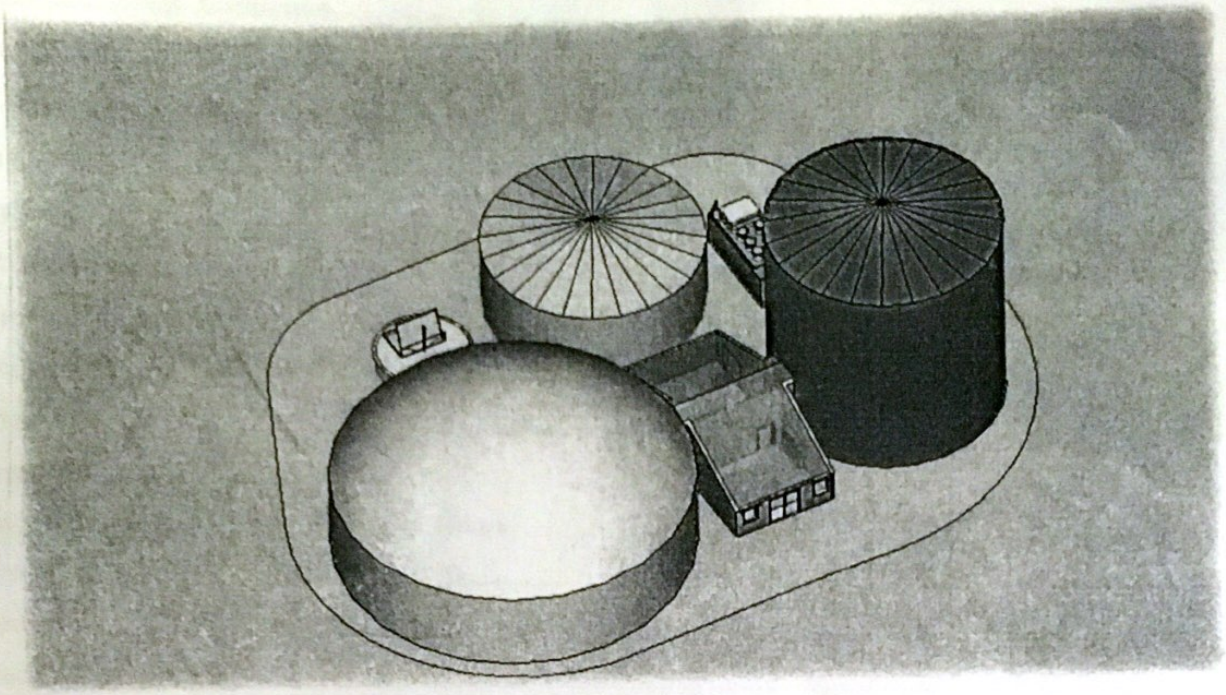

Bill Lloyd
200 kW

Project no.: 15.062
Hemmet, 05.11.2015 -/ABL

Revision 2

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Biomasses and energy production

Expected biomass and gas production

Input and gas production is estimated from the data on the quantity of biomasses, received from the customer and average dry matter content in the branch in Denmark, since we have no data from the customer about dry matter content in straw and dairy cake. This can be adjusted when we get further information.

The gas production is calculated for each biomass using Danish standard figures (GVS = production of methane per t of organic dry matter)

Input and gas production										
Biomass input	£ per ton	Cost	Biomass input t/year	TS%	Daily input VS/TS	Daily input VS%	Kg VS/ton	Daily input t VS/year	Standard GVS	Biogas CH4 m3/year
Chicken dung/litter	£15	£15,000	1.000	58,0%	80,0%	46,4%	464	464	290	134.560
Cattle dung/deep litter			500	30,0%	80,0%	24,0%	240	120	200	24.000
Grass silage	£30	£45,000	1.500	32,0%	95,0%	30,4%	304	456	350	159.600
Fruit scraps	£30	£30,000	1.000	25,0%	95,0%	23,8%	238	238	350	83.125
Water			7.000	0,0%	0,0%	0,0%	0	0	0	0
Recirculate			4.000	6,2%	85,0%	5,3%	53	211	70	14.756
Total		£90,000	15.000	11,4%		9,9%		1.488		416.041
Total production of CH4										416.041
Total production of biogas			61% CH4							680.068
			41 t/day							

The biomasses are suitable for digestion and based on the estimation of the nitrogen content. It is assed that the biomass can be digested in thermophile conditions (digestion at 50-53°C). The digester has an active volume of 760 m^3. The retention time in the first step is approx. 18 days. In total the retention time is approx. 55 days. The gas will be utilized in a gas engine for the production of electricity and heat. The engine will be chosen in cooperation with the client based on offers from potential suppliers taken in by ComBigaS.

Energy production				
	m3 CH4			kWh/m3 CH4
Gas production	416.041		4.135	9,94
Minimum engine size	202 kW electricity/h			
Electric production	1596 MWh/y	39%	Efficiency	
		5%	Servicetime	
		5%	Engine spare capacity	
Heat production	1.886 MWh/y	46%	Efficiency	
	215 kWh			
Heat demand for process	768 MWh/y	Deg C process	Deg C input	Loss
		52	12	10%
Equal to	88 kW heat			
Heat for external utilisation	1.118 MWh/y		128 kWh	

The electricity - approx. 1.600 MWh - can be used by the customer or sold to the grid. The surplus heat – approx. 1.115 MWh can be utilized for external purpose.

