **Solid feeder** | **V=30 m3** | **4** |
| 1.1 | Container bunker | | 4 |
| 1.2 | Feeding screws | set. | 4 |
| **2** | **Submersible mixer** | **N=3.0kW** | **1** |
| 2.1 | Airtight motor gearbox | | 1 |
| 2.2 | Hydraulic screw (wear-resistant steel) | | 1 |
| 2.3 | Mixer control mechanism | | 1 |
| 2.4 | Electric motor mount | | 1 |
| 2.5 | Set of fasteners | | 1 |
| **3** | **Reactor vertical agitator** | **N=15 kW** | **20** |
| 3.1 | Airtight motor gearbox | | 20 |
| 3.2 | Hydraulic screw (wear-resistant steel) | | 20 |
| 3.3 | Shaft (adapted to the height of the fermenter) | | 20 |
| 3.4 | Blade | | 20 |
| 3.5 | Frequency converter | | 20 |
| 3.6 | Mounting bracket to bottom of the mixer | | 20 |
| **4** | **Safety valve of reactors** | | **4** |
| **5** | **Window with a searchlight** | **set** | **4** |
| 5.1 | Inspection window RD300 (mounts and sealant included) | Ø300 | 8 |
| 5.2 | Spotlight (mount system bundled) VISULUX UL50 -G -H | 230V, 50W, IP65 | 4 |
| **6** | **Substrate digested pump** | **10-25 m3/hour N=11.0 kW** | **4** |

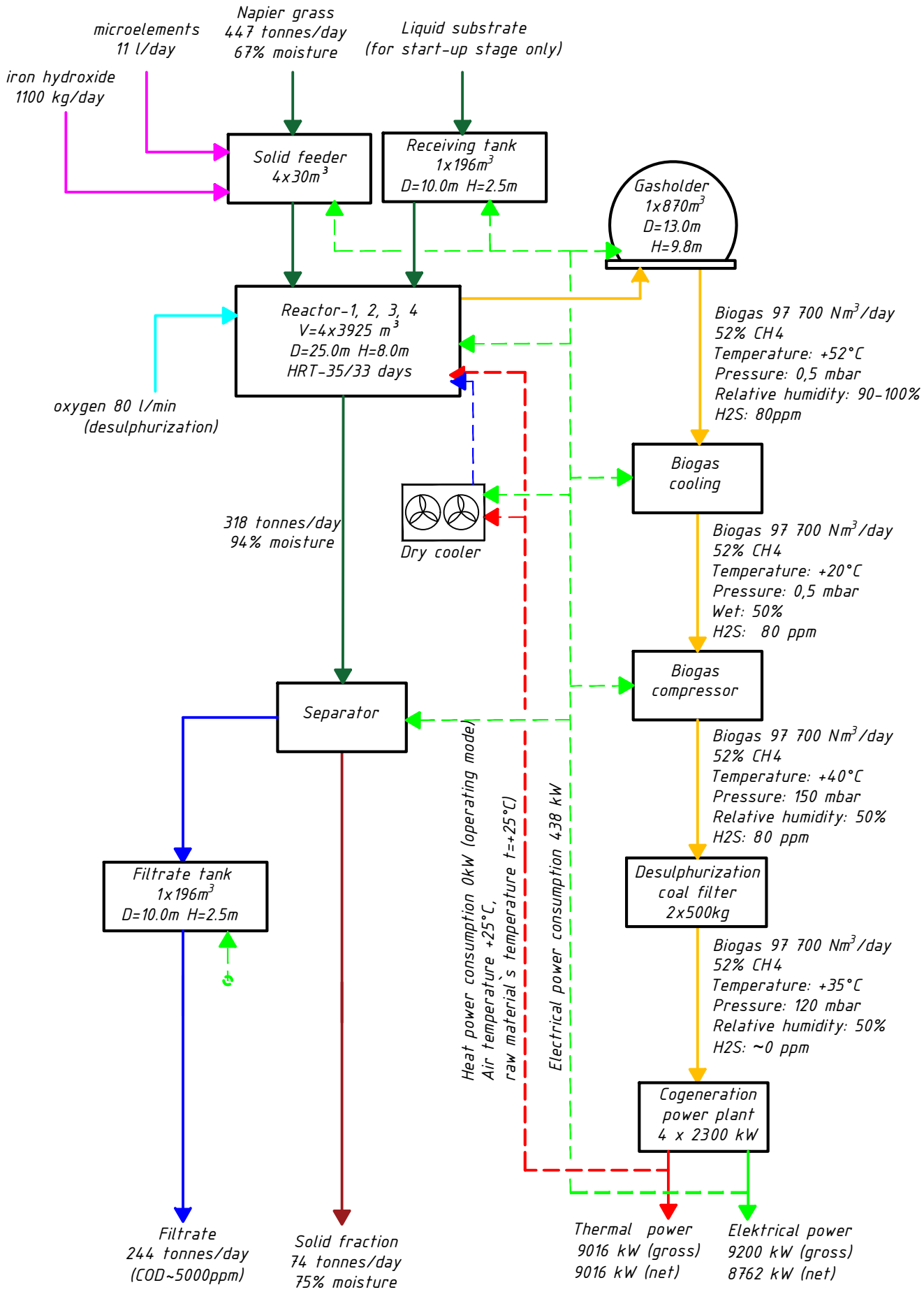
| № | Equipment | Characteristic | Quantity |
|---|---|---|---|
| **7** | **Separator** | **N=5.5 kW, Q=8-12m3/h** | **4** |
| 7.1 | Body | | 4 |
| 7.2 | Substrate Supply Pipe 4 ’’ | | 4 |
| 7.3 | Engine - Gearbox | N=5,5 kW | 4 |
| 7.4 | Frame | | 4 |
| 7.5 | Screw | | 4 |
| 7.6 | Sieve for filtration | | 4 |
| **8** | **Filtrate pump** | **50 m3/hour N=11.0kW** | **1** |
| **9** | **Submersible mixer** | **N=3.0kW** | **1** |
| **10** | **PVC external gas holder** | **Ø13.0m** | **1** |
| 10.1 | Weather protection film | Ø13.0m | 1 |
| 10.2 | Gasholder film PELD methane permeation max.260 cm3/m2*d*1 bar, 650 N/5cm bio-gas resistant | | 1 |
| 10.3 | Air blower | 16A, 0,5kW | 1 |
| 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 System** | **2100 m3/h** | **2** |
| 11.1 | Chiller | | 2 |
| 11.2 | Heat exchanger | | 2 |
| 11.3 | Polypropylene glycol tank | | 2 |
| **12** | **Desulphurization system** | | **1** |
| 12.1 | Numbers of charcoal columns | **500 kg** | 2 |

