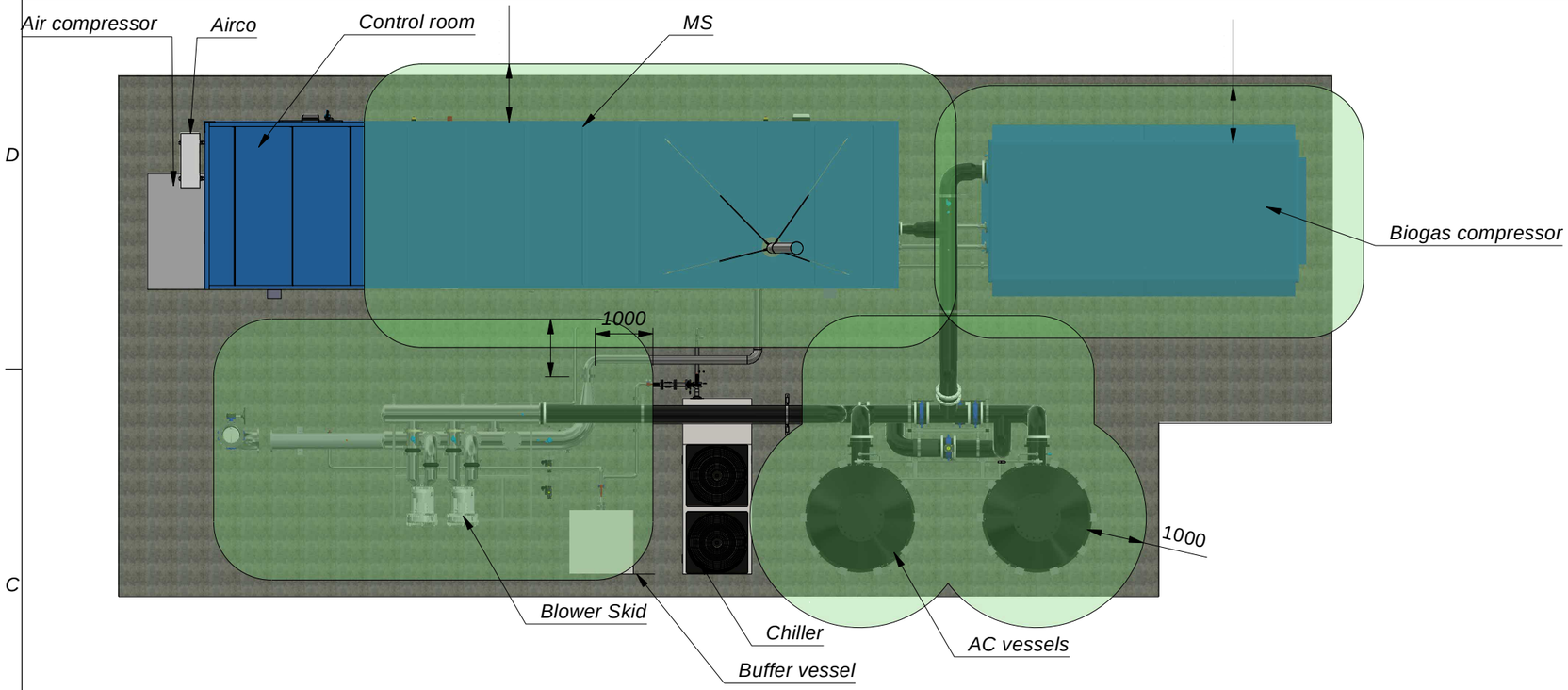
This document provides responses to the clarification questions raised by the LPA's expert witness on 29th November 2023. Accompanying files rereferred to in the response have been provided in an accompanying zipped folder.

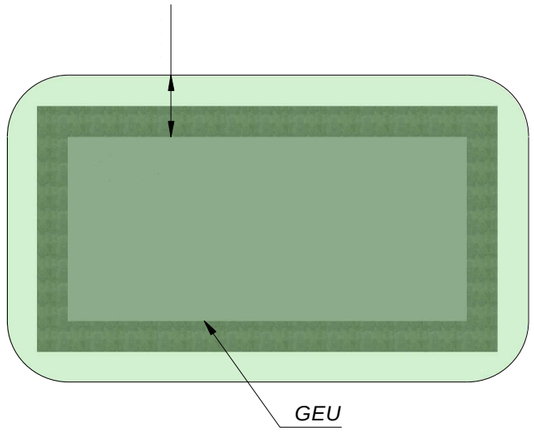
Number	LPA Question	Appellant Response	Accompanying File Reference	Planning Application Information Reference
1	Please can you provide your detailed process and mass balance calculations for the proposed development, including feed substrates, methane potential, dry solids, organic dry solids, process vessel capacity, heating requirements, dry matter control.	The technology provider is presently reviewing the mass balance model and a further revision will be provided in due course. Please refer to the heat demand calculations provided by the project technology supplier, and a statement of the sources of process heat.	[mass balance model file reference to be inserted upon receipt from Thoni] Document: "Heating Calculations"	This technical information is of a level of detail that would not ordinarily be included nor required for a planning application.
2	Please can you confirm how much digestate recirculation, as a daily mass, and its characteristics you have assumed in those process calculations (if not clear from the calculations themselves).	[Please refer to the mass balance model issued by the project technology provide Thoni which identified the substrate recirculation including the level of detail request].	[mass balance model file reference to be inserted upon receipt from Thoni]	This technical information is of a level of detail that would not ordinarily be included nor required for a planning application.
3	Please can you confirm where the proposed development will source process water from.	The project has several sources available which include, although may not be limited to: 1. Leachate collected from the site drainage system that services engineered areas of the site. 2. Rainwater collected by the site drainage system installed around the boundary of the site. 3. Waste water from the adjacent pig unit 4. Liquor produced by the on-site digestate separator (as expressed in response to question 2 above).	N/A	Section 4 4 of the design and access statement make reference to the use of on-site rainwater being harvested for use on site. Additional and supporting sources are referenced in this response should they be required.