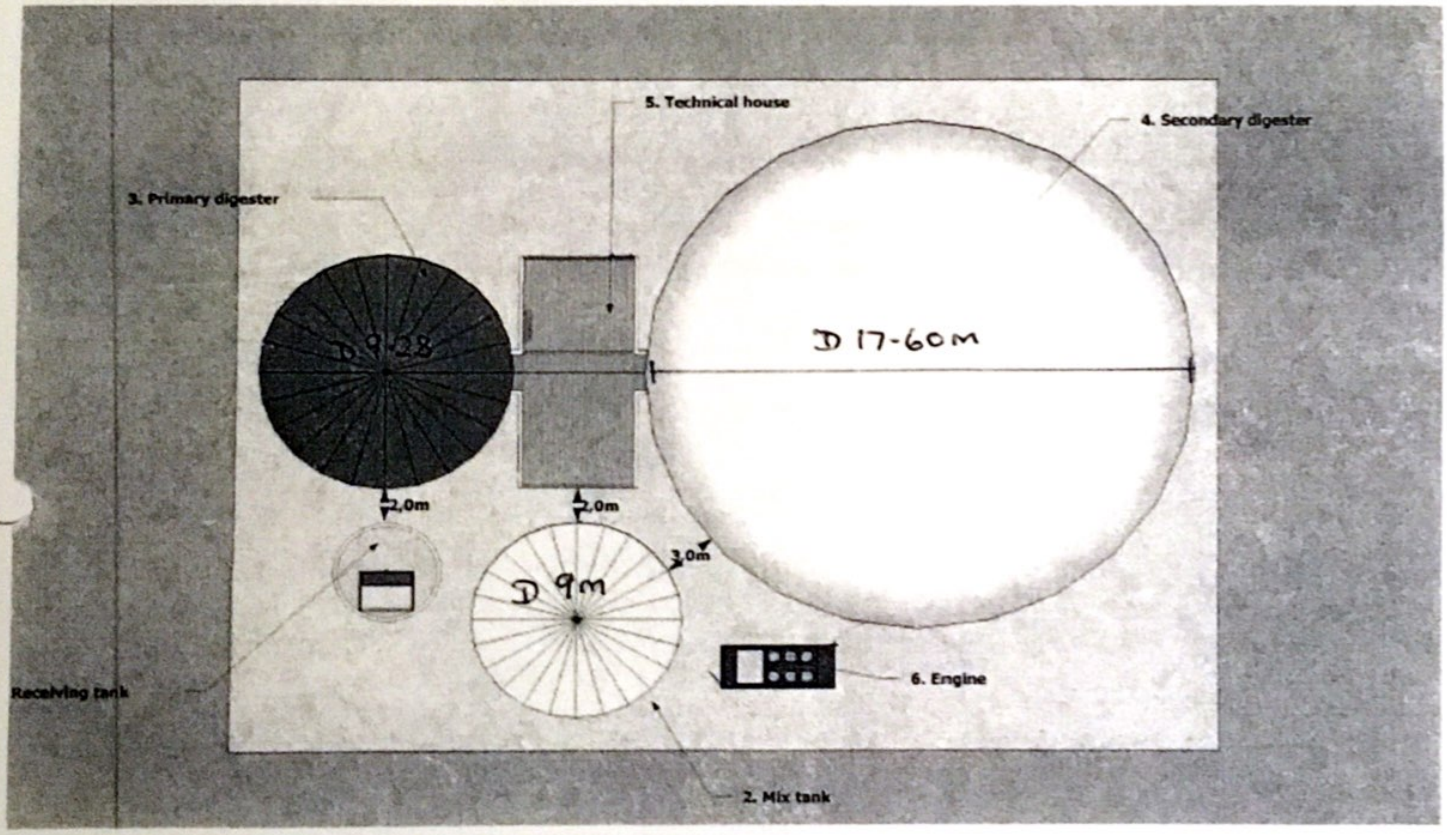
Technological description

The design is based on many years well proven Danish technology. The most important feature of almost all Danish biogas plants is the use of thermophilic fermentation process. Process design and handling system suit for the use of a wide range of agricultural biomasses as well as sewage sluts and industrial waste products.

Intake system

The system consists of an underground receiving tank, which is loaded with solid (not pumpable) biomass (straw and cattle manure), where it will be split and mixed with liquid materials from the mix tank (2) until a homogeneous consistency is suitable for pumping. The tank may also be used for other solid not pumpable biomasses, such as litter, energy crops (maize or sugar cane), as well as food industry waste (e.g. fruit and vegetable scraps)

The other container of the intake system is a mix tank (2), which is designed for more liquid types of biomass (e.g. water or slaughterhouse waste). This fluid biomass will be pumped into the receiving container when liquid is required to reduce the dry matter content to an optimum level for the production. The main mixing takes place in the mix tank (2).



Digesting

Digesting consists of 2 steps. First step is thermophile process at a temperature of 52 °C, which takes place in a primary digester tank (3). Total retention time in primary digester is calculated for approx. 18 days.