| № | Equipment | Characteristic | Quantity |
|---|---|---|---|
| **13** | **Biogas compressor** | **Q=4100m³/h<br>H=150mBar<br>N=35kW** | **2** |
| **14** | **Biogas analyzer (CH4 , CO2 , H2S, O2 )** | | **1** |
| **15** | **Electromagnetic flow meter** | | **1** |
| **16** | **Flare** | **4100 m3/h** | **1** |
| **17** | **Gas equipment included** | **set** | **1** |
| 17.1 | Drainage pump with float | DN=50<br>Q=1m³/h<br>H=13 m | 2 |
| **18** | **The heat supply system** | **set** | **1** |
| 18.1 | Diaphragm expansion tank | V=1000 l<br>P=6Bar T=120°C | 1 |
| 18.2 | Circulating pump for supplying heat carrier | Q=30 m³/h<br>H=1bar | 1 |
| 18.3 | Propylene glycol feed pump station<br>heating systems | Q=1,0 m³/h,<br>H=4 bar | 1 |
| 18.4 | Circulation pump for supplying heat carrier<br>to the digester | Q=18 m3/h,<br>H=1.1 bar | 1 |
| **19** | **Water supply and sewerage system, complete, disassembled** | **set** | **1** |
| **20** | **Automation with electrical equipment complete, disassembled** | **set** | **1** |
| 20.1 | Incoming distribution cabinet<br>with a set of automation DB-1 | | 1 |
| 20.2 | Incoming distribution cabinet<br>with a set of automation DB-2 | | 1 |
| **21** | **Sensors, set** | | **1** |
| 21.1 | Gas pressure sensor 0,025Bar | | 4 |
| 21.2 | Gas pressure sensor 0,4Bar | | 4 |
| 21.3 | Pressure sensor(substrate level) 1,0Bar | | 6 |
| 21.4 | Pressure sensor (substrate pressure) 2,5bar | | 6 |

