ZORG BIOGAS

Proposal

Biogas plant
20 tonnes biomethane/day

Date: 11/04/2024

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 20 tonnes bioCNG a day capacity just 2 HLR x 4152 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 47% 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 53%.

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 / year)
Napier grass	240	87 600	33	96	79.20	76.03	690	52 462	52	27 445

Biogas plant characteristics

Characteristics	Values	Figures
Number of reactors	units	2
Reactor		
a) volume:		
Work	m^3	3945
Overall	m^3	4152
b) Organic load	kgODM/ m^3	9.64
c) Hydraulic retention time (gross)	days	35/33
d) Overall dimensions of the reactor (diameter / height)	m	23.0/10.0
e) Temperature	^0C	+52
Gasholder (external)		
a) Volume	m^3	860
b) Number of gasholders	units	1
c) Dimensions of the gasholder (diameter / height)	m	12.5/9.3

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 31 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, 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)

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:	2.6 m
Height	3.4 m
Volume:	50 m³
Quantity:	2 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.

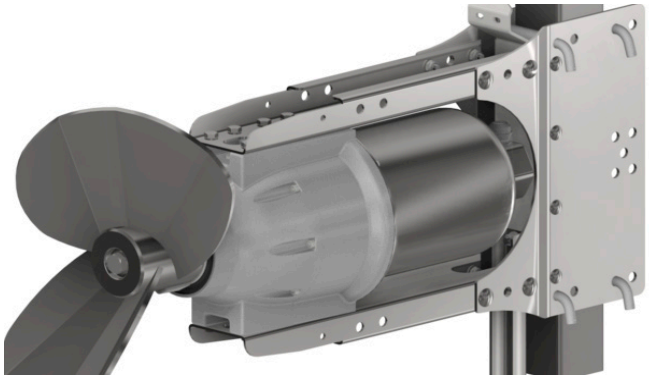
Specifications

Receiving tank (RT-01)

Diameter:	8.0 m
Height	2.5 m
Total volume:	125 m^3
Quantity:	1 pcs

Filtrate tank (FT-01)

Diameter:	8.0 m
Height	2.5 m
Total volume:	125 m^3
Quantity:	1 pcs



Submersible mixer (AG-11, AG-12)

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 mixer of the receiving tank (AG-11)	
Nominal power	N=5.0 kW
Quantity:	1 pcs
Submersible mixer of the filtrate tank (AG-12)	
Nominal power	N=3.0 kW
Quantity:	1 pcs

Reactor (R-01, R-02)

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 :	10.0 m
Diameter :	23,0 m
The total volume :	4152 m^3
The substrate volume :	3945 m^3
Quantity:	2 pcs

Reactor vertical agitator (AG-01 ... AG-10)

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

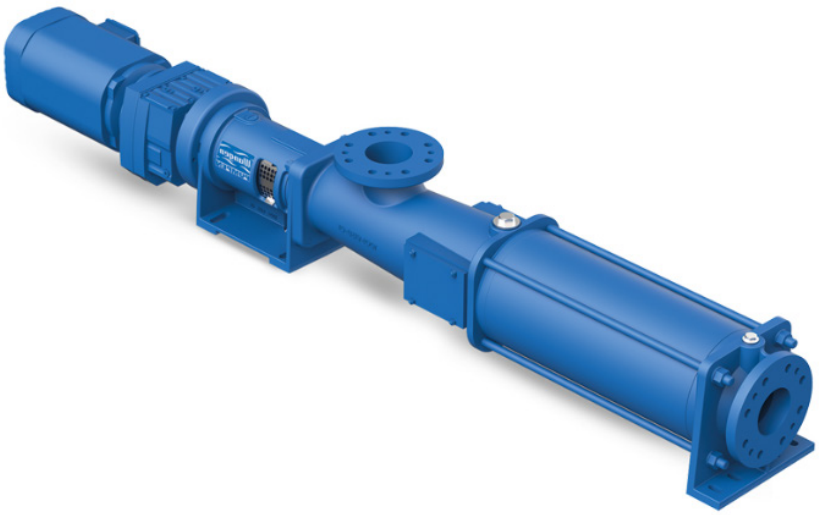
Engine power:	N=15 kW
Quantity per digester:	5 pcs
Quantity total:	10 pcs

Window with spotlight (SG-01, SG-02)

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)

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)	
Flow rate:	30 m3/hour
Engine power:	7,5 kW
Pressure:	4 bar
Quantity:	3 pcs
Liquid substrate pump (PU-03)	
Flow rate:	30 m3/hour
Engine power:	7,5 kW
Pressure:	4 bar
Quantity:	1 pcs
Filtrate pump (PU-04)	
Flow rate:	30 m3/hour
Engine power:	7,5 kW
Pressure:	4 bar
Quantity:	1 pcs