Mixing in primarily digester is based on an interval controlled circulation system – WITHOUT the high-maintenance big-bladed propellers which are characteristic of traditional digester mixing systems.
When the pump is running, it draws out thick liquid from the bottom of the tank into the chopper pump, whereby all lumps are comminuted.

1. In the first stage of the mixing process, the liquid is injected into the tank's upper half under high pressure while new biogas is being drawn from the top of the tank and mixed.

2. In the second stage of the mixing process the liquid is injected into the tank's lower half under high pressure which causes vigorous mixing of the tank contents.

Second step is a mesophilic process in secondary digester tank (4). Retention time in the secondary digester is approx. 36 days.

The combination of tank design, temperature handling and mixing system provides the necessary bacteria the best possible living conditions to achieve maximum digestion and thus the production of biogas.

Gas handling

Biogas is produced both in primary and secondary digesters. The biogas is self-flowing through related pipes at the top of the digesters. Gas is flowing to the storage facility designed as double membrane on top of the secondary digester.

Description of the Biogas plant

Intake tank solid biomasses – 3 m Wall Height (supplied by Hallmark)

Int. diameter 6,80 m

Gross capacity 75 m^3

The tank is equipped with:

- 1 pce mixer type POP-I 18,5 kW 3x400V/50Hz.
  Thermal sensors in the windings. With 7 m of electric cable. Stainless steel propeller.
  The unit is equipped with stainless steel suspension bracket and sliding console.
  Stainless steel installation equipment below liquid and galvanized equipment above liquid, consisting of guide pipe bottom bearing console, stop console, fixing bracket and upper guide holder.
- 1 pce radar to measure level of biomass
- 1 pce pump for mixing and pumping to primary digester 18,5 KW 3x400/50 Hz

Mix tank

The mix tank is a concrete digester and will be placed above ground.

Int. diameter:	9 m
Wall height:	6 m
Gross capacity:	370 m^3

The tank is equipped with:

1 pcs	Macerator - capacity from 30 – 150 m^3 per hour.
1 pcs	Mixer, type Gasmix 18,5 kW, 3x400V/50Hz. Placed outside chopper pump, type MPTK-I 18.5 kW, 3x400V/50Hz engine. Incl. galvanized support base and standard chopping system, Incl. piping, mixing nozzle at the bottom, injector, diffusor, bolt set for bolting the diffusor, one spray nozzle and slide valves in stainless steel for respectively manual and automatic operation.
pcs	Mixer, type Powermix POP-TR 18,5 kW 300 rpm, 3x400V/50Hz.
1 pcs	Pressure transmitter for level metering
1 pcs	Safety level switch to secure against overflow
1 pcs	Valve and coupling for trucks
1 pcs	Single membrane gastight cover to suit above tank

Pump

The pump installed at the Intake tank is a self-priming Lobe rotor pump. The pump is self-priming up to 8 meter vertical and can work up to 10 bar back pressure. The pump is particularly suitable operating with impure and/or high viscosity liquids.

The dimensioned pump flow rate is 25m3/hour. Same type of pump can be delivered with flow rate up to 30m^3/hour.

Primary Digester (base is supplied by Hallmark)

Gross volume:	802 m^3
Volume with 0,5 m freeboard:	760 m^3
Diameter:	9,28 m
Height, tank wall:	12,98 m
Roof pitch:	15°

The tank roof and wall sheets are made from galvanized steel sheets.

The tank is designed for seismic zone 0 (non-seismic) and a snow load of 1 kN/m^2.

The tank is designed according to applicable Eurocode standards.

The tank is designed for Gasmix stirring – without a top, centrally mounted stirrer.

Design:

The tank is designed for a max. internal operating pressure of 30 mm WG and a max. internal vacuum of 2,5 mm WG.

Further, the tank is equipped with:

1 pcs	Pressure / vacuum valve
1 pcs	Epoxy coated top hatch Ø 600 mm
1 pcs	Epoxy coated access hatch in the tank wall Ø 800 mm
1 pcs	Vertical ladder to edge of silo wall, incl. intermediate landing
1 pcs	Roof ladder to tank top and platform over the tank top Ø 2.00 m

Equipment

1 pcs	Radar for level metering
1 pcs	Internal heating in black steel pipes 5¼" in 3 circuits.
1 pcs	Pipe for emptying from floor
1 pcs	Valve and coupling for trucks

Insulation of the tank

Insulation of the tank with 200 mm wool. The tank is cladded with 0.5 mm trapezoid sheet in RAL color, according to customer's choice.

Mixing system in primary digester

1 pcs	Mixer type Gasmix 18,5 kW, 3x400V/50Hz. Placed outside chopper pump, type MPTK-I 18.5 kW, 3x400V/50Hz engine. Incl. galvanized support base and standard chopping system, Incl. piping, 90 ° intake elbow, mixing nozzle at the bottom and top, injector, diffusor, bolt set for bolting the diffusor, spray nozzles and slide valves in stainless steel for respectively manual and automatic operation.

Following the erection and concreting the tank performs a pressure test by means of air. Then the tank must be filled with water, before the insulation is carried out – in order to test the tank further. This test is performed by the customer– and is not included in the price.