| № | Equipment | Characteristic | Quantity |
|---|---|---|---|
| 21.5 | Resistive thermometer (gas temperature) | | 6 |
| 21.6 | Resistive thermometer with thermo well (fermenter substrate temperature) | | 6 |
| 21.7 | Resistive thermometer with thermo-well (digester tank substrate temperature) | | 6 |
| 21.7 | Resistive thermometer (heat conductor temperature) | | 6 |
| 21.9 | Conductometric sensor of maximum level | | 6 |
| 21.10 | Conductometric sensor of water level | | 6 |
| 21.11 | Dome position sensor | | 1 |
| 21.12 | Coolant pressure sensor | SEN 3276 B065 G1/2 6Bar | 4 |
| 21.13 | Humidity and gas temperature sensor | ESFTF-I | 2 |
| **22** | **Dry cooler 100kW heat pow.** | | **4** |
| **23** | **Laboratory** | | **1** |
| **24** | **Cogeneration power plant** | **2300 kW** | **4** |

# ANNEXES

# Material flow diagram

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Annex 2

## Explication

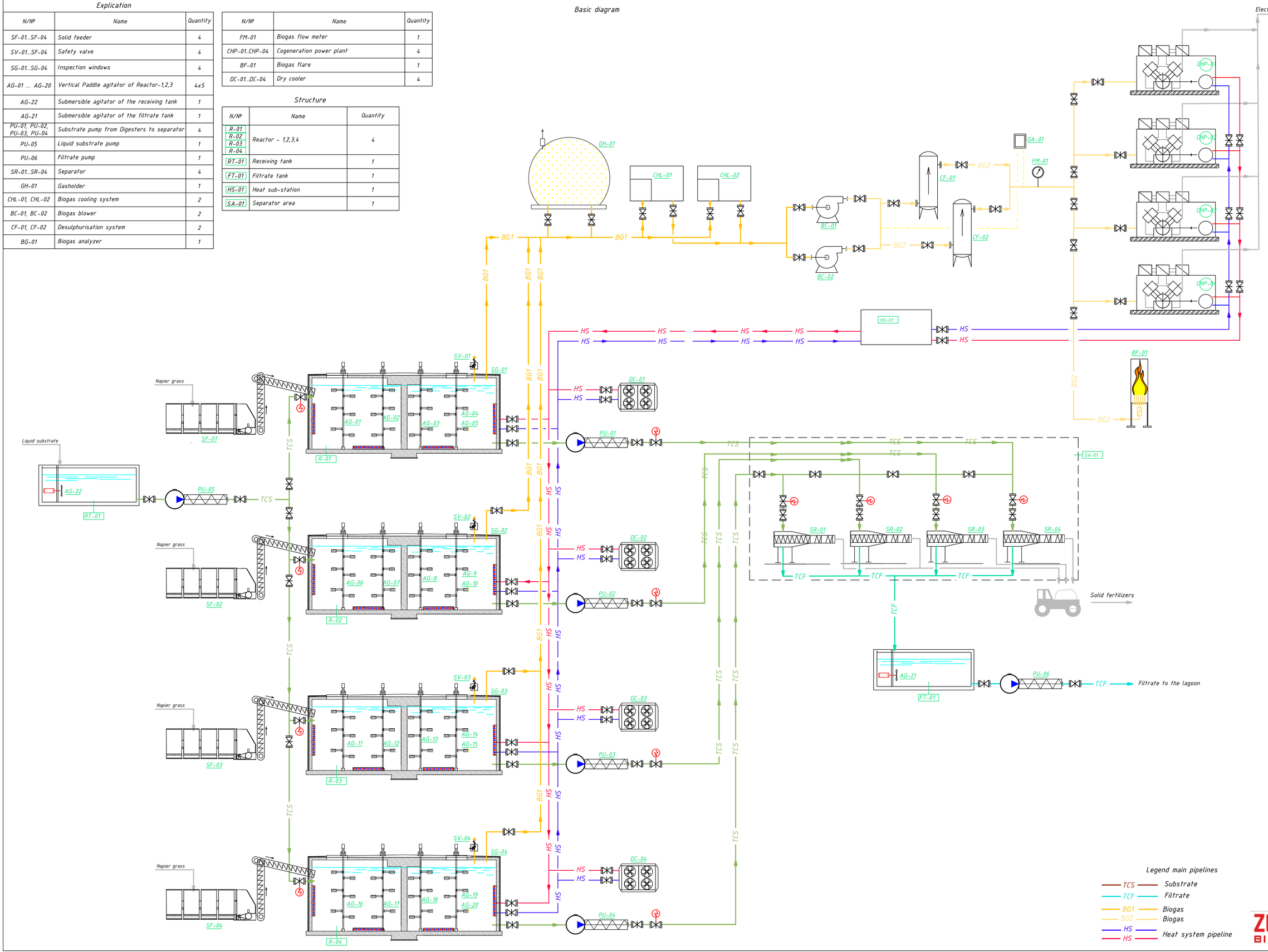
| N/№ | Name | Quantity |
|---|---|---|
| SF-01...SF-04 | Solid feeder | 4 |
| SV-01...SF-04 | Safety valve | 4 |
| SG-01...SG-04 | Inspection windows | 4 |
| AG-01 .... AG-20 | Vertical Paddle agitator of Reactor-1,2,3 | 4x5 |
| AG-22 | Submersible agitator of the receiving tank | 1 |
| AG-21 | Submersible agitator of the filtrate tank | 1 |
| PU-01, PU-02, PU-03, PU-04 | Substrate pump from Digesters to separator | 4 |
| PU-05 | Liquid substrate pump | 1 |
| PU-06 | Filtrate pump | 1 |
| SR-01...SR-04 | Separator | 4 |
| GH-01 | Gasholder | 1 |
| CHL-01, CHL-02 | Biogas cooling system | 2 |
| BC-01, BC-02 | Biogas blower | 2 |
| CF-01, CF-02 | Desulphurisation system | 2 |
| BG-01 | Biogas analyzer | 1 |