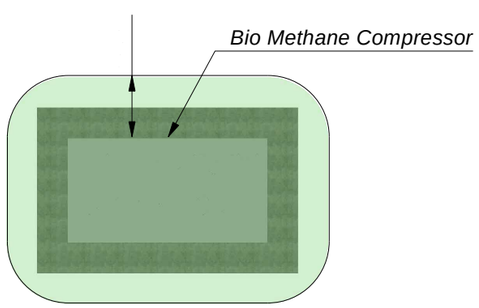
		5. Abstracted water from the site borehole		
4	Please can you confirm what subsidies the proposed development will benefit from (is this RHI or GGSS?).	The proposed development will apply to the Green Gas Support Scheme.	N/A	Information was not provided in planning application as those operating or experienced with AD facilities would understand that RHI accreditation has now ceased, and the GGSS is the sole tariff based financial incentive for injecting biomethane into the gas grid.This information is not normally relevant to the determination of a planning application.
5	Please can you confirm the specification for your CO2 capture equipment including its noise levels and also the level of electrical import required.	The specification of the CO_2 capture equipment has yet to be confirmed as the selection and ordering of the equipment has been delayed by the planning permission matters. Following initial discussions with technology providers, information on comparable projects has been provided. This suggests that the noise rating of the type of equipment (gas upgrade and CO2 compression) that may in due course be specified is 75dBA@10 mtr.	Brochure: “Pentair CH4 and CO2 Reference Equipment”	Information was not provided at planning as the specification has yet to be confirmed. This is an industry standard technology and is comparative with other types of available equipment.
6	Please can you confirm how odour from pasteurisation is intended to be controlled and what equipment will be used.	The proposal to utilise the second digester as a digestate store prior to pasteurisation will reduce residual biogas and therefore reduce odour potential.	N/A	3.1.3. and 3.1.14 of the odour impact assessment provide a reference to this odour management approach.

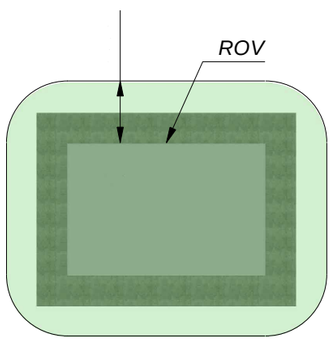
		Swan neck valves on each of the pasteurisation tanks shall be connected to feed either a carbon filter or acid scrubber filter for the treatment of displaced air within the pasteurisers. The specification of this equipment is to be confirmed.		
7	Please can you confirm if the straw is a clean agricultural crop or a contaminated waste FYM and if both, the quantities of each.	Straw inputs are top bales and low-grade product which may be unsuitable or undesirable in primary markets such as livestock bedding. As identified throughout the design and access statement, straw is a by-product of cereal production.	N/A	The design and access statement makes numerous references to straw as a by-product
8	Please can you confirm how the straw to enter the AD facility will be stored, processed and where.	Straw will be stored in the feedstock storage clamps. Straw will enter the anaerobic digestion process through one of two 90m^3 feeding hoppers. As part of the input feedstock, straw will then be conditioned for digestion through a Linder Limiator chopper pump to improve the digestion qualities of the material.	N/A	No reference was made in the application to storage and feeding arrangements for straw. Information was not provided in planning application as those operating or experienced with AD facilities would understand straw could be stored alongside ensiled feedstock.
9	Please provide DSEAR zoning drawings.	DSEAR Drawings are provided. Please note that a HAZOP and HAZID have been undertaken on the design which have resulted in operational controls to be implemented alongside these plans.	Drawing "AF300197_00_007c" shows ATEX/DSEAR zones on the digestion line Drawing "0273-GE.EH.06.0001 REV1.00" shows ATEX/DSEAR zones on the gas upgrade line Drawing "2554 - Deal Farm DSEAR - Rev 0" shows ATEX/DSEAR zones in the propane storage area	This technical information is of a level of detail that would not ordinarily be included nor required for a planning application.

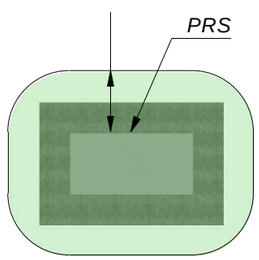
10	Please can you provide us with information as to how the facility will be commercially viable to run at a reduced feedstock level	The commercial viability of the facility is not a relevant material consideration. The Appellant has committed significant investment in the facility to date and is committed to the completion and operation of the same.	N/A	This commercial information is not necessary to include within a planning application or relevant to the determination of the appeal.











Estimated ATEX zone 2 in operation.
Zone 2 10% LEL.