Separator (SR-01, SR-02)

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	**2 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)

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	2200 m^3/ h
Gas inlet temperature	+50 C
Gas outlet temperature	+20 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:	2200 m^3/h
Pressure:	150 mbar
Engine power:	26 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)	300 kg
Numbers of charcoal columns	2 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	2200 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

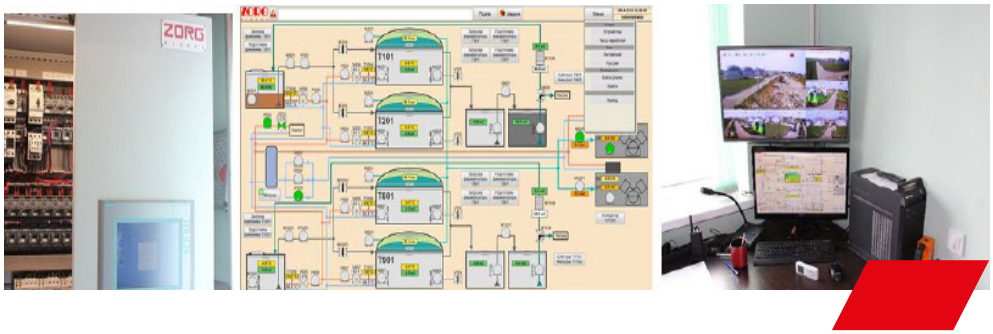
Circulating pump feeding heat carrier heating	
Flow	30 m3 / h;
Pressure	1 bar
Circulating pump feeding heat carrier to the digester	
Flow	18 m3 / h;
Pressure	1.1 bar
The pumping station feeding propylene glycol	
Flow	0.8 m3 / h;
Pressure	4 bar

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:	2 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=50 m3**	**2**
1.1	Container bunker		2
1.2	Feeding screws	set.	2
2	**Submersible mixer**	**N=5.0kW**	**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**	**10**
3.1	Airtight motor gearbox		10
3.2	Hydraulic screw (wear-resistant steel)		10
3.3	Shaft (adapted to the height of the fermenter)		10
3.4	Blade		10
3.5	Frequency converter		10
3.6	Mounting bracket to bottom of the mixer		10
4	**Safety valve of reactors**		**2**
5	**Window with a searchlight**	**set**	**2**
5.1	Inspection window RD300 (mounts and sealant included)	Ø300	4
5.2	Spotlight (mount system bundled) VISULUX UL50 -G -H	230V, 50W, IP65	2
6	**Substrate digested pump**	**30 m3/hour N=7.5 kW**	**2**

