ZORG BIOGAS

01

version

Quotation

Biogas plant
50 tonnes biomethane/day

Date: 17/04/2024

Validity: 3 months

CONTENT

OVERVIEW

We offer a solution to process Napier grass to biogas in high-load reactors (HLR). The proposed HLR technology is superior to the coventional CSTR . HLR is 3 times smaller and cheaper than CSTR. For 50 tonnes bioCNG a day just 5 HLR x 4200 m3 are enough.

Zorg makes the detailed engineering, supplies the equipment and provides supervision during construction as well as training and start-up. Zorg' part makes 50% from the total budget.

The construction and installation are done by Customer under Zorg' supervision and quality control. A purification from CO2 and compression 250 bar are an option. Customer may order this from Zorg or locally himself. The local part is 50%.

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 (%)	Biomethane (m^3 / day)
Napier grass	605	220 825	33	96	200	192	690	132 250	53	70 520

DM - dry matter content
ODM -organic dry matter content

Biogas plant characteristics

Characteristics	Values	Figures
Number of digesters	units	5
Digester		
a) volume:		
Work	m^3	4005
Overall	m^3	4292
b) Organic load	kgODM/ m^3	9.61
c) Hydraulic retention time (gross)	days	35/33
d) Overall dimensions of the digester (diameter / height)	m	27.0/7.5
e) Temperature	^0C	+52
Gasholder (external)		
a) Volume	m^3	1500
b) Number of gasholders	units	1
c) Dimensions of the gasholder (diameter / height)	m	15.4/11.8

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 digesters using augers. In the digesters 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 digesters operating regime is thermophilic. The heated substrate in the digesters is blended periodically. Mixing is performed by vertical mixers. The average time of processing in the digesters is 33 days. After the digesters, 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, biogas goes to biogas upgrading plant where raw biogas treats through the removal of CO2 and other soluble gases to produce primarily methane gas (~99%) which is clean and dry.

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, SF-05)

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

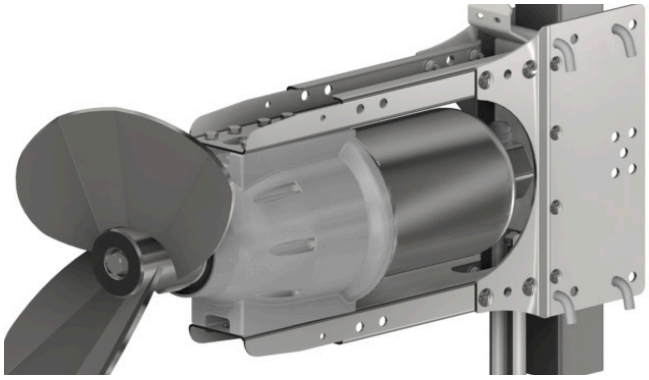
Length:	13.7 m
Width:	2.5 m
Height	3.6 m
Volume:	50 m³
Quantity:	5 pcs.

Filtrate tank (FT-01, FT-02)

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

Diameter:	8.0 m
Height	3.0 m
Total volume:	150 m^3
Quantity:	2 pcs



Submersible mixer (AG-31, AG-32)

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

Nominal power	N= 1.5 kW
Quantity:	2 pcs

Digester (D-01, D-02, D-03, D-04, D-05)

Digester 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 digester 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 digester 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 digester bottom has a slope 1%.

Specifications

Height :	7,5 m
Diameter :	27,0 m
The total volume :	4292 m^3
The substrate volume :	4005 m^3
Quantity:	5 pcs

Digester vertical mixer (AG-01 ... AG-30)

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

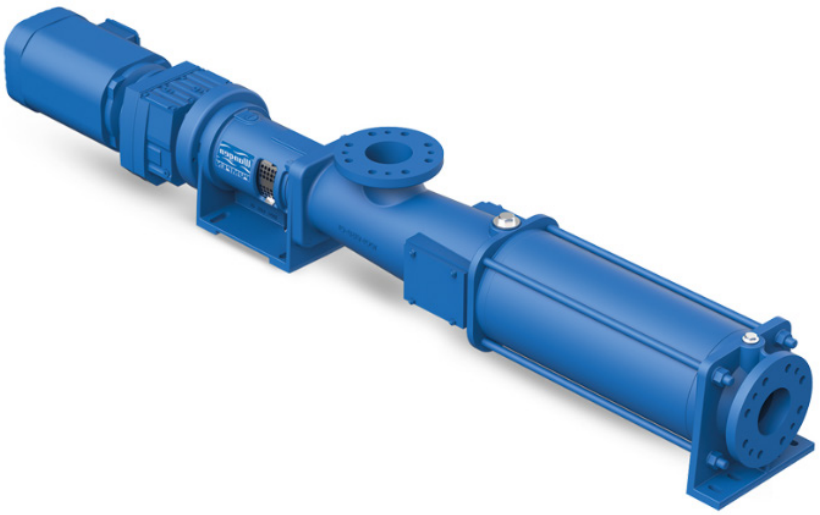
Engine power:	N=15 kW
Quantity per digester:	6 pcs
Quantity total:	30 pcs

Window with spotlight (SG-01, SG-02, SG-03, SG-04, SG-05)

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-05, PU-06, PU-07)

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-035)	
Flow rate:	30 m3/hour
Engine power:	7,5 kW
Pressure:	4 bar
Quantity:	5 pcs

Filtrate pump (PU-06, PU-07)	
Flow rate:	30 m3/hour
Engine power:	7,5 kW
Pressure:	4 bar
Quantity:	2 pcs

Separator (SR-01, SR-02, SR-03, SR-04, SR-05)

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	**5 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 :	11.8 m
Diameter :	15.4 m
The total/working volume :	1500 m^3
Quantity:	1 pcs

Biogas dryer and cooling (CHL-01, CHL-02, CHL-03)

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	1900 m^3/ h
Gas inlet temperature	+50 C
Gas outlet temperature	+10 C
Cooling power	200 kW
Engine power	54 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:	6500 m^3/h
Pressure:	150 mbar
Engine power:	59 kW
Quantity:	2 pcs

Desulphurization system (CF-01, CF-02)