| N/№ | Name | Quantity |
|---|---|---|
| FM-01 | Biogas flow meter | 1 |
| CHP-01..CHP-04 | Cogeneration power plant | 4 |
| BF-01 | Biogas flare | 1 |
| DC-01...DC-04 | Dry cooler | 4 |

## Structure

| N/№ | Name | Quantity |
|---|---|---|
| R-01<br>R-02<br>R-03<br>R-04 | Reactor - 1,2,3,4 | 4 |
| RT-01 | Receiving tank | 1 |
| FT-01 | Filtrate tank | 1 |
| HS-01 | Heat sub-station | 1 |
| SA-01 | Separator area | 1 |

## Basic diagram

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# Plan layout

N
W E
S

199
30
130
48
17
ϕ25
ϕ10
ϕ13

## Explication

| N/№ | Name | Note |
|---|---|---|
| 1.1,1.2, 1.3,1.4 | Solid loader -1, 2, 3, 4 | |
| 2.1,2.2, 2.3,2.4 | Reactor -1, 2, 3, 4 | |
| 3 | Receiving tank | |
| 4 | Filtrate tank | |
| 5 | Separator area | |
| 6 | Gas preparation | |
| 7 | Gasholder | |
| 8.1,8.2, 8.3,8.4 | Cogeneration power plant | |
| 9 | Biogas flare | |
| 10.1,10.2, 10.3 | Technological room | |
| 11 | Equipment room | |
| 12 | Operators room | |
| 13 | Warehouse | |
| 14 | Weigh bridge | |
| 15 | Storage of raw materials | |
| 16 | Fire pump station | |
| 17 | Fire tank | |
| 18 | Stormwater treatment | |
| 19 | Lagoon | |