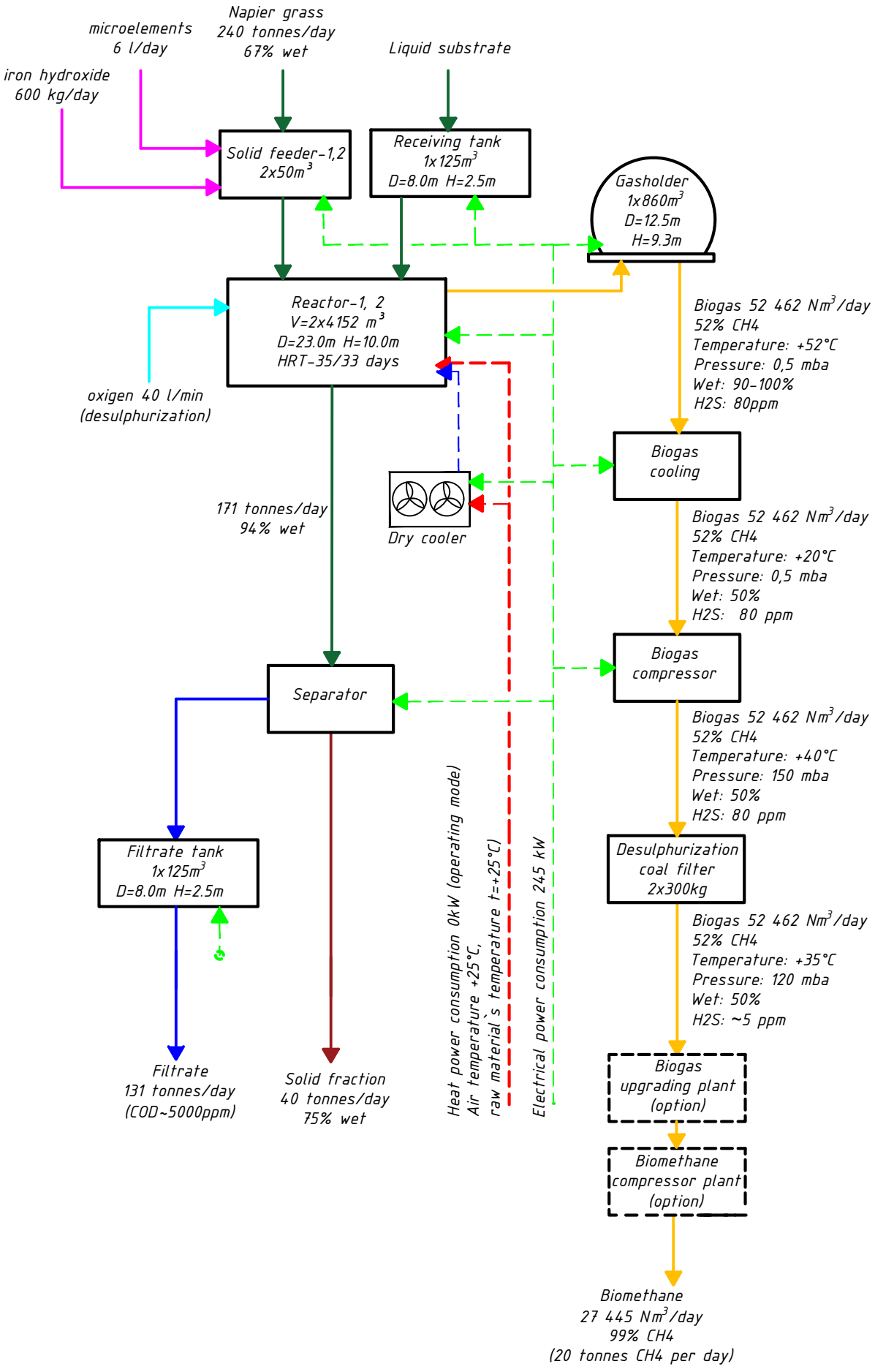
№	Equipment	Characteristic	Quantity
7	**Separator**	**N=5.5 kW, Q=8-12m3/h**	**2**
7.1	Body		2
7.2	Substrate Supply Pipe 4 ’’		2
7.3	Engine - Gearbox	N=5,5 kW	2
7.4	Frame		2
7.5	Screw		2
7.6	Sieve for filtration		2
8	**Filtrate pump**	**30 m3/hour N=7.5kW**	**1**
9	**Submersible mixer**	**N=3.0kW**	**1**
10	**PVC external gas holder**	**Ø15.4m**	**1**
10.1	Weather protection film	Ø15.4m	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**	**2200 m3/h**	**1**
11.1	Chiller		1
11.2	Heat exchanger		1
11.3	Polypropylene glycol tank		1
12	**Desulphurization system**		**1**
12.1	Numbers of charcoal columns	**300 kg**	2

№	Equipment	Characteristic	Quantity
13	**Biogas compressor**	**Q=2200m³/h H=150mBar N=26kW**	**2**
14	**Biogas analyzer (CH4 , CO2 , H2S, O2)**		**1**
15	**Electromagnetic flow meter**		**1**
16	**Flare**	**2200 m3/h**	**1**
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	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 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		3
21.4	Pressure sensor (substrate pressure) 2,5bar		3

№	Equipment	Characteristic	Quantity
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
21.7	Resistive thermometer (heat conductor temperature)		3
21.9	Conductometric sensor of maximum level		2
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	2
21.13	Humidity and gas temperature sensor	ESFTF-I	2
22	**Dry cooler 100kW heat pow.**		**2**
23	**Laboratory**		**1**