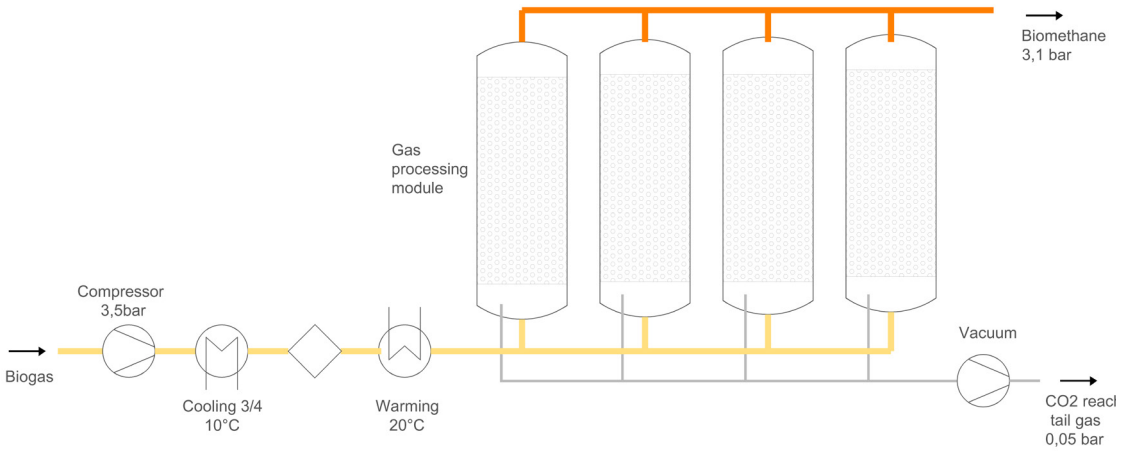
Desulfurization system is a one-step purification of sulfur that is contained in the biogas. The unit is a biogas cleaning system using activated charcoal filtration. Activated charcoal has the property to absorb sulfur. After passing through the activated charcoal filters, the sulfur concentration is reduced to 20 ppm.

Specifications

The volume of charcoal:	5 000 kg
Numbers of charcoal columns:	2 pcs.

Biogas upgrading plant (BUP-01)

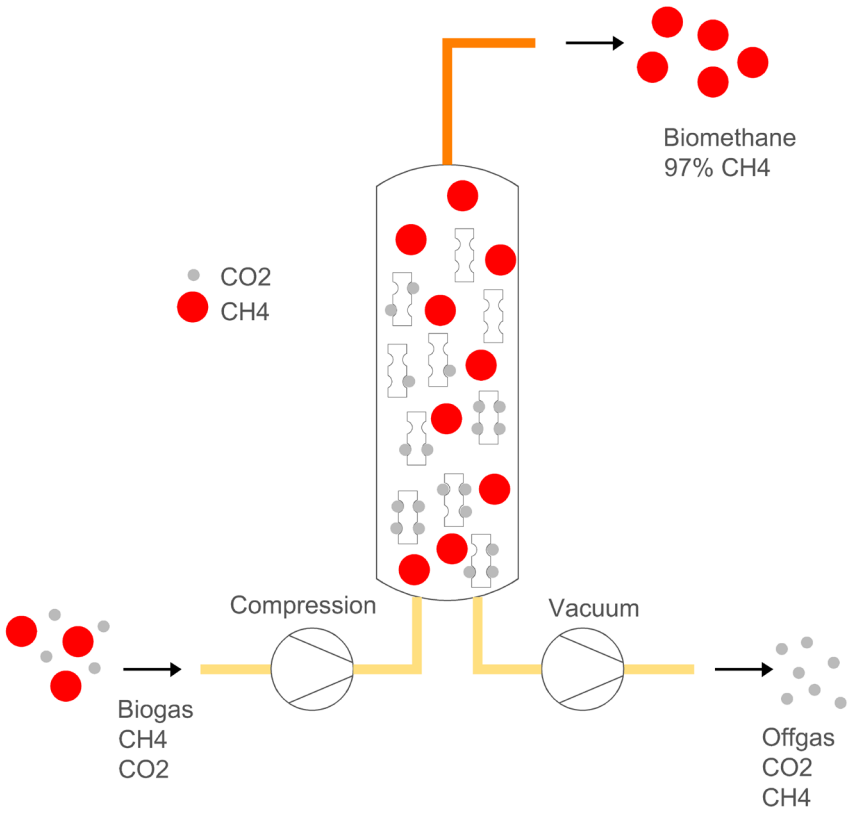
The biogas upgrading plant is used to purify biogas, landfill gas or sewage gas. The CO2 content is separated from the main gas stream with this plant and thus a product gas of natural gas quality is generated, which can be fed into the natural gas grid via a downstream feed-in plant. The gas mixture is separated by means of pressure swing adsorption (PSA), a physical process for separating gas mixtures under pressure by means of adsorption. The separation effect occurs because one of the components to be separated (CO2) adsorbs more strongly than the other (CH4). This results in an enrichment of the less adsorbent component (CH4) in the gas phase. The desulphurised and dried biogas is fed into the adsorbers under pressure. The gas flows through the adsorbers from bottom to top, whereby the CO2 is adsorbed. At the outlet of the adsorber, biomethane that meets the specifications is extracted. At the end of the adsorption time, the adsorber is saturated with CO2. By lowering the pressure into a vacuum, the adsorber is regenerated and is then ready for adsorption again.



Biogas flows through the adsorbent at 3-4 bar
Smaller molecules N2, O2, H2O, H2S, CO2 penetrate the pores in the sieve and are adsorbed.
The larger CH4 molecule is not adsorbed, thus separated from theCO2 molecules.
Biomethane CH4>> 99% can be fed in to the gas grid or compressed to CNG & LNG.
The saturated adsorbent can now be regenerated by vacuum, completing the cycle.
Performance is granted by a Smart, self-regulating cycle controll

Biogas upgrading plant nominal conditions

	Biogas	Biomethane	CO_2 reach tail gas
Flow max (Nm^3/h)	3000	1650	1242
Flow (Nm^3/h)	2755	1469	1183
CH_4 (Vol %)	53	99.5	1,67
CO_2 (Vol %)	43	1,6	96
H_2O (Vol %)	0,8	Dew-point < -65°C	1,82
N_2 (Vol %)	0,8	1,26	0,26
O_2 (Vol %)	0,2	0,11	0,30
H_2S (ppm)	<3	-	-
Temperature (°C)	20	25	40
Pressure (bar)	0,09	3,1	0,05



Scope of Supply of Biogas upgrading plant

Screw type compressor

Non-contact, wear-free, dry and oil free screw compressor unit to generate the necessary adsorption pres-sure.