Secondary digester tank

Concrete tank

Wall height:	6,0 m
Total height:	12,0 m
Int. diameter:	17,60 m
Gross capacity:	1480 m^3

The tank is made with an opening for a Landia mixer and pipes.

Central strengthening of base-slab for support of the center column for double membrane cover.

The tank is, 4.0 m from the bottom, painted with epoxy to ensure long life time.

Insulation of external wall – 100 mm polystyrene. Cladding of wall external above ground level using weatherproof profiled steel sheathings.

The tank is equipped with:

1 pcs	Mixer type Gasmix 18,5 kW, 3x400V/50Hz. Placed outside chopper pump, type MPTK-I 18.5 kW, 3x400V/50Hz engine. Incl. galvanized support base and standard chopping system, Incl. piping, 90 ° intake elbow, mixing nozzle at the bottom and top, injector, diffusor, bolt set for bolting the diffusor, spray nozzles and slide valves in stainless steel for respectively manual and automatic operation.
1 pcs	Mixer type, Power Mix POPTR-I 18,5 kW 300 rpm, 3x400V/50Hz Stainless steel propeller. All parts in contact with the liquid are made from stainless steel. The unit is assembled with acid proof screws only.
1 pcs	Pressure transmitter for level metering
200 m	Internal heating in black steel pipes 5¼" in 3 circuits.
1 pcs	Safety level switch to secure against overflow
1 pcs	Valve and coupling for trucks
pcs	Gas inlet and outlet
1 pcs	Gas purification unit. This unit will add atmospheric air to the anaerobic biological process. This will bind the sulfur as a solid.
1 pcs	Temperature sensor
1 pcs	Double membrane gastight cover to suit above tank

Included items:

- Centre column
- Inflation pump/Ventilator unit (Gas-output max. 200 m^3/h)
- 6" Safety device (pressure valve) – max. flow 300
- All straps and fixings

The foil has been UV stabilized, and has a minimum tensile strength of 4000 N/50 mm, and a gas permeability of < 350 $cm^3/m^2/bar/24$ h.

Insulation of external wall – 100 mm polystyrene. Cladding of wall external above ground level using weatherproof profiled steel sheathing.

Technical Building (supplied by Hallmark)

There is a technical building between primary and secondary digesters, which is used to manage and control all the processes taking place at the Biogas plant. The house is divided into two rooms. There are electrical control panels in one of the rooms and pumping heat distribution to the tanks and other mechanical installations in another room.

The house is supplied as prefabricated elements with an inner side made of the wood panels, which should be painted. The external side of the house is covered with steel sheets, which can be painted in any color. The outer steel plates can be supplied in trapezoidal or sinusoidal profile. The house is provided with double doors to the both of the rooms.

In the technical building a 3.0 kW compressor and adsorption dryer, plus an extra 90 liters container of dry air is mounted.
Pumps, valves, etc. should be as far as possible placed in technical building where it is possible according to the design.

The buildings are not heated.

Control system

The control system is a Beckhoff Industrial PC platform with a user interface being a 15 "touch panel with software for visualization and operation. The touch panel is mounted in front of the management board. On the graphical user interface the system displays current process values in a simple and straightforward manner – for example temperatures and levels of individual tanks.

Via the user interface more details about the individual processes can be obtained and plant operating parameters can be adjusted within some predefined limits. Should circumstances require that individual sections / components of the plant need manual operation, this similarly occurs via the graphical user interface.

Alarm / error situations within the plant are displayed on the control panel from where they can be reset. The setup of alarm levels etc. defines whether the alarms are automatically forwarded, via email / hotline, to the manufacturer.

This allows for remote system access, either from the PC or tablet. Remote access provides the same monitoring and management options that are possible on the control panel in front of the management board.

Facility operating data are stored in log files and can be continuously retrieved and analyzed. Additionally, changes to the operating parameters can be stored in the system.

Valves

Automatic valves on the system is pneumatically operated and located as far as possible in the technical building.
The valves are provided with end stops, and are fitted with a spring, which ensures the closure. Manual valves are fitted with hand wheels. All valves for biomass are industrial knife gate valves.
All valves on biogas piping are Atex approved butterfly valves.
There are mounted valves on all pump components, so servicing is possible.

Gas flare

Included items:

1 pcs.	Gas Flare Type GF 100 with a maximum incineration of 200 m^3/h with an inlet pressure of at least 7 mbar. Gas flare consists of gas pipe (DN 100) and burner head in stainless steel AISI 316L, mounted on a galvanized steel stand.
1 pcs.	Condensate trap (and rain water) Control cabinet Documentation and instruction manual.

Standard foundations

All tanks are installed on standard concrete foundations with reinforced steel structure. Concrete foundations are included in the scope.

-Standard foundations require a minimum of 80kN load bearing soil.
-Geo survey will be performed to verify load bearing on site - included.
-If bespoke foundations / piling systems will be required these are supplied against additional charges, prior to be prior approved by Client.

Client must level site prior to installation of foundations.

A standard CHP concrete base will be installed as per CHP manufacturer's specification / requirements for soil load bearing of 80kN.

Standard foundations, per above soil loadings, will be supplied and installed for the Technical Buildings

Electrical works

All electrical works are included for inside the red development area as indicated on the Planning Permit.