APPENDICES

Material flow diagram



ZORG BIOGAS

Appendix 2

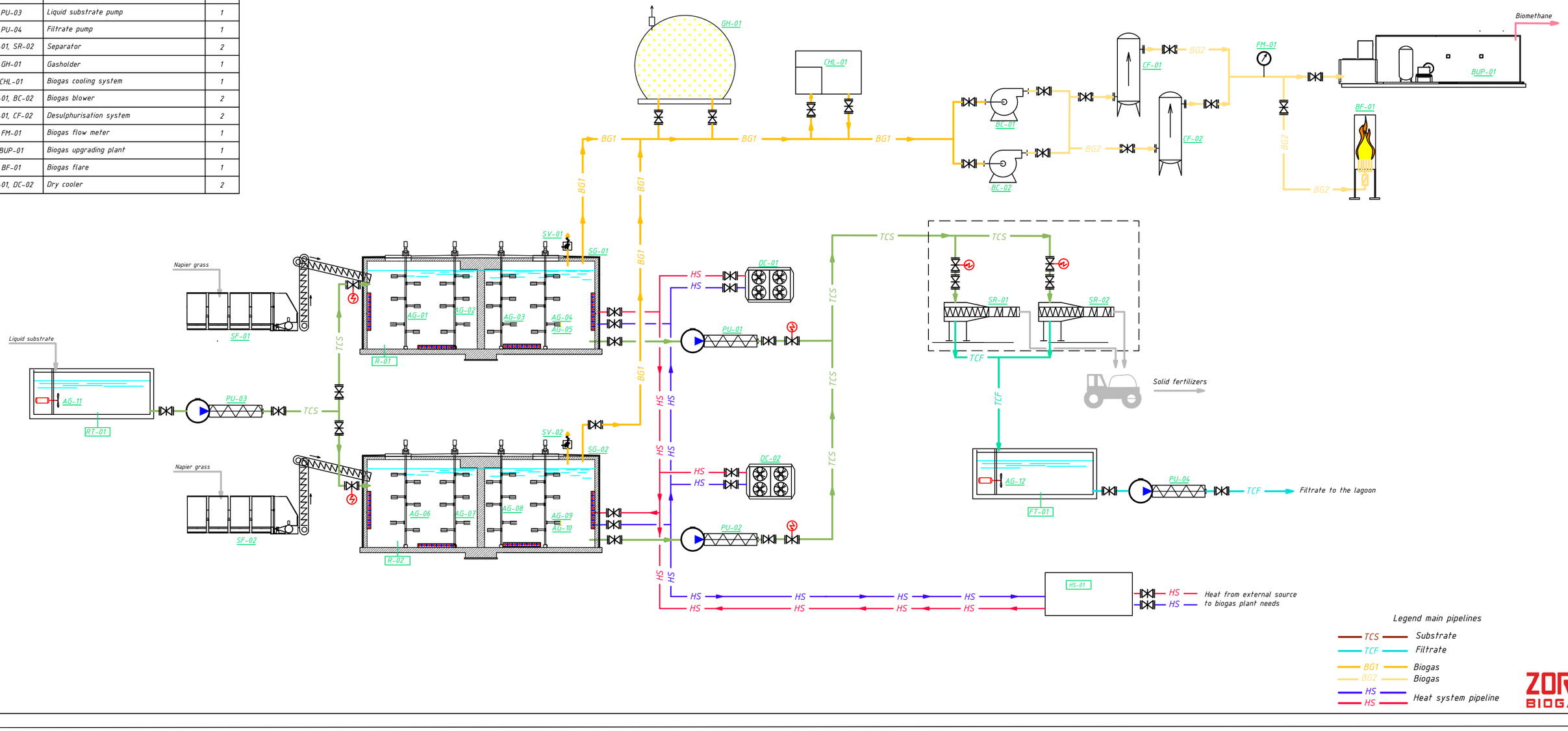
Explication

N/№	Name	Quantity
SF-01, SF-02	Solid feeder	2
SV-01, SF-02	Safety valve	2
SG-01, SG-03	Inspection windows	2
AG-01 .... AG-10	Vertical Paddle agitator of Reactor-1,2	2x5
AG-11	Submersible agitator of the receiving tank	1
AG-12	Submersible agitator of the filtrate tank	1
PU-01, PU-02	Substrate pump from Digesters tos eparator	2
PU-03	Liquid substrate pump	1
PU-04	Filtrate pump	1
SR-01, SR-02	Separator	2
GH-01	Gasholder	1
CHL-01	Biogas cooling system	1
BC-01, BC-02	Biogas blower	2
CF-01, CF-02	Desulphurisation system	2
FM-01	Biogas flow meter	1
BUP-01	Biogas upgrading plant	1
BF-01	Biogas flare	1
DC-01, DC-02	Dry cooler	2