Connection 3 x 400 V
Protection type IP 55
Efficiency class: IE3
Lubrication Bearings lubricated by oil injection but no oil/gas contact

Description:
- with rotor profile 4+6 developed for the design case and adapted internal compression ratio 4 for op mum low energy consumption,
- Gearbox i_11/12, water-cooled stage,
- Torsion-resistant welded base beam. Base support on elastic machine feet for structure-borne noise insulation,
- Drive coupling with coupling guard,
- Intake silencer with connection flange,
- Axial expansion joint (pressure side), flange according to DIN, incl. tie rod,
- Axial expansion joint (suction side), flange to DIN,

Gas cooling 3/4 and heating 2 after the screw type compressor

Active gas cooling with cold water replacement and gas heat exchanger for the condensation of water in the product gas.
Max. operating pressure 3,5 bar
Gas temperature after cooling 10 °C

Gas-processing module

Methane enrichment system using the vacuum pressure swing absorption (VPSA) process. In the PSA process, biogas (approx. 55-% CH4, 45% CO2) flows through an adsorbent (Molecular sieve) at elevated pressure. The smaller molecules (mostly CO2) penetrate the pores and are adsorbed while the larger CH4 molecule passes right through the sieve, thus resulting in a pure Biomethane gas that can directly substitute natural gas in any application or compressed to CNG for vehicle fuel. Once the mo-lecular sieve is saturated, it is regenerated by vacuum and the resulting off-gas eliminated, treated or used for CO2 applications. PSA is a self-regenerating system.

Control range 40 - 100% (raw gas), automatic load adjustment
Adsorbent lifetime > 15 years

Vacuum pumps

Rotary vane vacuum pump for vacuum generation / regeneration of the absorbent beds

Nominal suction volume (per vacuum pump)	3000 Nm³/h
Type of cooling	Water flow
Cooling medium	Water-Glycol
Connection	3 x 400 V
Lubrication	Oil injection

Biomethane compressor suction drum

Suction drum for the downstream HP Biomethane compressor/grid injection plant.

Material	Steel
MOP (Maximum operation pressure)	3,5 bar

Instrument compressed air supply

Screw compressor station to provide the required oil-free process compressed air. Complete with adsorption dryer, dew point transmitter and compressed air reservoir. The supply of an optional 02 PSA is not provided in this configuration. Corresponding expansion options are offered separately

Quantity	2
Motor power	6 kW
Protection class	IP54
Outlet pressure during operation	10 bar

Gas analysis system raw biogas

Process gas analysis system for the measurement of raw biogas.

Analysis cabinet, sample gas cooler, condensate pump, sample gas pump, switch-over tap for sample gas, sample gas filter, solenoid valve, water protection filter, deflagration protection, display and control unit

Flow meter biogas

Type:	Proline Prosonic Flow B 200
Housing:	GT20 two chambers, Aluminium

System control

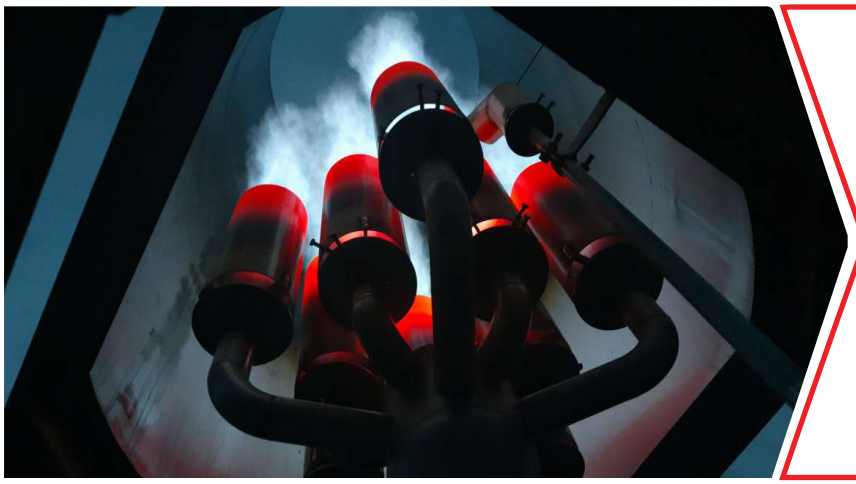
Basic functions:
- Automatic programme sequence for starting and stopping the BGAA system
- Superordinate control for monitoring and regulating all assemblies
- PLC Siemens S7-1500
- TÜV-tested safety chain with quick-stop button and connection option for all safety-related encoders
- Control and monitoring of the cooling circuits and room ventilation
- Parameter is able messages for recording system-specific messages
- Electronic operating diary for recording operating, warning and fault messages with date and time for detailed observation of operation
- Electronic operating hours counter

Industrial PC for operation, process visualisation, data archiving and remote control of the system consisting of:
- 19" touch panel
- DSL modem for remote diagnosis, remote monitoring and remote control of the system
- Windows operating system
- Messages: Collective malfunction as email and SMS, collective warning as email and SMS, any recipient can be selected
- Commands: Remote acknowledgement of faults, selection and deselection, power control, change of parameters, maintenance switch for suppression of messages
- Visualisation: Plant flow diagram with display of current operating values, states and counter values, 32 trends
- Language: English

Container plant

The special container is brand new and each is equipped with doors and inspection openings for accessibility of all internal main components. All doors are fire-retardant. The container is a special construction for gas processing plants, with cross-frame stiffeners. The floor is constructed of bulb plate. Insulation construction is individual sound insulation cassettes made of galvanised perforated sheet with an insulation of 50 mm high-density mineral wool with fleece lamination as trickle protection, non-combus-tible according to DIN 4102 A2. The insulation is designed for a sound pressure level of 65 dB(A) at 10m. The container is primed and painted with colour RAL 7042. Quality of the paint: C4

Further equipment of the container:
- Interior lighting with switches on each main door
- "NOT STOP" button on the main door of the engine room
- Gas warning system 2-stage
- Fire alarm / smoke detection system in engine room and control room
- 2x fire extinguisher 6 kg



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	5500 m³/h
Quantity:	1 pcs

Gas analyzer (CH4, CO2, H2S, O2)

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

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

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

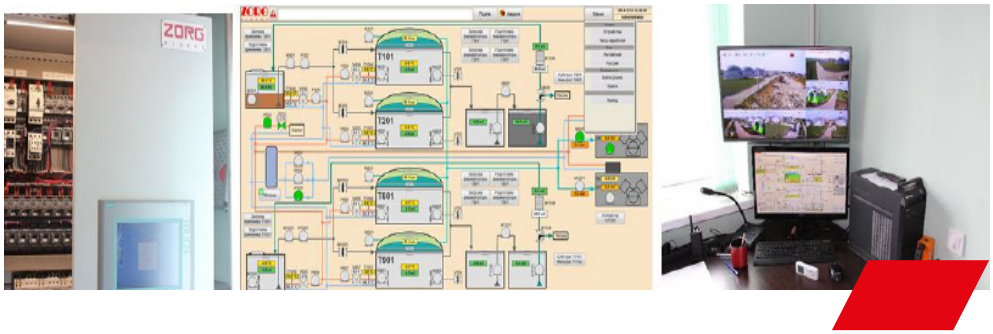
Circulating pump feeding heat carrier heating	
Flow	30 m3 / h;
Pressure	1 bar
Circulating pump feeding heat carrier to the digester	
Flow	18 m3 / h;
Pressure	1.1 bar
The pumping station feeding propylene glycol	
Flow	0.8 m3 / h;
Pressure	4 bar