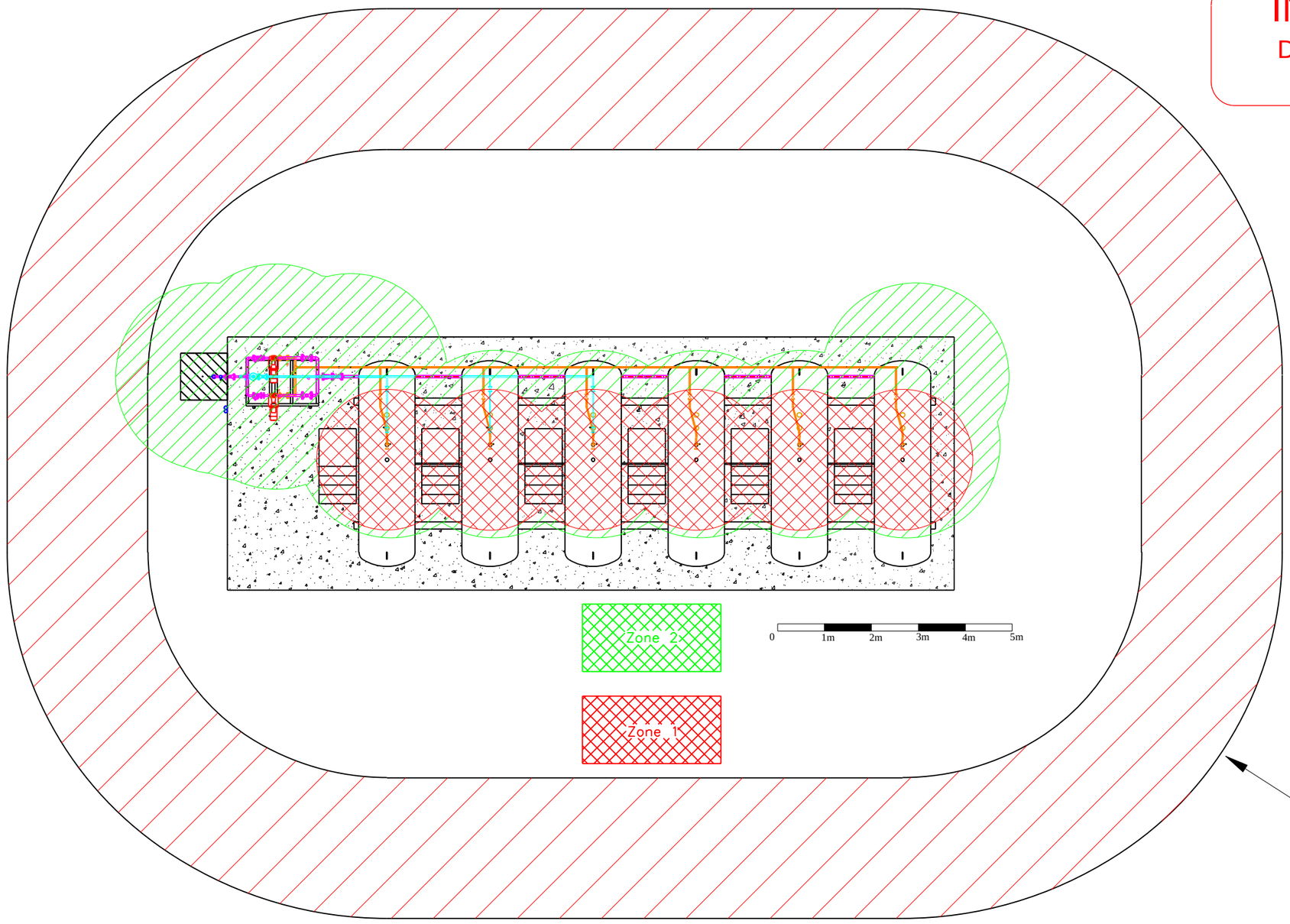
PRELIMINAIRY

Drawn by: AAG	Status: Preliminary	Title: GA			Project: Deal Farm	
Checked by: JWO	DMT Environmental Technology, Yndustrywei 3, 8501 SN Joure, Netherlands					
Checked date: 1 Jun 2021		Dwg std: ISO 216		Project no: 0273	Drawing no: 0273-GE.EH.06.0001	Revision:
Appr: MH		Toll: ISO 2768-1				
Appr. date: 1 Jun 2021	Client: Bio Watt	Size: A3	Scale at A3 1 : 100	Units: mm	Third angle projection:	Sheet: 1/1
Creation date: 31 May 2021	Doc type: Classification					

DRG. No. 2554 - 1	REV 0			THIS DRAWING, AND ANY INFORMATION CONTAINED THEREIN, IS THE PROPERTY OF FLOGAS BRITAIN LTD AND MUST NOT BE REPRODUCED WITHOUT WRITTEN PERMISSION	UNLESS OTHERWISE STATED THIS DRAWING IS FOR INFORMATION ONLY	ALL DIMENSIONS ARE IN MILLIMETERS. IF IN DOUBT ASK.

INDICATIVE ONLY

DSEAR is subject to as-built conditions



7.5m separation distance from valve arrangement, no buildings, boundaries or fixed sources of ignition to be located in this area.
Area should be free of drains, manholes gullies, deep rooted shrubs and tress.
And drains or manholes located within the exclusion zone must either be relocated or sealed to prevent the passage of LPG in the event of a leak.

Drawn using Hazardous Classification Zones Methodology Document Issue 4 - 12/08/2019

REV	DRAWN	DATE	CHKD	DATE	APPD	DATE	MODIFICATION
7							
6							
5							
4							
3							
2							
1							
0	RW	13/01/22					INITIAL ISSUE

TITLE: DSEAR
Deal Farm - Plan View
6 x 2T LPG Vessels
Pumped Liquid - Biomethane

FLOGAS REF: C3214

CLIENT ORDER REF:

CLIENT: Storengy

TOLERANCE: NA

FLOGAS BRITAIN LIMITED
WATERMEAD BUSINESS PARK,
RAYNS WAY,
SYSTON, LEICESTER LE7 1PF,
United Kingdom
Tel: +44 (0) 1162 649 000
Fax: +44 (0) 1162 649 012
Email:flogasenergyservices@flogas.co.uk
Website: www.flogas.co.uk

SCALE NTS @ A3 | SHEET 1 OF 3

DRG. No 2554 - 1 | REV 0

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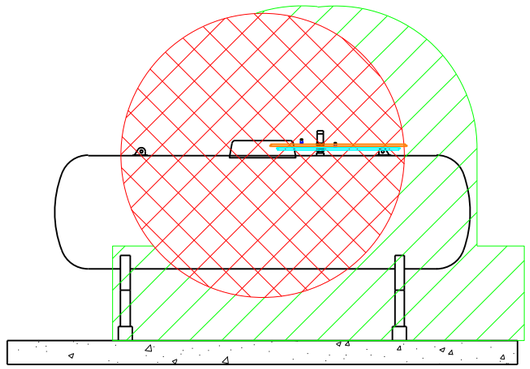
INDICATIVE ONLY

DSEAR is subject to as-built conditions



Drawn using Hazardous Classification Zones Methodology Document Issue 4 - 12/08/2019

REV	DRAWN	DATE	CHKD	DATE	APPD	DATE	MODIFICATION
7							
6							
5							
4							
3							
2							
1							
0	RW	13/01/22					INITIAL ISSUE