Structure

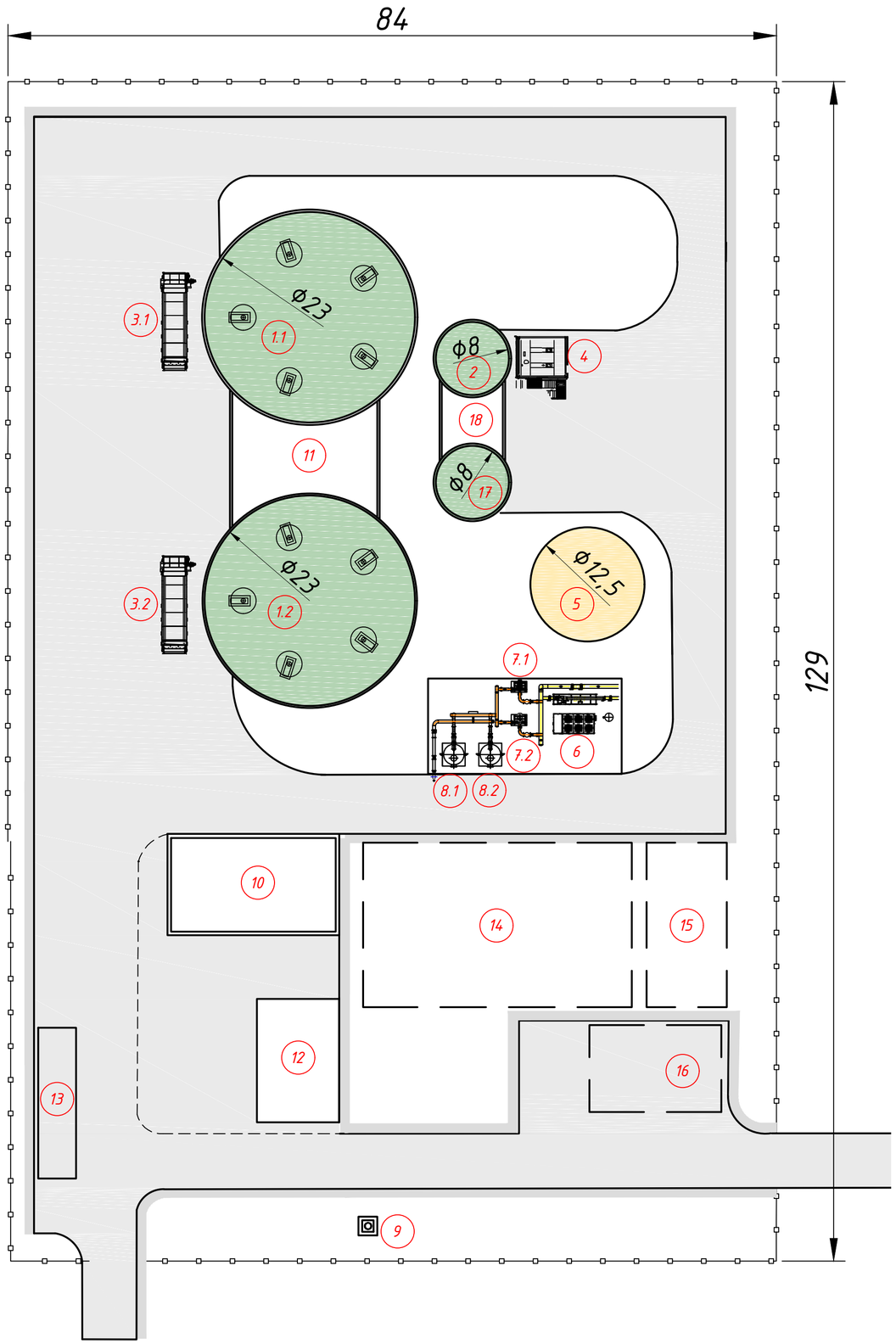
N/№	Name	Quantity
R-01 R-02	Reactor - 1,2	2
RT-01	Receiving tank	1
FT-01	Filtrate tank	1
HS-01	Heat sub-station	1

Basic diagram



Appendix 3

Plan



Explication

N/№	Name	Note
1.1	Reactor-1	R-01
1.2	Reactor-2	R-02
2	Filtrate tank	FT-01
3.1 , 3.2	Solid feeder-1 -2	SF-01, SF-02
4	Separation area	SR-01, SR-02
5	Gasgolder	GH-01
6	Biogas cooling system	CHL-01
7.1 , 7.2	Biogas compressor	BC-01, BC-02
8.1 , 8.2	Carbon filter (desulphurization)	CF-01, CF-02
9	Biogas flare	BF-01
10	Technical room (operator room)	TR-01
11	Equipment room	ER-01
12	Warehouse	WH-01
13	Truck scale	W-01
14	Biogas upgrading plant	BUP-01
15	Biomethane compressor plant	BCP-01
16	Gas station	GS-01
17	Receiving tank	RT-01
18	Pump station	PS-01

Biogas plant area - 0,87 ha

Total plant area with options - 1,0 ha

ZORG BIOGAS

Appendix 4

Electric energy consumption for own needs of the 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	22,0	2	44,0	8,0	352,0
Screw set.	16,5	2	33,0	8,0	264,0
Reactor Vertical agitator	15,0	10	150,0	18,0	2700,0
Submersible mixer in receiving tank	5,0	1	5,0	12,0	60,0
Submersible mixer in filtrate tank	3,0	1	3,0	12,0	36,0
Biogas cooling system	56,0	1	56,0	24,0	1344,0
Biogas compressor	26,0	2	52,0	12,0	624,0
Separator	5,5	2	8,0	8,0	64,0
Substrate pump to separator	7,5	2	8,0	8,0	64,0
Liquid substrate pump	7,5	1	4,0	2,0	8,0
Filtrate pump	7,5	1	4,0	2,0	8,0
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	2	8,0	24,0	192,0
Circulation pump for supplying heat carrier to the digester	0,8	2	1,5	24,0	36,0
Circulation pump for supplying heat carrier to the digester cooling system	2,0	2	4,0	24,0	96,0
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			**387**		
Total consumed electric energy, kWh per day					**5885**
Total consumed power, kW					**245**