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:	5 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	**Loader**	**V=50 m3**	**5**
1.1	Container bunker		5
1.2	Feeding screws	set.	5
2	**Submersible mixer**	**N=3.0kW**	**2**
2.1	Airtight motor gearbox		2
2.2	Hydraulic screw (wear-resistant steel)		2
2.3	Mixer control mechanism		2
2.4	Electric motor mount		2
2.5	Set of fasteners		2
3	**Digester vertical mixer**	**N=15 kW**	**30**
3.1	Airtight motor gearbox		30
3.2	Hydraulic screw (wear-resistant steel)		30
3.3	Shaft (adapted to the height of the fermenter)		30
3.4	Blade		30
3.5	Frequency converter		30
3.6	Mounting bracket to bottom of the mixer		30
4	**Safety valve of digesters**		**5**
5	**Window with a searchlight**	**set**	**5**
5.1	Inspection window RD300 (mounts and sealant included)	Ø300	10
5.2	Spotlight (mount system bundled) VISULUX UL50 -G -H	230V, 50W, IP65	5
6	**Substrate digested pump**	**30 m3/hour N=7.5 kW**	**5**

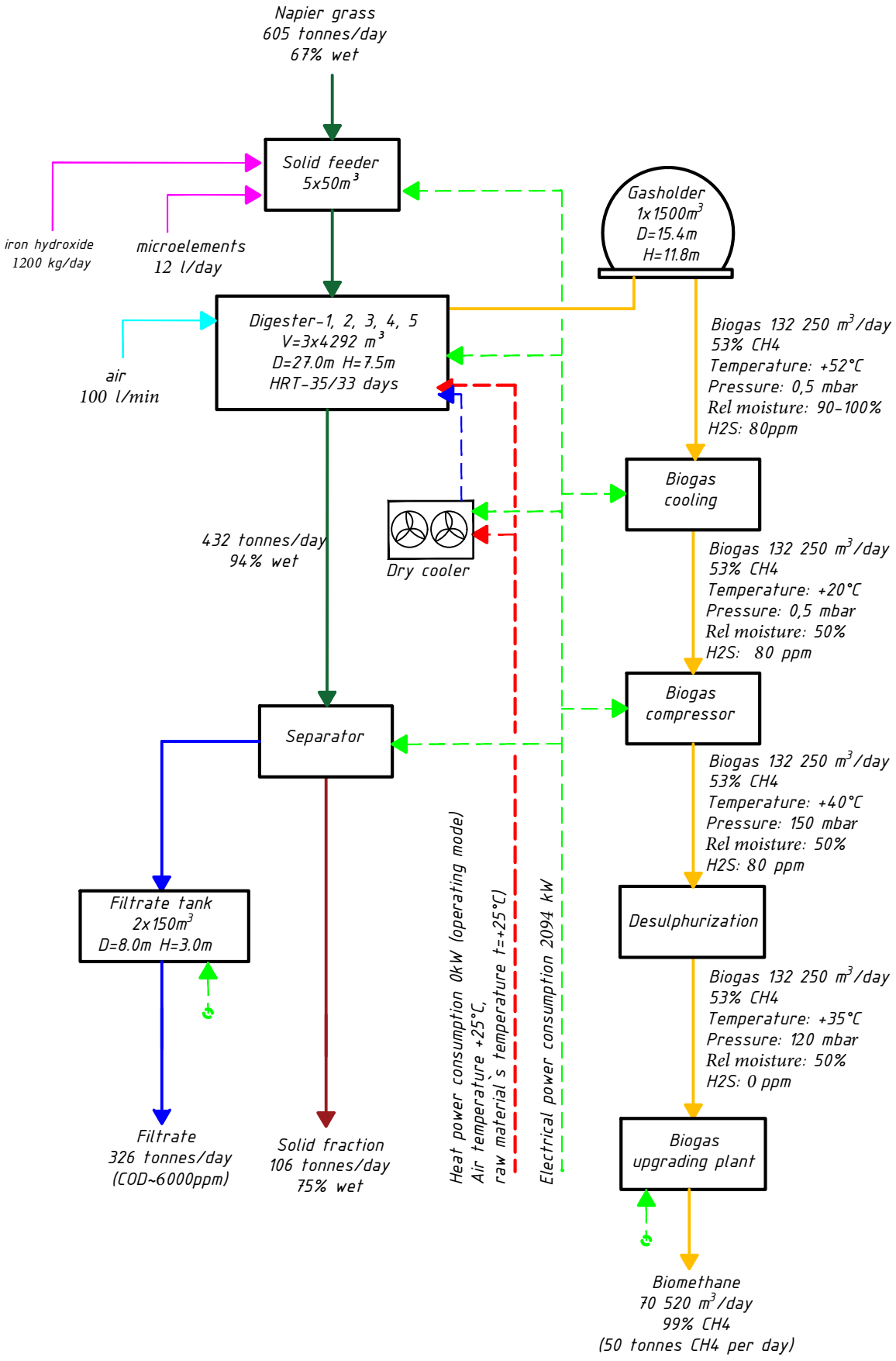
№	Equipment	Characteristic	Quantity
7	**Separator**	**N=5.5 kW, Q=8-12m3/h**	**5**
7.1	Body		5
7.2	Substrate Supply Pipe 4 ’’		5
7.3	Engine - Gearbox	N=5,5 kW	5
7.4	Frame		5
7.5	Screw		5
7.6	Sieve for filtration		5
8	**Filtrate pump**	**30 m3/hour N=7.5kW**	**2**
9	**PVC external gas holder**	**Ø15.4m**	**1**
9.1	Weather protection film	Ø15.4m	1
9.2	Gasholder film PELD methane permeation max.260 cm3/m2*d*1 bar, 650 N/5cm bio-gas resistant		1
9.3	Air blower	16A, 0,5kW	1
9.4	Excess and minimum pressure valve		1
9.5	Dome level sensor		1
9.6	Mounting system		1
9.7	Accessories		1
9.8	Safety valve		1
10	**Biogas Cooling System**	**1900 m3/h**	**3**
10.1	Chiller		3
10.2	Heat exchanger		3
10.3	Polypropylene glycol tank		3
11	**Desulphurization system**		**1**
11.1	Numbers of charcoal columns	**5000 kg**	2