**Annex 4**

| Name equipment | Instal. Pow. (kW) | Quantity (pcs) | Total installed power (kW) | Working hours per day | Consumption kWh per day |
|---|---|---|---|---|---|
| Loader V=30 $m^3$ | 12,0 | 4 | 48,0 | 6,0 | 288,0 |
| Screw set. | 23,0 | 4 | 92,0 | 6,0 | 552,0 |
| Reactor Vertical agitator | 15,0 | 20 | 300,0 | 18,0 | 5400,0 |
| Submersible agitator in receiving tank | 3,0 | 1 | 3,0 | 12,0 | 36,0 |
| Submersible agitator in filtrate tank | 3,0 | 1 | 3,0 | 12,0 | 36,0 |
| Biogas cooling system | 48,5 | 2 | 97,0 | 24,0 | 2328,0 |
| Biogas compressor | 35,0 | 2 | 70,0 | 12,0 | 840,0 |
| Separator | 5,5 | 4 | 8,0 | 8,0 | 64,0 |
| Substrate pump to separator | 11,0 | 4 | 8,0 | 8,0 | 64,0 |
| Liquid substrate pump | 11,0 | 1 | 4,0 | 4,0 | 16,0 |
| Filtrate pump | 11,0 | 1 | 4,0 | 4,8 | 19,2 |
| CHP | 10,5 | 4 | 4,0 | 24,0 | 96,0 |
| Circulation pump for CHP | 5,5 | 4 | 4,0 | 24,0 | 96,0 |
| Air compressor for gasholder lock | 1,5 | 1 | 1,5 | 1,0 | 1,5 |
| Air blower for double membrane | 1,0 | 1 | 1,0 | 24,0 | 24,0 |
| Digester cooling system | 4,0 | 4 | 16,0 | 24,0 | 384,0 |
| Circulation pump for supplying heat carrier to the digester | 0,8 | 4 | 3,0 | 24,0 | 72,0 |
| Circulation pump for supplying heat carrier to the digester cooling system | 2,0 | 4 | 8,0 | 24,0 | 192,0 |
| Circulating pump feeding hot water at technical building | 0,1 | 1 | 0,1 | 24,0 | 1,9 |
| Propylene glycol pump station | 0,8 | 1 | 0,8 | 0,5 | 0,4 |
| Drinage pump | 1,0 | 2 | 2,0 | 0,5 | 1,0 |
| Lighting of the biogas plant territory | 1,0 | 1 | 1,0 | 8,0 | 8,0 |
| Spot light for digesters inspection windows | 0,1 | 1 | 0,1 | 0,5 | 0,0 |
| Working lighting of switchboard | 0,1 | 1 | 0,1 | 0,5 | 0,1 |
| Total installed power, kW | | | **679** | | |
| Total consumed electric energy, kWh per day | | | | | **10520** |
| Total consumed power, kW | | | | | **438** |

ZORG BIOGAS

## Prices for quipment and services for a biogas plant 9,2 MW electric power brutto / 8,7MW netto

| Pos | Name | Number of units | Unit price, EUR | Discounts* | Discounted unit price, EUR | Discounted price sub-total, EUR | |
|---|---|---|---|---|---|---|---|
| 1 | Project documention | 1 | 145 000 | 0% | 145 000 | 145 000 | |
| 2 | Supervision | 1 | 75 000 | 0% | 75 000 | 75 000 | |
| 3 | Startup and training | 1 | 75 000 | 0% | 75 000 | 75 000 | |
| 4 | Living and travel expences | 1 | 75 000 | 0% | 75 000 | 75 000 | |
| 5 | Delivery of the equipment (container) | 22 | 8 000 | 0% | 8 000 | 176 000 | |
| 6 | Laboratory | 1 | 28 000 | 0% | 28 000 | 28 000 | |
| 7 | Solid feeder (dosing buffer machine) | 4 | 145 000 | 0% | 145 000 | 580 000 | |
| 8 | Screw conveyor | 4 | 204 000 | 0% | 204 000 | 816 000 | |
| 9 | Digester vertical agitator | 20 | 87 000 | 0% | 87 000 | 1 740 000 | |
| 10 | Frame for Digester vertical agitator pos 3 | 20 | 6 000 | 0% | 6 000 | 120 000 | |
| 11 | Substrate pump | 4 | 29 000 | 0% | 29 000 | 116 000 | |
| 12 | Digested substrate pump | 1 | 29 000 | 0% | 29 000 | 29 000 | |
| 13 | Filtrate supply pump | 1 | 29 000 | 0% | 29 000 | 29 000 | |
| 14 | Substrate separation unit | 4 | 58 000 | 0% | 58 000 | 232 000 | |
| 15 | Submersible agitator for receiving tank | 1 | 12 000 | 0% | 12 000 | 12 000 | |
| 16 | Submersible agitator for filtrate tank | 1 | 12 000 | 0% | 12 000 | 12 000 | |
| 17 | Over- and under pressure safeguard | 4 | 9 000 | 0% | 9 000 | 36 000 | |
| 18 | Sight glasses/viewing windows with projector | 4 | 6 000 | 0% | 6 000 | 24 000 | |
| 19 | Water supply and canalization system | 1 | 55 000 | 0% | 55 000 | 55 000 | |
| 20 | Heat supply station | 1 | 67 000 | 0% | 67 000 | 67 000 | |
| 21 | Dry-cooler  cooling system for reactors | 4 | 36 000 | 0% | 36 000 | 144 000 | |
| 22 | Automation and electric cabinet | 1 | 420 000 | 0% | 420 000 | 420 000 | |
| 23 | Motorized valves (set) | 24 | 7 000 | 0% | 7 000 | 168 000 | |
| 24 | Sensors (set) | 6 | 25 000 | 0% | 25 000 | 150 000 | |
| 25 | Gasholder | 1 | 127 000 | 0% | 127 000 | 127 000 | |
| 26 | Biogas chiller (Biogas cooling system) | 2 | 135 000 | 0% | 135 000 | 270 000 | |
| 27 | Biogas blower | 2 | 75 000 | 0% | 75 000 | 150 000 | |
| 28 | Desulphurization column with active coal 500 kg | 2 | 45 000 | 0% | 45 000 | 90 000 | |
| 29 | Biogas flare | 1 | 265 000 | 0% | 265 000 | 265 000 | |
| 30 | Gas analyzer | 1 | 27 000 | 0% | 27 000 | 27 000 | |
| 31 | Gas conditioning unit | 1 | 75 000 | 0% | 75 000 | 75 000 | |
| 32 | Cogeneration power plants 2.3 MW el with the additional equipment like dry-coolers, silencers, pumps, HAS cabinet | 4 | 930 000 | 0% | 930 000 | 3 720 000 | |
| 33 | Reserve diesel generator 400 kW | 1 | 320 000 | 0% | 320 000 | 320 000 | |
| 34 | Construction and installation with materials and works | 1 | 3 800 000 | 0% | 3 800 000 | 3 800 000 | client |
| 35 | Filtrate Storage | 1 | 80 000 | 0% | 80 000 | 80 000 | client |
| 36 | Silage storage  14500m3 | 1 | 160 000 | 0% | 160 000 | 160 000 | client |
| 37 | Weight control (truck scale) | 1 | 50 000 | 0% | 50 000 | 50 000 | client |
| | | TOTAL by ZORG, EUR | | | | 10 368 000 | |
| | Total by Client but except of the list of exclusions, EUR | | | | | 4 090 000 | client |
| | **TOTAL ZORG+ Client, EUR** | | | | | **14 458 000,00** | |