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	340	1	340	24,0	8160
Biomethane compressor plant	250	1	250	24,0	6000
Total installed power, kW			**590**		
Total consumed electric energy, kWh per day					**14160**
Average consumed electric power, kW					**590**

Total average consumed electric power, kW					**835**

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Appendix 5

Prices for Zorg' services and equipment (part I)

Pos	Name	Number of units	Unit price, EUR	Discounts *	Discounted unit price, EUR	Discounted price sub-total, EUR
A	Project documention	1	95000	0%	95000	95000
B	Supervision	1	40000	0%	40000	40000
C	Startup and training	1	40000	0%	40000	40000
D	Living and travel expences	1	40000	0%	40000	40000
E	Delivery of the equipment	7	10000	0%	10000	70000
1	Solid feeder (dosing buffer machine)	2	145000	0%	145000	290000
2	Screw conveyor	2	144000	0%	144000	288000
3	Digester vertical mixer	10	78000	0%	78000	780000
4	Frame for Digester vertical mixer pos 3	10	6000	0%	6000	60000
5	Substrate pump	2	27000	0%	27000	54000
6	Biogas blower 1100 m3/h	2	52000	0%	52000	104000
7	Automation and electric cabinet	1	290000	0%	290000	290000

Appendix 6

Prices for equipment (part II)

Pos	Name	Number of units	Unit price, EUR	Discounts *	Discounted unit price, EUR	Discounted price sub-total, EUR
8	Gasholder	1	125000	0%	125000	125000
9	Over- and under pressure safeguard	2	5100	0%	5100	10200
10	Sight glasses/viewing windows with projector	2	4900	0%	4900	9800
11	Substrate pump	1	21000	0%	21000	21000
12	Filtrate supply pump	1	21000	0%	21000	21000
13	Substrate separation unit	2	44000	0%	44000	88000
14	Submersible mixer for receiving tank	1	11000	0%	11000	11000
15	Submersible mixer with guiding unit for filtrate tank	1	8000	0%	8000	8000
16	Biogas chiller (Biogas cooling system)	1	145000	0%	145000	145000
17	Desulphurization column with active coal 300 kg	2	35000	0%	35000	70000
18	Gas conditioning unit	1	17000	0%	17000	17000
19	Biogas burner	1	125000	0%	125000	125000
20	Heat supply station	1	37000	0%	37000	37000
21	Sensors (set)	1	100000	0%	100000	100000
22	Water supply and canalization system	1	27000	0%	27000	27000
23	Gas analyzer	1	27000	0%	27000	27000
24	Dry-cooler (Substrate cooling system for fermenter)	2	26000	0%	26000	52000

Total budget Zorg + Client

Appendix 7

#	Title	Cost	Value	Comments
A	Project documentation	95000	Euro	ZORG
B	Supervision and adjustment	40000	Euro	ZORG
C	Start-up and training	40000	Euro	ZORG
D	Living and travel expenses	40000	Euro	ZORG
E	Delivery (7 containers x 10000 EUR)	70000	Euro	ZORG
Pos 01-07	Equipment part 1	1866000	Euro	ZORG
Pos 08-24	Equipment part 2	894000	Euro	ZORG
25	Biomethane upgrading plant	1200000	Euro	local
26	Biomethane compressor plant	250000	Euro	local
F	Laboratory	25000	Euro	local
G	Construction	1800000	Euro	local
H	Napier grass bagger machinery	145000	Euro	local
I	Filtrate Storage	20000	Euro	local
J	Weight control (truck scale)	35000	Euro	local
	Total without subsidy	**6520000**	**Euro**	
	Subsidy	-800000	Euro	
	Total with subsidy	**5720000**	Euro	
	Zorg' part (pos. A-E, 1-24)	**3045000**	Euro	**47%**
	Client' part if no subsidy (pos. 25-26, F-J)	**3475000**	Euro	**53%**

Initial Data

Daily of raw materials, t	**239**
Amount of raw materials, t	**87.091**
Cost of raw materials, euro/t	
Total cost of raw materials per year, euro	**1.374.870**
Biogas output from 1 t of raw material, m3	
Total annual biogas output, m3	**18.987.975**
Biomethane equivalent 1m3	**0,53**
Biomethane module working days per year	**360**
Elec. energy for own needs per year, kWh	**7.214.400**
Total annual biomethane production, t/per year	**7.217**
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	**5.720.000**
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*
238,0	0,6	0,0060	
86.870	216,0	2,2	0,30
15,0	80,0	25.000,00	1.800,00
1.303.050	17.280	54.000	540
218,6			
18.987.975			