№	Equipment	Characteristic	Quantity
12	**Biogas compressor**	**Q=6500m³/h H=150mBar N=59kW**	**2**
13	**Biogas analyzer (CH4 , CO2 , H2S, O2)**		**1**
14	**Electromagnetic flow meter**		**1**
15	**Flare**	**5500 m3/h**	**1**
16	**Biogas upgrading plant**	**3000 m3/h**	**2**
17	**Gas equipment included**	**set**	**1**
17.1	Drainage pump with float	DN=50 Q=1m³/h H=13 m	2
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	5
19	**Water supply and sewerage system, complete, disassembled**	**set**	**1**
20	**Automation with electrical equipment complete, disassembled**	**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		5
21.2	Gas pressure sensor 0,4Bar		5
21.3	Pressure sensor(substrate level) 1,0Bar		7
21.4	Pressure sensor (substrate pressure) 2,5bar		7

№	Equipment	Characteristic	Quantity
21.5	Resistive thermometer (gas temperature)		4
21.6	Resistive thermometer with thermo well (fermenter substrate temperature)		4
21.7	Resistive thermometer with thermo-well (digester tank substrate temperature)		4
21.7	Resistive thermometer (heat conductor temperature)		4
21.9	Conductometric sensor of maximum level		7
21.10	Conductometric sensor of water level		4
21.11	Dome position sensor		1
21.12	Coolant pressure sensor	SEN 3276 B065 G1/2 6Bar	5
21.13	Humidity and gas temperature sensor	ESFTF-I	5
22	**Dry cooler 100kW heat pow.**		**5**

APPENDICES

Material flow diagram



ZORG BIOGAS

Appendix 2

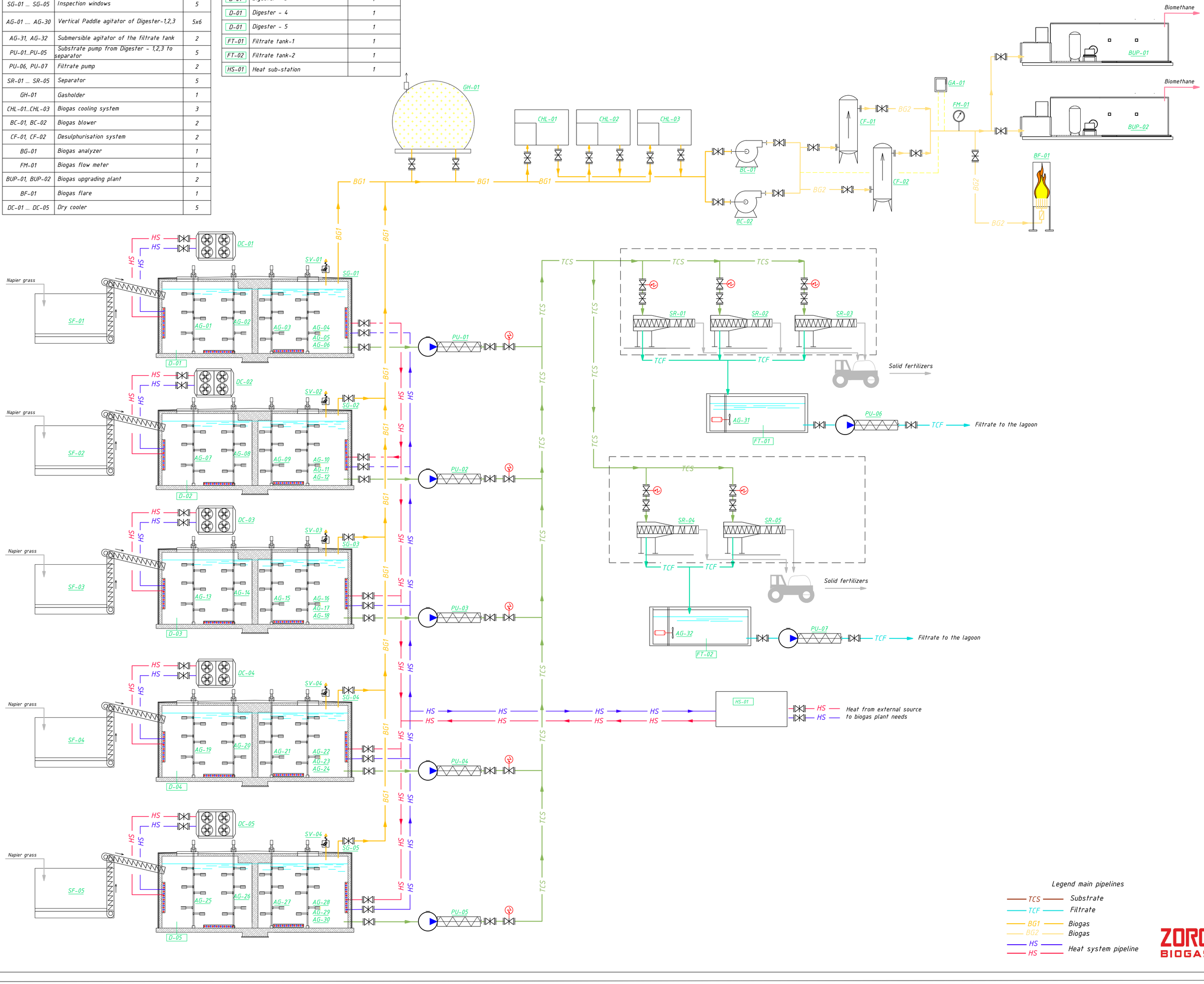
Basic diagram

Explication

N/№	Name	Quantity
SF-01 ... SF-05	Solid feeder	5
SV-01 ... SV-05	Safety valve	5
SG-01 ... SG-05	Inspection windows	5
AG-01 .... AG-30	Vertical Paddle agitator of Digester-1,2,3	5x6
AG-31, AG-32	Submersible agitator of the filtrate tank	2
PU-01...PU-05	Substrate pump from Digester - 1,2,3 to separator	5
PU-06, PU-07	Filtrate pump	2
SR-01 ... SR-05	Separator	5
GH-01	Gasholder	1
CHL-01...CHL-03	Biogas cooling system	3
BC-01, BC-02	Biogas blower	2
CF-01, CF-02	Desulphurisation system	2
BG-01	Biogas analyzer	1
FM-01	Biogas flow meter	1
BUP-01, BUP-02	Biogas upgrading plant	2
BF-01	Biogas flare	1
DC-01 ... DC-05	Dry cooler	5