# Implementation terms and payment

| Months | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Project documentation | 50% | 50% | | | | | | | | | |
| Approvals and permits | | | | | | | | | | | |
| Equipment supply | 30% | 20% | 20% | 20% | 10% | | | | | | |
| CHP | 30% | | | | 70% | | | | | | |
| Construction | | | | | | | | | | | |
| Supervision | 50% | | 50% | | | | | | | | |
| Plant start-up | | | | | | | | | | | |

# 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 9,2 MW biogas plant:

1) Import taxes and local duties
2) Civil permits and authorizations, adaptation of the project documentation by a licensed local engineering organisation for the permit purposes. Namely the organisation puts their stamp and acts act the face of the project.
3) Topographic and geological surveys 5000-7000 EUR
4) Electric transformer 1300 kVA, gears, vacuum switchers,counters and the external electric line
5) Temporary electric line 370 kW for the start-up
6) External roads
7) Temporary water supply during the construction and the hydraulic test of reactors at least 700 m3 water per day. It can be a technical quality water from a river, lake, well. Not salty.
8) Bacterial seed for the start-up. It can be biomass from another biogas plant. Possibley 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 550-900 m3. The rest is filled with the water item 7 above.
9) Machinery to transport Napier grass to and from silage storage to the solid feeders (a truck, a frontal loader, a tractor)
10) Machinery to transport filtrate and the digested mass from the biogas plant to the agricultural fields (a truck, a frontal loader, a tractor)
11) Activated carbon 1,0 tonne per year x 4800 EUR/tonne = 4800 EUR
12) Fe(OH)3, Fe(OH)2 = 400 tonnes per year x 180 EUR/tonne = 72 000 EUR
13) Anti-foam reagent 7 tonnes annually (all kinds of vegetable oil, for example, palm oil or rapeseed oil)
14) Microelements 4 000 liters per per year x 25 EUR/l= 100 000 EUR
15) PVC foil for the silage storage to cover grass 3900 m2
16) Demineralized water to the heating system 3 tonnes
17) Spare parts for the biogas plant for 2 years 200 000 EURO
18) Spare parts for the gen sets for 2 years 200 000 EURO

ZORG BIOGAS

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