Biogas, m3/day	Biomethane, m3/day	Biomethane, t/day	El.pow self consum, kW
52.022	27.740	20,0	835,0

Biofertlizer, t
40,0

Equity investment	*Bank financing*	
20%	80%	
1.144.000	4.576.000	*Sum*
13,0%	13,0%	*Interest rate*

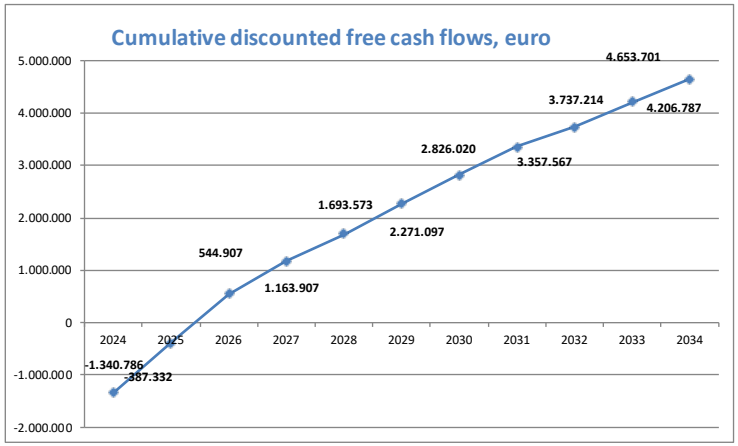
Economic effect

IRR	**76%**
NPV, euro	**4.653.701**
Payback period, years	**2,2**
Discounted payback period, years	**2,4**
Cummulative net profit, euro	**9.910.174**
Cost of 1 t of biomethane, Euro	**315,88**
Cost of production of 1000 m3 of biogas, Euro	**117,91**

CapEx amortization		**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Incoming balance		**0**	**6.520.000**	**5.868.000**	**5.281.200**	**4.753.080**	**4.277.772**	**3.849.995**	**3.464.995**	**3.118.496**	**2.806.646**	**2.525.982**
Amortization	10%	0	652.000	586.800	528.120	475.308	427.777	384.999	346.500	311.850	280.665	252.598
Outcoming balance		**6.520.000**	**5.868.000**	**5.281.200**	**4.753.080**	**4.277.772**	**3.849.995**	**3.464.995**	**3.118.496**	**2.806.646**	**2.525.982**	**2.273.383**

Cash-Flows	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Gross revenue from biomethane +biofertlizer	0	5.268.484	5.268.484	5.268.484	5.268.484	5.268.484	5.268.484	5.268.484	5.268.484	5.268.484	5.268.484
Net revenue from biomethane production	**0**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**	**5.268.484**
Operating costs	**0**	**-2.221.500**	**-2.221.500**	**-2.221.500**	**-2.390.130**	**-2.221.500**	**-2.221.500**	**-2.221.500**	**-2.635.410**	**-2.221.500**	**-2.221.500**
Raw materials cost	0	-1.374.870	-1.374.870	-1.374.870	-1.374.870	-1.374.870	-1.374.870	-1.374.870	-1.374.870	-1.374.870	-1.374.870
Biogas plant service	0	-27.990	-27.990	-27.990	-130.620	-27.990	-27.990	-27.990	-279.900	-27.990	-27.990
Biomethane module service	0	-18.000	-18.000	-18.000	-84.000	-18.000	-18.000	-18.000	-180.000	-18.000	-18.000
Elec. energy for own needs	0	-721.440	-721.440	-721.440	-721.440	-721.440	-721.440	-721.440	-721.440	-721.440	-721.440
Salaries	0	-79.200	-79.200	-79.200	-79.200	-79.200	-79.200	-79.200	-79.200	-79.200	-79.200
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**	**3.046.984**	**3.046.984**	**3.046.984**	**2.878.354**	**3.046.984**	**3.046.984**	**3.046.984**	**2.633.074**	**3.046.984**	**3.046.984**
EBITDA margin		*58%*	*58%*	*58%*	*55%*	*58%*	*58%*	*58%*	*50%*	*58%*	*58%*
Finance expenses	-343.200	-545.307	-446.160	-347.013	-247.867	-148.720	-49.573	49.573	99.147	198.293	297.440
VAT		-565.953	-565.953	-565.953	-547.480	-565.953	-565.953	-565.953	-520.609	-565.953	-565.953
VAT credit balance	-800.000	-565.953	-565.953	-565.953	-547.480	-565.953	-565.953	-565.953	-520.609	-565.953	-565.953
Profit before tax	**-343.200**	**2.501.677**	**2.600.824**	**2.699.971**	**2.630.487**	**2.898.264**	**2.997.411**	**3.096.557**	**2.732.221**	**3.245.277**	**3.344.424**
Net profit tax	0	0	0	-434.370	-431.036	-494.097	-522.482	-550.012	-484.074	-592.923	-618.365
Net profit	**-343.200**	**1.935.724**	**2.034.871**	**1.699.647**	**1.651.972**	**1.838.214**	**1.908.975**	**1.980.593**	**1.727.537**	**2.086.402**	**2.160.106**
Net margin		*37%*	*39%*	*32%*	*31%*	*35%*	*36%*	*38%*	*33%*	*40%*	*41%*
Own investment	**-1.144.000**										
Loan repayment	0	-762.667	-762.667	-762.667	-762.667	-762.667	-762.667	-762.667	-762.667	-762.667	-762.667
Free Cash Flows	**-1.487.200**	**1.173.058**	**1.272.204**	**936.981**	**889.305**	**1.075.547**	**1.146.309**	**1.217.926**	**964.871**	**1.323.735**	**1.397.439**
Cumulative free fash flows	-1.487.200	-314.142	958.062	1.895.043	2.784.348	3.859.895	5.006.203	6.224.129	7.189.000	8.512.735	9.910.174
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	**-1.340.786**	**953.454**	**932.239**	**619.001**	**529.665**	**577.524**	**554.923**	**531.547**	**379.647**	**469.572**	**446.914**
Cumulative discounted free cash flows	-1.340.786	-387.332	544.907	1.163.907	1.693.573	2.271.097	2.826.020	3.357.567	3.737.214	4.206.787	4.653.701