Structure

N/№	Name	Quantity
D-01	Digester - 1	1
D-01	Digester - 2	1
D-01	Digester - 3	1
D-01	Digester - 4	1
D-01	Digester - 5	1
FT-01	Filtrate tank-1	1
FT-02	Filtrate tank-2	1
HS-01	Heat sub-station	1

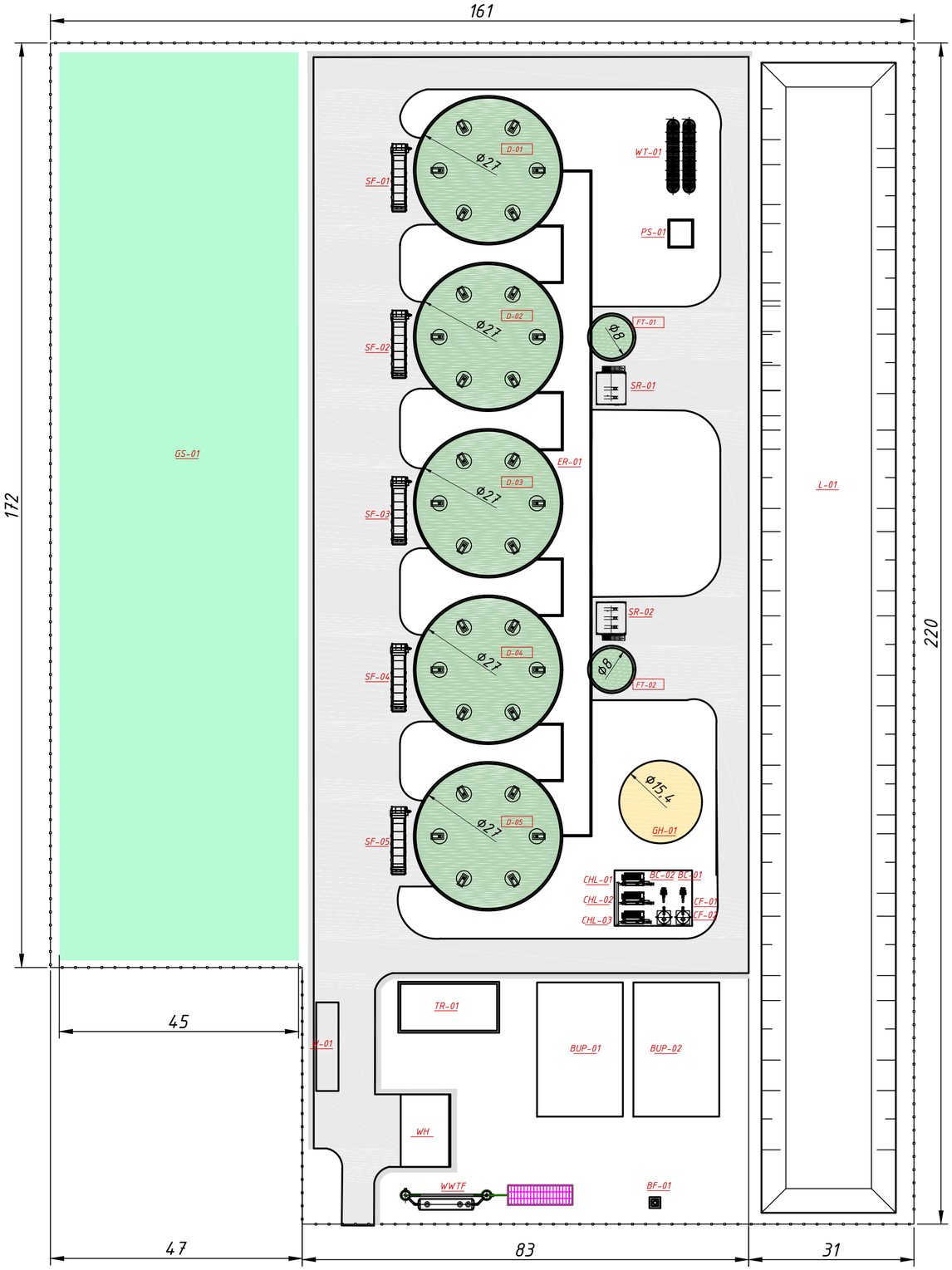


Legend main pipelines

- TCS — Substrate
- TCF — Filtrate
- BG1 — Biogas
- BG2 — Biogas
- HS — Heat system pipeline

ZORG BIOGAS

Plan



Appendix 3

Explication

N/№	Name	Note
D-01	Digester-1	
D-02	Digester-2	
D-03	Digester-3	
D-04	Digester-4	
D-05	Digester-5	
FT-01	Filtrate tank-1	
FT-02	Filtrate tank-2	
SR-01	Separation platform -1	
SR-02	Separation platform -2	
SF-01, SF-02, SF-03, SF-04, SF-05	Solid feeder-1 -2 -3 -4 -5	
GH-01	Gasgolder	
CHL-01, CHL-02, CHL-03	Biogas cooling system	
BC-01, BC-02	Biogas compressor	
CF-01, CF-02	Carbon filter (desulphurization)	
BF-01	Biogas flare	
BUP-01, BUP-02	Biogas upgrading plant	
TR-01	Technical room (operator room)	
ER-01	Equipment room	
WH-01	Warehouse	
GS-01	Grass storage	
L-01	Lagoon	
W-01	Truck scale	
WT-01	Water fire tanks	
WWTF	Waste water treatment facilities	

ZORG BIOGAS

Appendix 4

Electric energy consumption biogas plant					
Name equipment	**Instal. Pow. (kW)**	**Q-y (pcs)**	**Total installed power (kW)**	**Working hours per day**	**Consumption kWh per day**
Loader V=50 m^3	16,0	5	80,0	8,0	640,0
Screw set.	24,0	5	120,0	8,0	960,0
Digester Vertical mixer	15,0	30	450,0	18,0	8100,0
Submersible mixer in filtrate tank	3,0	2	6,0	12,0	72,0
Biogas cooling system	56,0	3	168,0	24,0	4032,0
Biogas compressor	59,0	2	118,0	12,0	1416,0
Separator	5,5	5	27,5	8,0	220,0
Substrate pump to separator	7,5	5	37,5	8,0	300,0
Filtrate pump	7,5	2	15,0	5,0	75,0
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	5	20,0	24,0	480,0
Circulation pump for supplying heat carrier to the digester	0,8	5	3,8	24,0	90,0
Circulation pump for supplying heat carrier to the digester cooling system	2,0	5	10,0	24,0	240,0
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			**1062**		
Total consumed electric energy, kWh per day					**16662**
Total consumed power, kW					**694**