TITLE
DSEAR
Deal Farm - Side Elevations
6 x 2T LPG Vessels
Pumped Liquid - Biomethane

FLOGAS REF: C3214

CLIENT ORDER REF:

CLIENT: Storengy

TOLERANCE: NA

FLOGAS BRITAIN LIMITED
WATERMEAD BUSINESS PARK,
RAYNS WAY,
SYSTON, LEICESTER LE7 1PF,
United Kingdom
Tel: +44 (0) 1162 649 000
Fax: +44 (0) 1162 649 012
Email:flogasenergyservices@flogas.co.uk
Website: www.flogas.co.uk

SCALE NTS @ A3 | SHEET 2 OF 3

DRG. No 2554 - 2 | REV 0

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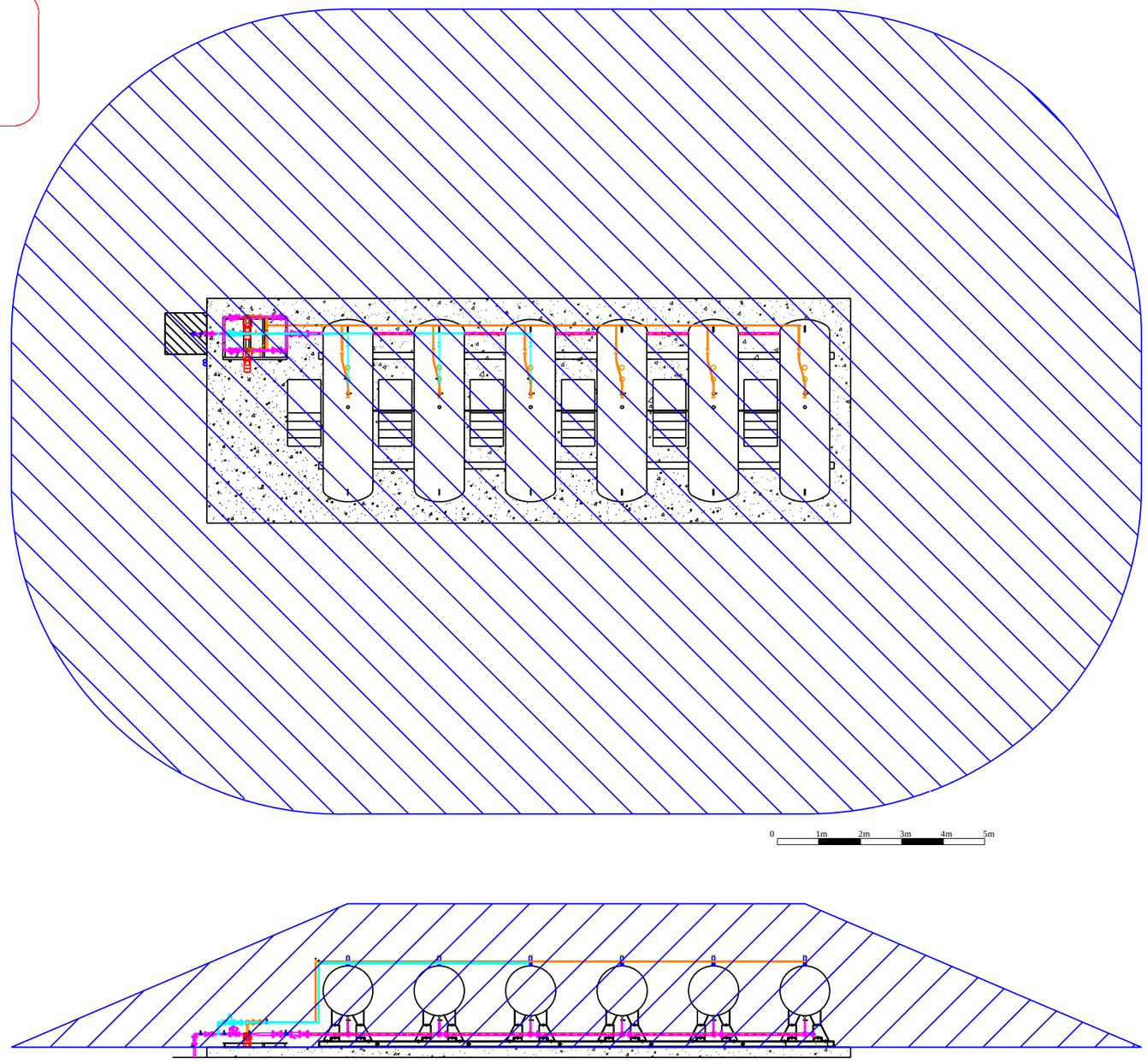
ALL DIMENSIONS ARE IN MILLIMETERS. IF IN DOUBT ASK.

INDICATIVE ONLY

DSEAR is subject to as-built conditions



Drawn using Hazardous Classification Zones Methodology Document Issue 4 - 12/08/2019

REV	DRAWN	DATE	CHKD	DATE	APPD	DATE	MODIFICATION
7							
6							
5							
4							
3							
2							
1							
0	RW	13/01/22					INITIAL ISSUE

TITLE: Protected Area
Deal Farm
6 x 2T LPG Vessels
Pumped Liquid - Biomethane

FLOGAS REF: C3214

CLIENT ORDER REF:

CLIENT: Storengy

TOLERANCE: NA

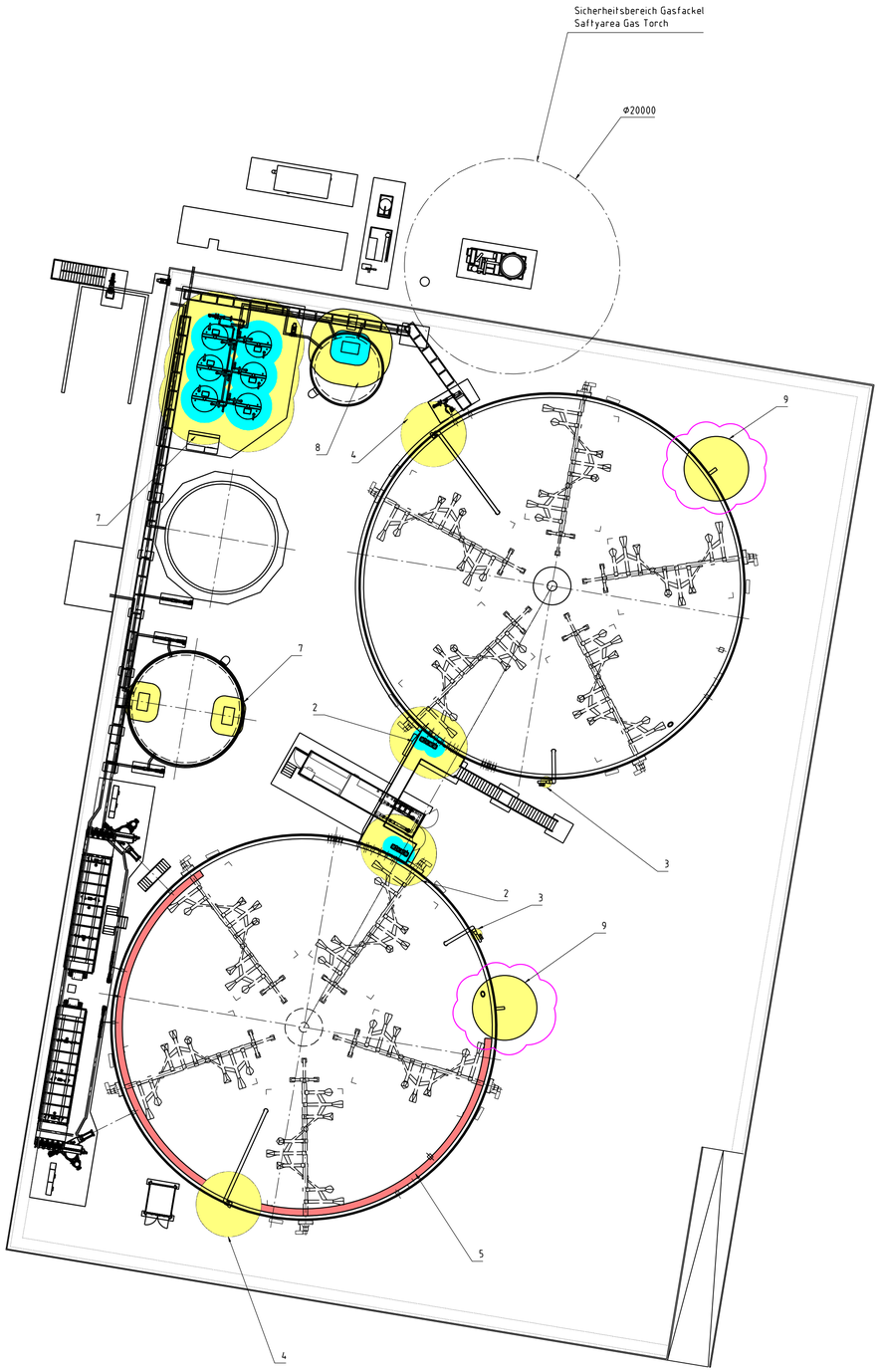
SCALE: NTS @ A3

SHEET: 3 OF 3

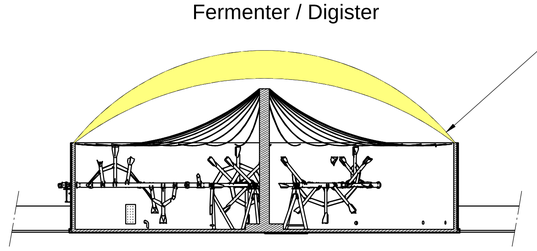
DRG. No 2554 - 3

REV 0

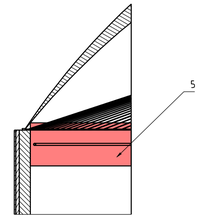
FLOGAS BRITAIN LIMITED
WATERMEAD BUSINESS PARK,
RAYNS WAY,
SYSTON, LEICESTER LE7 1PF,
United Kingdom
Tel: +44 (0) 1162 649 000
Fax: +44 (0) 1162 649 012
Email:flogasenergyservices@flogas.co.uk
Website: www.flogas.co.uk



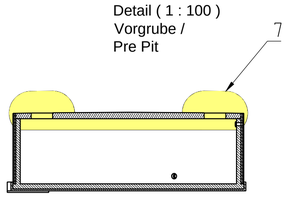
Detail (1 : 100)
Fermenter / Digister



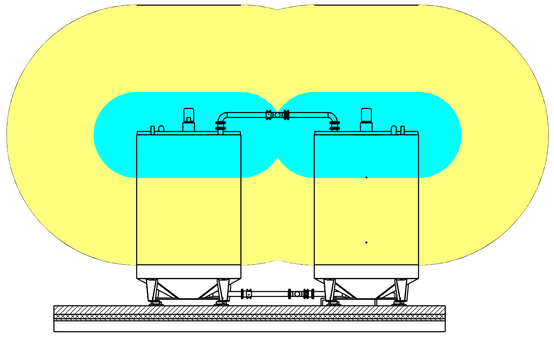
Detail (1 : 50)
Sauerstoffzuführung /
Oxygen supply



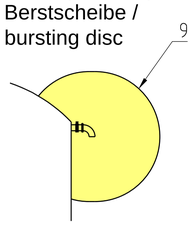
Detail (1 : 100)
Vorgrube /
Pre Pit



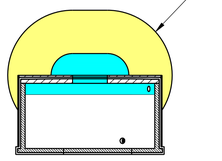
Detail (1 : 50)
Hygienesierung /
Hygenisation



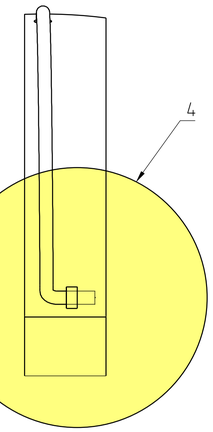
Detail (1 : 100)
Berstscheibe /
bursting disc