- Exclusion hereto is the connection from the Main LV panel in the abattoir to the AD distribution board installed in the Control Building

Following works are supplied and performed for electrical connection of supplied components and will be according to the bespoke PI diagram for the plant:

- AD Distribution Board with Main Switch installed in Control housing
- Cabling from Control Housing to all motors.
- Control wiring to all valves and sensors
- Lighting inside control buildings

All cabling will be installed in cable trays or suitable fixtures on walls / ground.

Pipe works

Following works are supplied and performed for Pipe Works between supplied components and will be according to the bespoke PI diagram for the plant:

- Pipe connections to transport biomasses between tanks.
  - Mild steel piping execution
  - Galvanized piping execution on exposed pipe works
- Pipe connections for gas between tanks
  - PEDH and Stainless Steel execution
- Pipe / hose connection for water connection between and into tanks
  - PVC execution
- Pipe / hose connections for air between controls and valves
  - PVC exectuion

All Pipe works included flange connection and welded connections as required

The gas pipe works terminates in a gas well located inside the works area, as designated by the red line on the planning permit, and max 10m from the Storage Tank

Pipe works termination point will be a 4" valve on the storage tank.

Investment

Please refer to the EPC Contract for costing details

Included in the EPC pricing is the following as supplied via local contracts

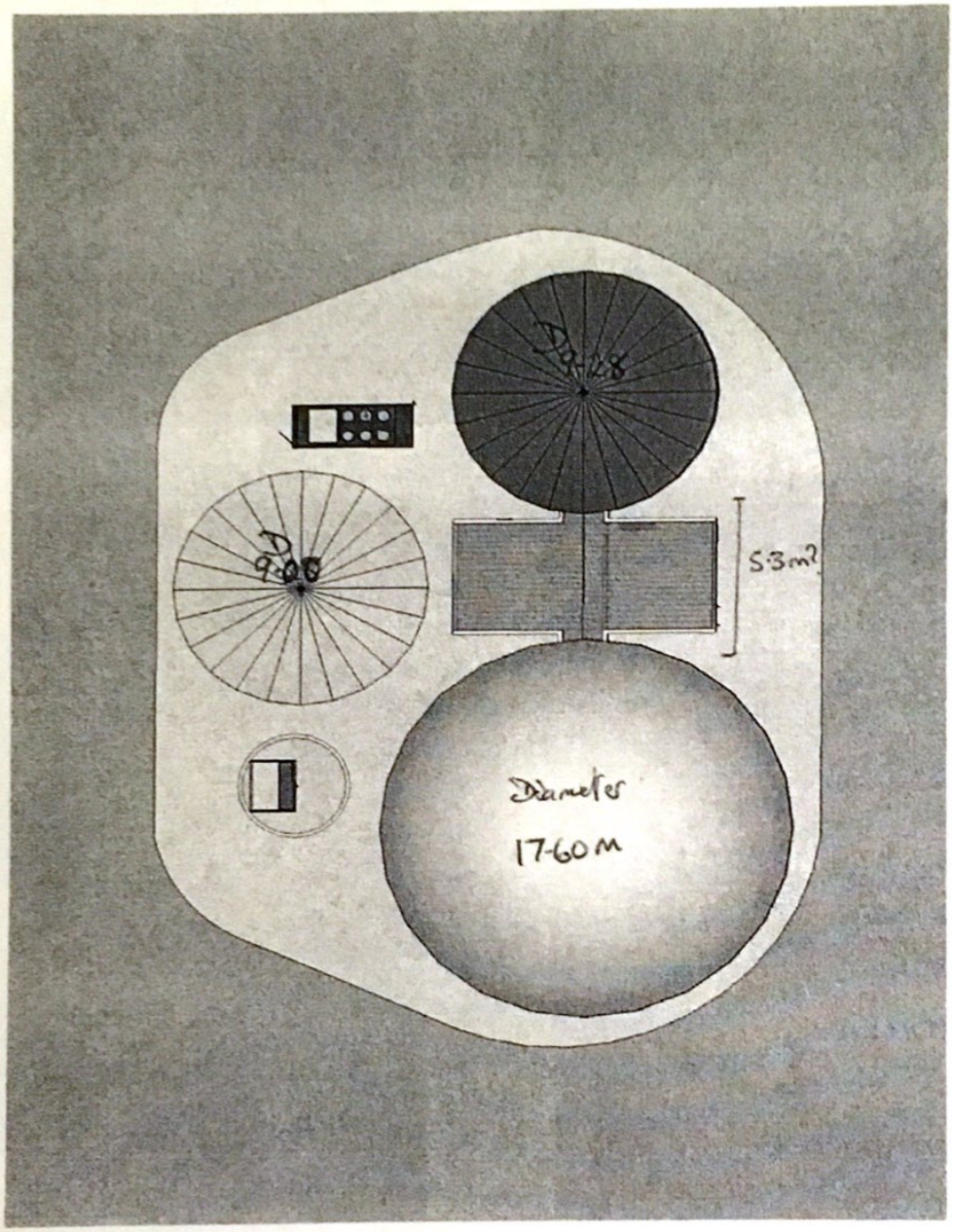
70 m^3 intake tank with a lid
Static calculation for digester base
Concrete work for digester base
Concrete work for technical house
Concrete work for CPH unit
Mounting of gas membrane. (Supervisor is included in price from ComBigaS)
Gas well
Electrical works including mounting of instruments
Pipework incl. heat pipe from CHP to primary digester
Mounting of machinery
Crane and scaffold