Biogas upgrading plant					
Name equipment	**Instal. Pow. (kW)**	**Q-y (pcs)**	**Total installed power (kW)**	**Working hours per day**	**Consumption kWh per day**
Biogas upgrading plant+ compressor 250 bar	1400	1	1400	24,0	33600
Total installed power, kW			**1400**		
Total consumed electric energy, kWh per day					**33600**
Average consumed electric power, kW					**1400**

Total average consumed electric power, kW					**2094**

ZORG BIOGAS

Appendix 5

Prices for Zorg' services and equipment part 1

Pos	Name	Number of units	Unit price, EUR	Discounts *	Discounted unit price, EUR	Discounted price sub-total, EUR
A	Project documention	1	144000	0%	144000	144000
B	Supervision	1	60000	0%	60000	60000
C	Startup and training	1	60000	0%	60000	60000
D	Living and travel expences	1	60000	0%	60000	60000
E	Delivery of the equipment	15	10000	0%	10000	150000
1	Solid feeder (dosing buffer machine)	5	145000	0%	145000	725000
2	Screw conveyor	5	144000	0%	144000	720000
3	Digester vertical mixer	25	78000	0%	78000	1950000
4	Frame for Digester vertical mixer pos 3	25	6000	0%	6000	150000
5	Substrate pump	5	27000	0%	27000	135000
6	Biogas blower	2	75000	0%	75000	150000
7	Automation and electric cabinet	1	478000	0%	478000	478000
			TOTAL, EUR			**4782000**

Appendix 6

Prices for equipment part 2

Pos	Name	Number of units	Unit price, EUR	Discounts *	Discounted unit price, EUR	Discounted price sub-total, EUR
8	Gasholder	1	140000	0%	140000	140000
9	Over- and under pressure safeguard	5	5100	0%	5100	25500
10	Sight glasses/viewing windows with projector	5	4900	0%	4900	24500
11	Substrate pump	2	21000	0%	21000	42000
12	Filtrate supply pump	2	21000	0%	21000	42000
13	Substrate separation unit	5	44000	0%	44000	220000
14	Submersible mixer for receiving tank	2	11000	0%	11000	22000
15	Submersible mixer with guiding unit for filtrate tank	3	11000	0%	11000	33000
16	Biogas chiller (Biogas cooling system)	2	195000	0%	195000	390000
17	Desulphurization column with active coal 500 kg	2	45000	0%	45000	90000
18	Gas conditioning unit	1	27000	0%	27000	27000
19	Biogas burner	2	137000	0%	137000	274000
20	Heat supply station	1	52000	0%	52000	52000
21	Sensors (set)	1	250000	0%	250000	250000
22	Water supply and canalization system	1	35000	0%	35000	35000
23	Gas analyzer	1	27000	0%	27000	27000
24	Dry-cooler (Substrate cooling system for fermenter)	5	26000	0%	26000	130000
		TOTAL, EUR				**1824000**

Total budget Zorg + Client

Appendix 7

#	Title	Cost	Value	Comments
A	Project documentation	144000	Euro	ZORG
B	Supervision and adjustment	60000	Euro	ZORG
C	Start-up and training	60000	Euro	ZORG
D	Living and travel expenses	60000	Euro	ZORG
E	Delivery (10 containers x 10000 EUR)	150000	Euro	ZORG
Pos 01-07	Equipment part 1	4308000	Euro	ZORG
Pos 08-24	Equipment part 2	1824000	Euro	ZORG
25	Biomethane upgrading plant	3500000	Euro	local
26	Biomethane compressor plant	530000	Euro	local
F	Laboratory	25000	Euro	local
G	Construction	3000000	Euro	local
H	Napier grass bagger machinery	270000	Euro	local
I	Filtrate Storage (V=2000 m3)	150000	Euro	local
J	Weight control (truck scale)	35000	Euro	local
	Total without subsidy	**14116000**	**Euro**	
	Subsidy	-800000	Euro	
	Total with subsidy	**13316000**	Euro	
	Zorg' part (pos. A-E, 1-24)	**6606000**	Euro	**50%**
	Client' part (pos. 25-26, F-J)	**6710000**	Euro	**50%**

Initial Data	
Daily of raw materials, t	601
Amount of raw materials, t	219.442
Cost of raw materials, euro/t	
Total cost of raw materials per year, euro	3.428.460
Biogas output from 1 t of raw material, m3	
Total annual biogas output, m3	47.868.845
Biomethane equivalent 1m3	0,53
Biomethane module working days per year	360
Elec. energy for own needs per year, kWh	18.092.160
Total annual biomethane production, t/per year	18.194
Number additional modules	0
Cost of 1t biofertlizer, euro	0,00
Cost of 1 t of biomethane, euro	730,00
Cost of 1 kWh (el.power), euro	0,1000
Cost of biogas plant with VAT, euro	13.316.000
Net profit tax	20,0%
Value Added Tax	18,0%
WACC	10,92%
Credit term, years	6

Napier grass	*iron hydroxide*	*Trace elements*	*Activated carbon*
600,0	1,2	0,0120	
219.000	432,0	4,3	0,50
15,0	80,0	25.000,00	1.800,00
3.285.000	34.560	108.000	900
218,6			
47.868.845			

Biogas, m3/day	Biomethane, m3/day	Biomethane, t/day	El.pow self consum, kW
131.148	69.932	50,5	2.094,0

Biofertlizer, t
106,0

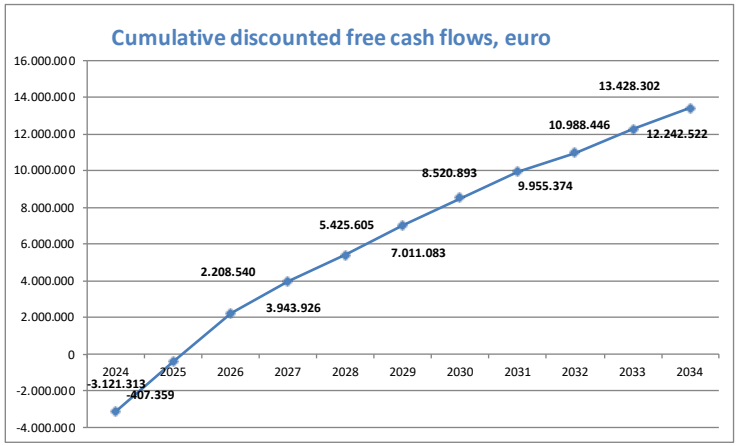
Equity investment	*Bank financing*	
20%	80%	
2.663.200	10.652.800	*Sum*
13,0%	13,0%	*Interest rate*