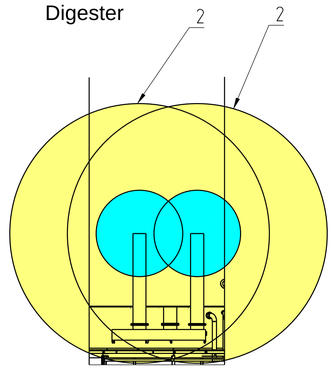
Detail (1 : 100)
Seperation



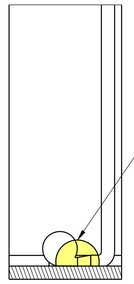
Detail (1 : 50)
Abluft Gashaube /
Exhaust air - gas hood
Digester



Detail (1 : 50)
Ü / Unterdrucksicherung /
Over- and underpressure safety
Digester



Detail (1 : 50)
Zuluft Gashaube /
supply air gas hood
Digester



Legende Ex-Zonenplan

Nr.	Benennung / Designation	Zone 0	Zone 1	Zone 2
1	Zwischenraum Tragluft von Gasspeicher Gas membrane system	/	/	Gesamter Raum Whole area
2	Fermenter Uber- Unterdrucksicherung Digester Over-and underpressure safety	/	R= 1m	R= 3m
3	Zuluft Gashaube / Supply air Gas hodd	/	/	R= 0,5m
4	Abluft Gashaube / Exhaust air Gas hood	/	/	R= 3m
5	Sauerstoffzufuhrung / Oxygen supply	R=0,5m	/	/
6	Hygienisierung / Hygienisation	/	R= 1m	R= 3m
7	Vorgrube / Pre Pit	/	/	R= 1m
8	Separation	/	R= 1m	R= 3m
9	Berstscheibe / bersteing disc	/	/	R= 3m

Zone 0 Zone 1 Zone 2

REV	MODIFICATION	Datum/DATE	Name/NAME
c	Hygienisierung verschoben. Pufferbank laut Kunde neu positioniert. Fundamente Gasbereich hinzugefügt Hygenisation new position Puffer tank new position. Foundation Gasarea added	03.08.2021	uf-kk
b	Ex-Zonen angepasst. Ex-Zone for Separation. Vorgrube und Berstscheibe hinzugefügt. Layout neu ausgerichtet Ex-zone added Ex-Zone Separation. Pre Pit and bursting disc. Realigned layout	22.06.2021	uf-kk
a	Ex-Zone der Hygienisierung hinzugefügt Ex-zone of the sanitation added	02.06.2021	uf-kk

Vorabzug / Preliminary

Name/Name | Bemerkung / In Arbeit
Datum/Date | Notice

Entwurf / draft

thöni.

Geschäftsbereich/DIVISION: Umwelt Energietechnik

Benennung / DESIGNATION:
BioWatt_Deal Farm_THV_UK

Layout

Vorschlag EX-Zonenplan
Suggestion EX-Zone plan

SAP PSP: AF300197
SAP Mat: ---

	Datum/DATE	Name/NAME
gez./des.	28.05.2021	kf-tk
gepr./ch.		

Zeichnungs-Nr. / DRAWING-NO.: AF300197_00_007
Revision: C
Gewicht / WEIGHT: ---
Proj.-Masßst. / MAIN SCALE: 1:200
Bl. / SH.: 1/1
Format: A0

Ers. durch / REPL. BY: | SAP-Mat.:
Ers. für / REPL. FOR: AF300197_00_007b | SAP-Mat.:
Ersatz aus / ORIGIN FROM: | SAP-Mat.:

Digester Heating Calculations.

The following digester heat balance was calculated by the technology provider for an annual input of 58,150 tonnes per annum.

The reduced input of 23,950 tonnes per annum will require around half of the energy load at 1,315 GWh/a.

This heating load will be met by a 500kW gas boiler which provides sufficient capacity for the calculated peak loading.

7.2 Assumed Parasitic Thermal Heat Consumption

The net heat requirement from the Biogas Boiler is: **1.600 MWh/a ***

The calculated total parasitic Thermal Heat Consumption of the Fermenters is: 2.630 MWh/a
These values are based on the following calculation:

Average Temperature per month:

January	February	March	April	May	June	July	August	September	October	November	December
4,4	4,6	6,3	8,8	12,1	15	17,3	17	14,8	11,6	7,6	5,1

Input stated in 2.1 digester temperature 42 °C 8,760 h/ a heating

Average temperature of the input substrate per month:

January	February	March	April	May	June	July	August	September	October	November	December
10	10	10	15	20	25	28	28	24	15	10	10

Peak heat consumption: 402 kW (in Jan.)

* Due to the heat recovery from the recirculated material and use of the CHP engine off-heat to preheat the incoming water, the net heat to be produced by the Bigas Boiler can be reduced to the value addressed above.

Pasteuriser Heating Calculation

The following pasteuriser heat balance was calculated by the technology provider, identifying a peak loading of 750kW.

This heating load will be met by and Edina genset with thermal output of 862kW, providing sufficient capacity for the calculated peak loading.

Pasteurisation Unit

Pasteurisation is required to prevent of the distribution of pathogens that might have survived the digestion process. The unit is set up as a batch system holding the substrate at a temperature level of min. 70°C for one hour of time.