Options not included

- Soil tests
- Access roads
- Preparation of site
- Preparation of site ready for Excavation and groundworks
- Water, electricity and waste handling in construction period
- Storage for silage
- Cladding of wall above ground level using weatherproof profiled steel sheatings.
- Pump between secondary digester and storage tank.
- Fence
- Front loader
- Main switchboard
- Connection cost for grid connection including transformer
- Connection charges and possible transformer for internal use of electricity
- Internet connection for remote connection
- Lab equipment.
- All risk insurance
- Startup cost for example to heating up digestate until biogas is produced

The size and equipment of the additional units is a matter of further agreement.

Drawings



Figur 1 Plan

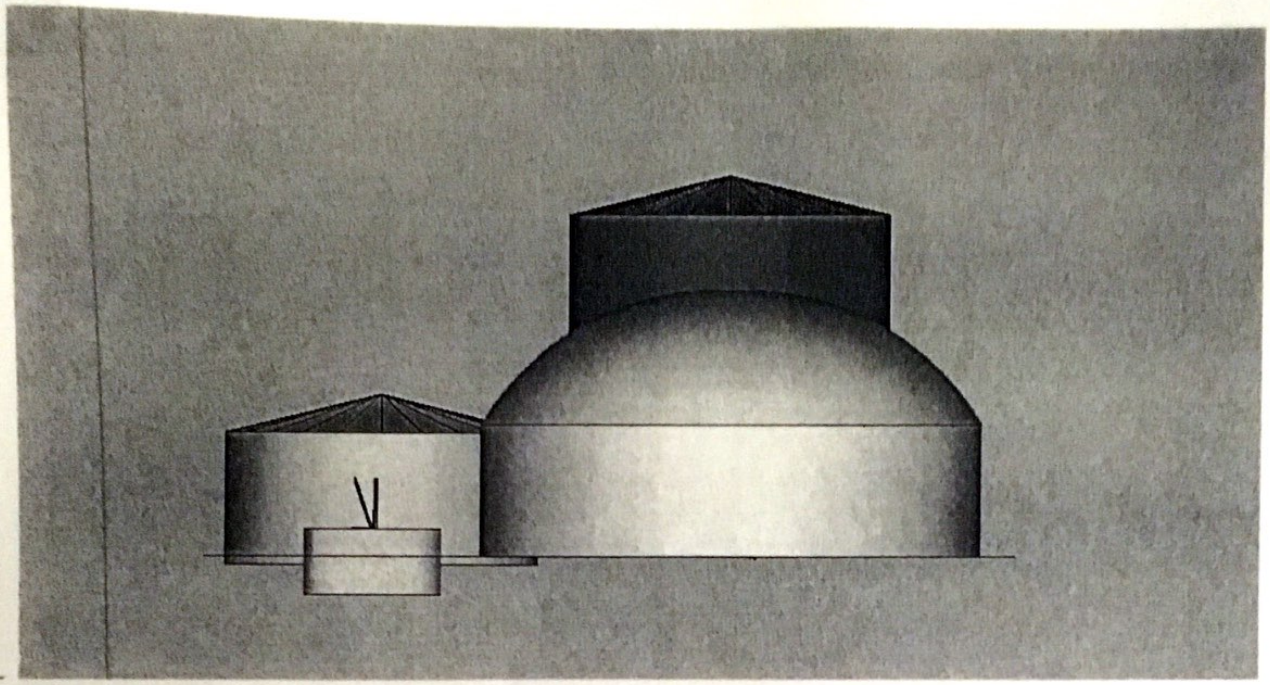


Figure 2 Left view

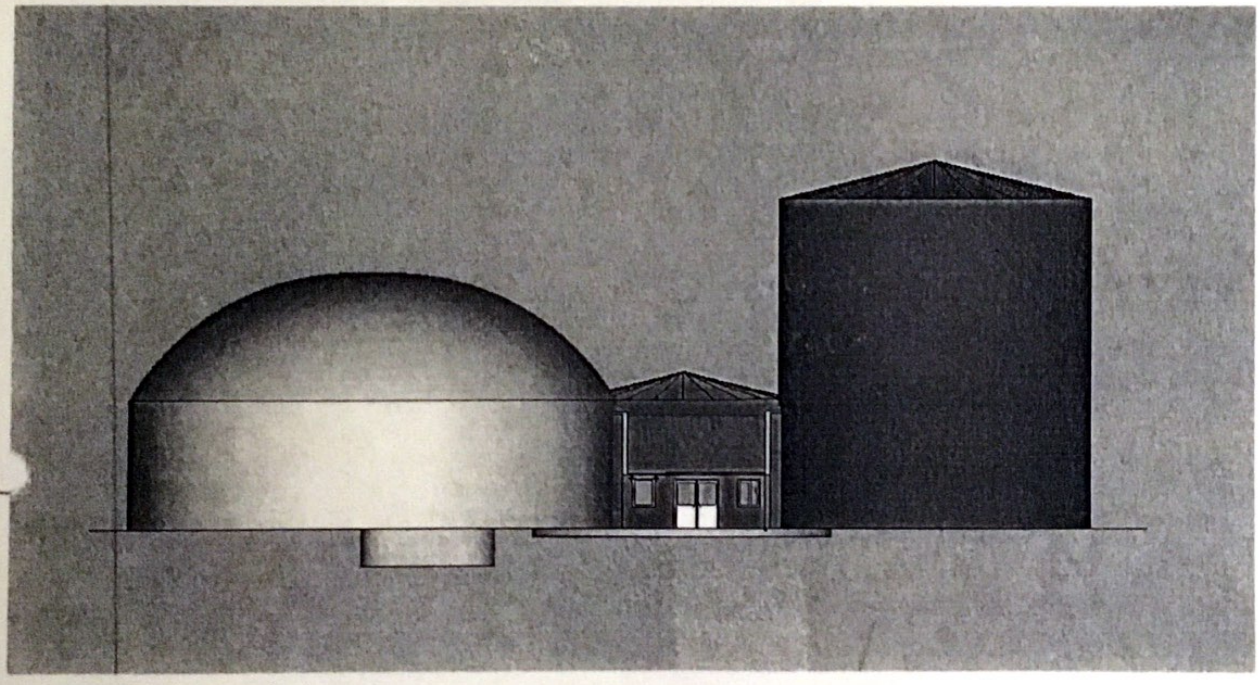


Figure 3 Front view

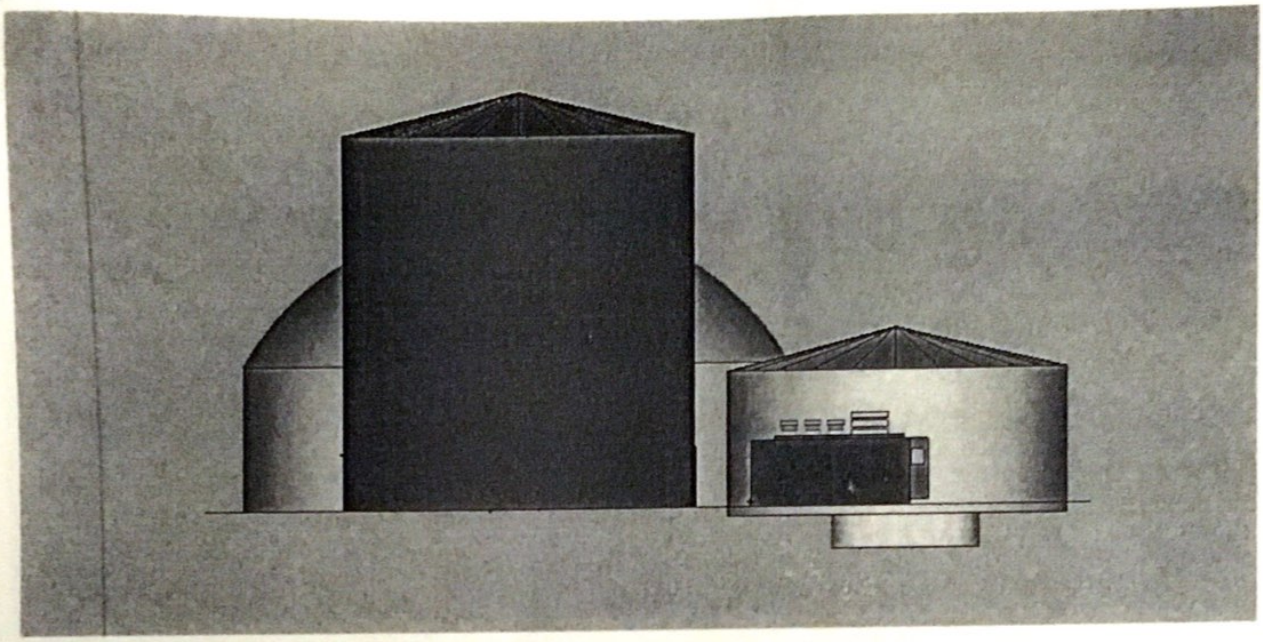


Figure 4 Right view

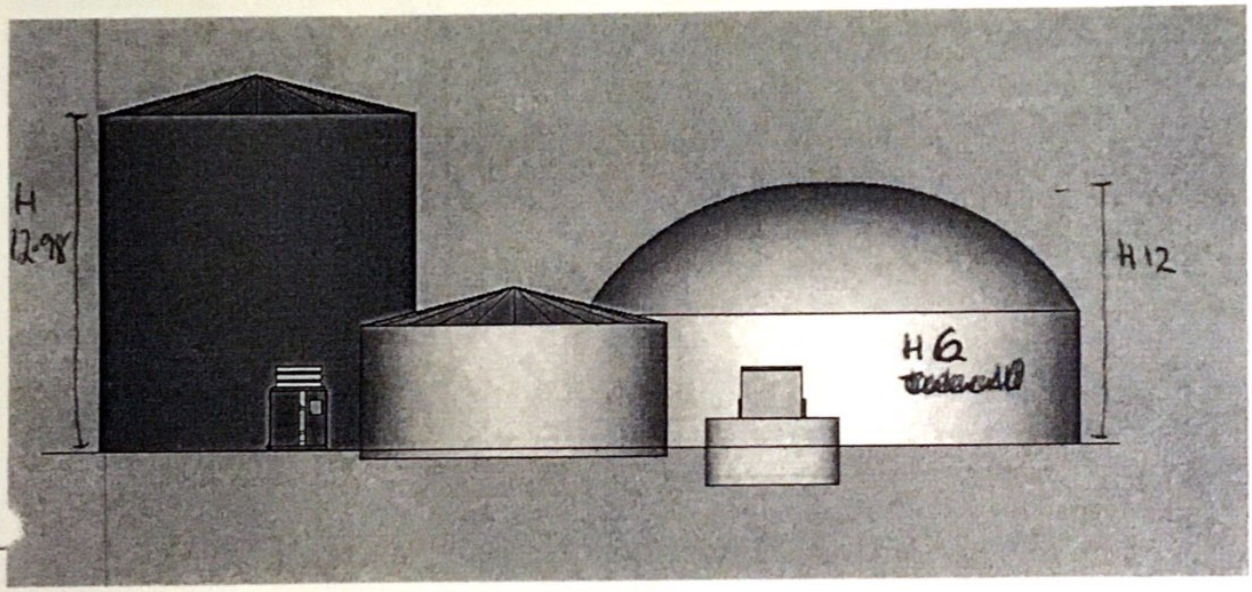
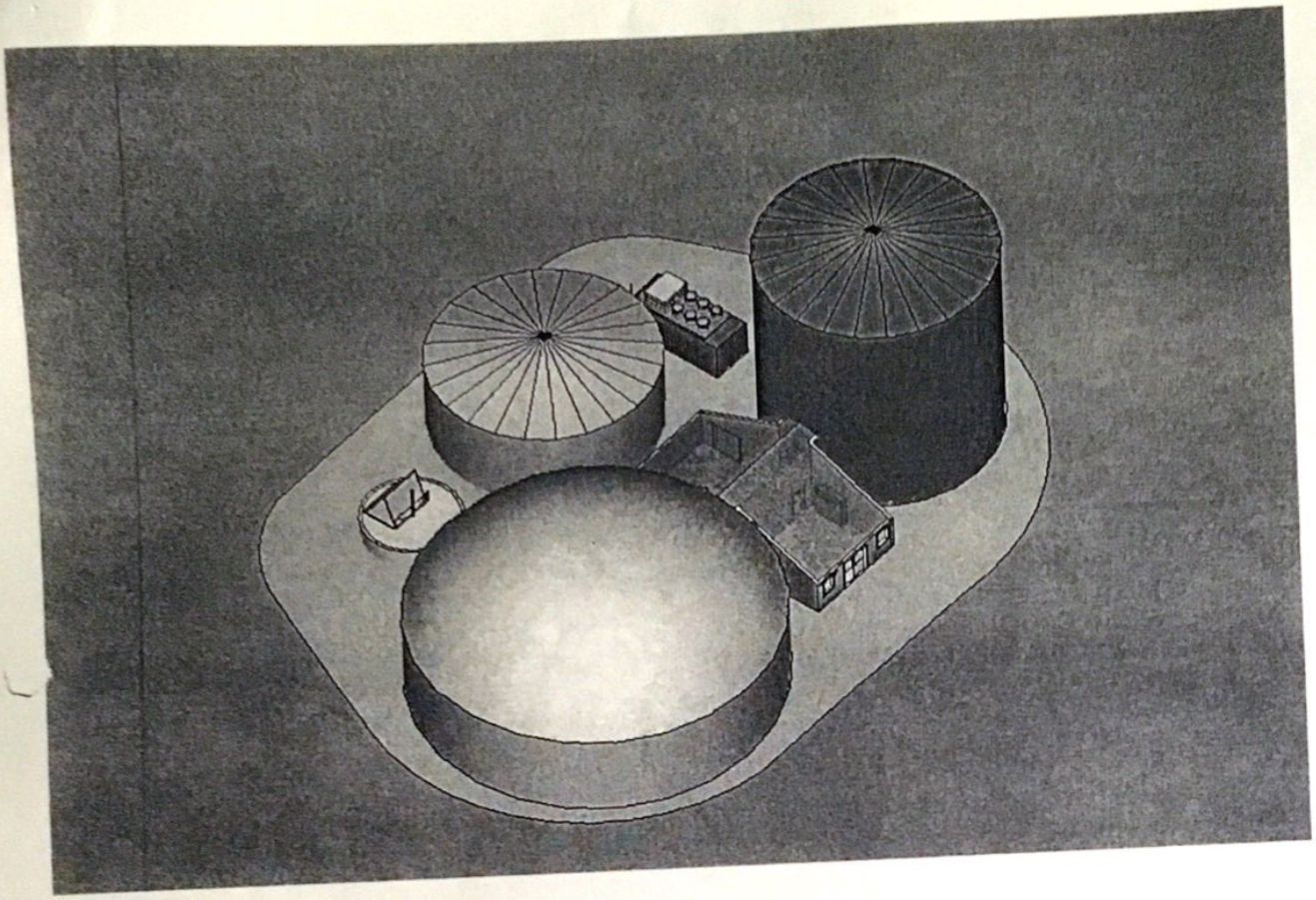


Figure 5 Back view



Figur 6 Iso view