Economic effect	
IRR	93%
NPV, euro	13.428.302
Payback period, years	2,0
Discounted payback period, years	2,2
Cummulative net profit, euro	27.788.232
Cost of 1 t of biomethane, Euro	308,33
Cost of production of 1000 m3 of biogas, Euro	114,71

CapEx amortization		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Incoming balance		**0**	**14.116.000**	**12.704.400**	**11.433.960**	**10.290.564**	**9.261.508**	**8.335.357**	**7.501.821**	**6.751.639**	**6.076.475**	**5.468.828**
Amortization	10%	0	1.411.600	1.270.440	1.143.396	1.029.056	926.151	833.536	750.182	675.164	607.648	546.883
Outcoming balance		**14.116.000**	**12.704.400**	**11.433.960**	**10.290.564**	**9.261.508**	**8.335.357**	**7.501.821**	**6.751.639**	**6.076.475**	**5.468.828**	**4.921.945**

Cash-Flows	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Gross revenue from biomethane +biofertlizer	0	13.281.893	13.281.893	13.281.893	13.281.893	13.281.893	13.281.893	13.281.893	13.281.893	13.281.893	13.281.893
Net revenue from biomethane production	**0**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**	**13.281.893**
Operating costs	**0**	**-5.461.596**	**-5.461.596**	**-5.461.596**	**-5.891.036**	**-5.461.596**	**-5.461.596**	**-5.461.596**	**-6.515.676**	**-5.461.596**	**-5.461.596**
Raw materials cost	0	-3.428.460	-3.428.460	-3.428.460	-3.428.460	-3.428.460	-3.428.460	-3.428.460	-3.428.460	-3.428.460	-3.428.460
Biogas plant service	0	-64.620	-64.620	-64.620	-301.560	-64.620	-64.620	-64.620	-646.200	-64.620	-64.620
Biomethane module service	0	-52.500	-52.500	-52.500	-245.000	-52.500	-52.500	-52.500	-525.000	-52.500	-52.500
Elec. energy for own needs	0	-1.809.216	-1.809.216	-1.809.216	-1.809.216	-1.809.216	-1.809.216	-1.809.216	-1.809.216	-1.809.216	-1.809.216
Salaries	0	-106.800	-106.800	-106.800	-106.800	-106.800	-106.800	-106.800	-106.800	-106.800	-106.800
wear out of equipment, %		1,5	1,5	1,5	7,0	1,5	1,5	1,5	15,0	1,5	1,5
EBITDA	**0**	**7.820.297**	**7.820.297**	**7.820.297**	**7.390.857**	**7.820.297**	**7.820.297**	**7.820.297**	**6.766.217**	**7.820.297**	**7.820.297**
EBITDA margin		*59%*	*59%*	*59%*	*56%*	*59%*	*59%*	*59%*	*51%*	*59%*	*59%*
Finance expenses	-798.960	-1.269.459	-1.038.648	-807.837	-577.027	-346.216	-115.405	115.405	230.811	461.621	692.432
VAT		-1.436.327	-1.436.327	-1.436.327	-1.393.678	-1.436.327	-1.436.327	-1.436.327	-1.331.643	-1.436.327	-1.436.327
VAT credit balance	-800.000	-1.436.327	-1.436.327	-1.436.327	-1.393.678	-1.436.327	-1.436.327	-1.436.327	-1.331.643	-1.436.327	-1.436.327
Profit before tax	**-798.960**	**6.550.838**	**6.781.649**	**7.012.459**	**6.813.830**	**7.474.081**	**7.704.891**	**7.935.702**	**6.997.027**	**8.281.918**	**8.512.729**
Net profit tax	0	0	0	-1.173.813	-1.156.955	-1.309.586	-1.374.271	-1.437.104	-1.264.373	-1.534.854	-1.593.169
Net profit	**-798.960**	**5.114.511**	**5.345.321**	**4.402.319**	**4.263.197**	**4.728.167**	**4.894.293**	**5.062.271**	**4.401.012**	**5.310.736**	**5.483.232**
Net margin		*39%*	*40%*	*33%*	*32%*	*36%*	*37%*	*38%*	*33%*	*40%*	*41%*
Own investment	**-2.663.200**										
Loan repayment	0	-1.775.467	-1.775.467	-1.775.467	-1.775.467	-1.775.467	-1.775.467	-1.775.467	-1.775.467	-1.775.467	-1.775.467
Free Cash Flows	**-3.462.160**	**3.339.044**	**3.569.855**	**2.626.853**	**2.487.730**	**2.952.701**	**3.118.826**	**3.286.804**	**2.625.545**	**3.535.270**	**3.707.765**
Cumulative free fash flows	-3.462.160	-123.116	3.446.738	6.073.591	8.561.321	11.514.022	14.632.848	17.919.652	20.545.197	24.080.467	27.788.232
Period (years)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Discount Factor	*90%*	*81%*	*73%*	*66%*	*60%*	*54%*	*48%*	*44%*	*39%*	*35%*	*32%*
Discounted Free Cash Flows	**-3.121.313**	**2.713.954**	**2.615.899**	**1.735.387**	**1.481.679**	**1.585.478**	**1.509.809**	**1.434.481**	**1.033.072**	**1.254.076**	**1.185.779**
Cumulative discounted free cash flows	-3.121.313	-407.359	2.208.540	3.943.926	5.425.605	7.011.083	8.520.893	9.955.374	10.988.446	12.242.522	13.428.302

Bank credit amortization	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Starting debt dalance	0	10.652.800	8.877.333	7.101.867	5.326.400	3.550.933	1.775.467	0	-1.775.467	-3.550.933	-5.326.400
Credit drawdowns	10.652.800										
Principal repayment		1.775.467	1.775.467	1.775.467	1.775.467	1.775.467	1.775.467	1.775.467	1.775.467	1.775.467	1.775.467
Ending debt balance	10.652.800	8.877.333	7.101.867	5.326.400	3.550.933	1.775.467	0	-1.775.467	-3.550.933	-5.326.400	-7.101.867
Comission	106.528										
Interest	692.432	1.269.459	1.038.648	807.837	577.027	346.216	115.405	-115.405	-230.811	-461.621	-692.432


Cumulative discounted free cash flows, euro
16.000.000
14.000.000
12.000.000
10.000.000
8.000.000
6.000.000
4.000.000
2.000.000
0
-2.000.000
-4.000.000
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
-3.121.313
-407.359
2.208.540
3.943.926
5.425.605
7.011.083
8.520.893
9.955.374
10.988.446
12.242.522
13.428.302

Implementation terms and payment

Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project documentation	50%			50%												
Approvals and permits																
Equipment supply	50%		20%	20%		10%										
Biogas upgrading plant	30%					70%										
Construction																
Supervision	50%					50%										
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

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