Nominal capacity: **10 m³/h**

- ✓ Loading pump speed controlled (Wangen KL65 S.114)
- ✓ Vogelsang RotaCut maszeration unit
- ✓ Mazerator unit to keep particle size to acceptable dimensions
- ✓ 6 Pasteurisation tanks (10 m³ each)
- ✓ Discharge pump
- ✓ Process valves, instrumentation
- ✓ All process piping (including heat supply lines from the CHP to the unit)
- ✓ Control system to the unit

Product side:	AISI 316L stainless steel
Service side:	AISI 304 stainless steel
Support structure:	Galvanised steel

Thermal energy consumption nominal:	Hot water 90-92°C; app. 500 kW
Thermal peak consumption at start up:	Hot water 90-92°C app. 750 kW
Electrical power consumption:	app. 40 kW

BUDGET QUOTATION

Biogas Upgrading Facility for 1680 Nm^3/h and SE Solution
(BioComplete Solution)

Quotation no.:

Customer:
Attention:
Email:
C.c.:
Telephone:
Reference:

Pentair:
From:
Email:
C.c.:
Telephone:
Date:

Haffmans BV • Marinus Dammeweg 30 • 5928 PW Venlo • P.O. Box 3150 • 5902 RD Venlo • The Netherlands
T +31 (0)77 323 23 00 • **F** +31 (0)77 323 23 23 • **E** info@haffmans.nl • **I** www.haffmans.nl
Chamber of Commerce 12030119 (Venlo) • VAT nr. NL801391490B01

Index

1. Executive Summary

1.1. Introduction

Thank you for your interest in our Pentair upgrading solutions. Based on your request and our ongoing discussions, we are pleased to present a budgetary proposal for a Pentair Biogas upgrading solution for your review and evaluation.

Biogas is a general term for gas produced through an anaerobic fermentation process and primarily consists of a mixture of methane (CH_4) and CO_2. When upgrading raw biogas, we break the process into pre-treatment, primary upgrading, and compression. Pre-treatment and compression are options,which, if executed by Pentair, will adjust the inlet/outlet specifications of the raw biogas and/or finished renewable biomethane product in accordance with the transfer point gas specifications.

Your request to upgrade the raw biogas fromAD for pipeline injection (CNG, CHP, boiler etc) is an excellent use of Pentair's membrane upgrading technology. With a methane slip of 0/0.5/2.5 %, more revenue and billable molecules are recovered to optimize the business case over the life of the investment. Focusing on your CAPEX and OPEX constraints allow for a customized solution to achieve your desired recovery and methane yield. With very low power consumption, the cost of finished biomethane is controlled while still maintaining the required final quality for grid/CNG/LNG applications and use.

Following your review of our proposal, I would be pleased to discuss the solution with you and your colleagues ensuring we can align the scope of our capabilities to your requirements. In the meantime, should you or your colleagues have any questions or require additional information please feel free to contact us so that we can be of further service to you.

We look forward to the development and execution of this Biogas upgrading project in the near future.

1.2. Process Description: Pentair Biogas Upgrading Technology

Biogas is a general term for gas produced through an anaerobic fermentation process and primarily consists of a mixture of methane (CH_4) and CO_2. The separation of CH_4 and CO_2 is performed by high quality membranes in such a way that the highest economic value is achieved by the biogas upgrading system. By using a solely membrane separation system the installation becomes most cost efficient. The system is designed to gain the best out of electrical usage and yield of methane in such a way that the methane slippage is kept at a minimum.

Pre-Treatment Process:

The pre-treatment system focuses on conditioning the raw biogas for further processing and separation. Typically, the raw biogas is slightly pressurized with a centrifugal booster blower followed by dehumidification, drying and conditioning of the gas stream. The gas stream is optimized (dew point) for the performance of the H_2Sand VOC removal beds for optimal gas conditions prior to entry into the upgrading unit. Analytical sample points and Biosense analytical systems can be provided (optional) with the pre-treatment equipment.

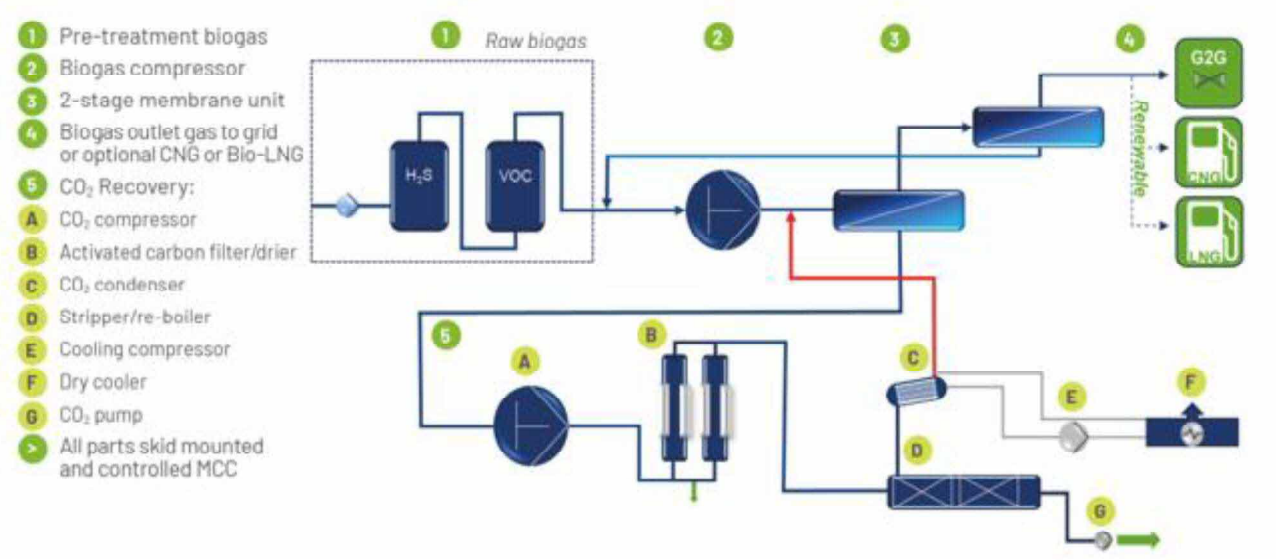
Primary Upgrading:

The pre-treated raw biogas is boosted (if necessary) and compressed to the optimal pressure for membrane separation. Coalescing and polishing is completed (as necessary) for membrane separation processing. Pressure and flow is controlled based on the outlet methane concentration atthe outlet of the processing skid. The biogas is conditioned for temperature and flow utilizing a chilled glycol cooling circuit to manage the gas temperature throughout the upgrading process. The glycol circuit can also support final product adherence to specifications when necessary. The upgrading system is PLC controlled with combination of drives, starters, valves and sensors for proper autonomous operation of the system. Final product quality is confirmed via the online analysis system prior to release.