Bank credit amortization	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
Starting debt dalance	0	4.576.000	3.813.333	3.050.667	2.288.000	1.525.333	762.667	0	-762.667	-1.525.333	-2.288.000
Credit drawdowns	4.576.000										
Principal repayment		762.667	762.667	762.667	762.667	762.667	762.667	762.667	762.667	762.667	762.667
Ending debt balance	4.576.000	3.813.333	3.050.667	2.288.000	1.525.333	762.667	0	-762.667	-1.525.333	-2.288.000	-3.050.667
Comission	45.760										
Interest	297.440	545.307	446.160	347.013	247.867	148.720	49.573	-49.573	-99.147	-198.293	-297.440


Cumulative discounted free cash flows, euro
5.000.000
4.000.000
3.000.000
2.000.000
1.000.000
0
-1.000.000
-2.000.000
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
-1.340.786
-387.332
544.907
1.163.907
1.693.573
2.271.097
2.826.020
3.357.567
3.737.214
4.206.787
4.653.701

Implementation terms and payment

Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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

List of exclusions

for a 20 tpd bioCNG plant:

1) Import taxes and local duties in India. The importer needs to apply the Ministry of Economy of India. To get waiving of the import duties. Biogas plant is a plant for renewables.
2) Project report, 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. The design documentation is not changed in fact. 10 000 – 15 000 EUR
3) Topographic and geological surveys 3000-7000 EUR
4) Electric transformer and the external electric line 250 kW for start-up, for construction period and 800 kW for normal operation.
5) Construction and installation materials and works, namely 1,8 million EUR, mentioned on the page 39 of the proposal. Zorg provides prelim drawings and bill of quantities for your evaluation and our fore cast verification.
6) External roads,
7) Temporary water supply during the construction and the hydraulic test of reactors at least 500 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 600-800 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) pos. 25-26 page 39 namely biogas to bioCNG purification (namely CO2 removal), compressor are Client' scope as well as gas cylinder cascades 200-250 bars, a truck for gas cylinders, gas fuelling station, bioCNG gas storage, a chromatograph,
12) oxygen generator 40 liter pro min for the desuphur system in order to keep the definite O2 and N level in the end-gas. If the requirements are not strict air can be used.
13) Oxidation of the refuse CO2 gas.
14) Liquefaction and storages of CO2
15) Activated carbon 0,3 tonne per 2 years x 1800 EUR/tonne
16) Fe(OH)3, Fe(OH)2 – 219 tonnes per year x 80 EUR/tonne = 17 520 EUR
17) Anti-foam reagent 7 tonnes annually (all kinds of vegetable oil, for example, palm oil or rapeseed oil)
18) PE foil for the silage storage
19) Demineralized water to the heating system 3 tonnes,
20) Spare parts

ZORG BIOGAS

Business center “Twin Yards”
Walter-Gropius-Straße 23,
DE-80807, München, Germany

Mob. +49 1511 457 29 45 (WhatsApp, Viber, Telegram)

igor.reddikh@zorg-biogas.com
www.zorg-biogas.com