CO_2 Recovery System:

Pentair has over 60 years experience in CO_2 recovery technology designs and solutions for CO_2 recovery systems. The CO_2 that is produced in the recovery installation exceeds food grade quality as specified by global gas associations (EIGA, CGA, ISBT) and could be sold to the beverage industry, green houses and for food freezing applications. The CO_2 recovery installation has one additional significant advantage in that it increases the Methane yield to 100%.

Generic ProcessFlow Diagram:



1.3. Operational Benefits

- **Variable Frequency Driveson biogas compressor and blower/booster:**
  The biogas compressor and blower/booster are equipment with and VFD for energy optimized capacity control.

- **Gas Filtration & membrane safeguard:**
  The gas filtration and oil filtering system comprises of 2 steps for effective prevention ofcontamination to the membranes:
  - The CPM sterile filter, type PSF, is a coalescing filter for 100 percent filtration of compressed biogas. Equipped with the patented, flexible Ecofilter® element, consisting of filter membranes in between segmented stainless steel disks, the PSF offers the highest filtration efficiency and security. The PSF's filter membranes, made of high-quality PTFE, are permanently hydrophobic. The filter membranes have an extremely high, 95 percent, pore distribution. This allows high flow capacitieswithminimal pressure drop.
  - A large carbon bed polishing filter provides additional safeguards designed to remove oil to low ppb levels
- **Capacity controlled membrane system:**

Depending on the required capacityandthe available biogasinlet flow, the system will automatically managegroups of membranesfor optimal separation.

- **Membrane design:**

Our membrane design and automated control allowsfor a wide range of biogas inlet CH_4 composition.

- **Fully automated system:**

The system is fully automated and will start, stopand control without operator requiredtointervention.

- **Remote control and support:**

The system incorporates the capabilityfor remote control and remote support. Asecure modem is installed allowing for a VPN connection between remote support and the system. Through this secure connection, we can provide "real time" remote support the plant operators.

- **CO_2 Recovery Systems:**

All Pentairmembrane and amine based upgrading technologies are compatible with our efficient CO_2 recovery technologies, adding another valuable revenue stream to your biogas plant: industrial or foodgrade CO_2.

- **Pentair Carbon Capture:**

Pentair is a partner and solution provider with Climeworks to remove CO_2 from ambient air and convert it into Food Grade CO_2. Pentair's solution is ideal given the requirement for high quality CO_2 and a compact technology solution.

A leading carbonated beverage company is supplying 25% of the CO_2 requirements for its premium water products from Direct Air Capture.

Pentair recently commissioned a capture and recovery system at a chemical facility that produces sodium bicarbonate used in food, pharmaceuticalsand animal feed.The CO_2 will be recovered and purified from the CHP flue gas before venting to atmosphere by capturing and producing up to 40,000 tons of CO_2 per year

Additional focus areasfor short term development are for Carbon Capture and Storage (CCS).

2. Commercial Summary

2.1. Scope of Supply

Each system consisting off:

Description	Quantity	Price
Oxygen Sensor	1	
H_2S Sensor	1	
Biogas Oil Lubricated Screw Compressor	1	
High Pressure Biogas Conditioning Unit	1	
Biogas Separation Membrane Unit	1	
Temperature Conditioning Unit	1	
Dry-Running CO_2 Gas Compressor	2	
High Pressure CO_2 Conditioning Unit	1	
Regenerative Activated Carbon Filter & Dryer Unit	1	
CO_2 Evaporator	1	
Methane Recovery / Liquid CO_2 System	1	
Refrigerant Compressor Unit (NH_3)	1	
Refrigerant Condenser – Air Cooled	1	
Refrigerant Evaporator / CO_2 Condenser	1	
Bleed System	1	
CO_2 Stripper – Reboiler	1	
CO_2 Liquid Transfer Pump	1	
Internal Cooling Circuit Utilities	1	
Electrical Hardware & Control System	1	
Skid Enclosed Housings	2	
Skid Enclosed Housing Services	1	
Supervisor for Mounting & Installation (17 weeks)	1	
Engineering, Design & Project management	1	
Design, Approvals & Certification	1	
Project Manager On Site Visit	1	
Interface Hazop Participation, remote support (2 days)	1	
Health & Safety Participation, remote support (2 days)	1	
Packing	1	
Total	**EUR**	[redacted]

Final costs of transport will be subjected upon readiness to shipment and will be charged to customer costs plus a handlings fee of 15%.

2.2. Options

As an addition to scope of supply, see the option list below:

Description	Quantity	Price (EUR)
Extra Oxygen Sensor	1	[redacted]
Raw Biogas Analyzer	1	
Biogas Fan Blower	1	
Gas cooling (Gas Chiller/Heat exchangers)	1	
Integration of 4 Active Carbon Filters – 2x H_2S Removal and 2x VOC	1	
BioSENSE – Online VOC SENSOR + Valve management system	1	
CO_2 Tank 80.000 liters – *Vertical (day price, excl. transport, incl. integration) (estimated)*	1	
Road Tanker Pump	1	
Air Compressor	1	
Interconnecting Materials, Pipes, Cables & Insulation – *estimation (based on standard layout on paragraph 6.3)*	1	
Onsite Labor, Tools & Equipment – *estimation (based on standard layout on paragraph 6.3)*	1	

Final costs of transport will be subjected upon readiness to shipment and will be charged to customer costs plus a handlings fee of 15%.

3. Terms & Conditions

3.1. General

The above-mentioned prices are calculated in accordance with the actual cost basis at date of issue of this proposal and under the condition that there is no partial delivery or variance from the scopeof supply.

3.2. Delivery

Packing included FCA Pentair manufacturing site(s) / ManufacturerEx works factory.

3.3. Delivery time

To be agreed upon subject to time of order.

3.4. Delivery conditions

According to ICC Incoterms 2020

3.5. Terms & Conditions

Our 'General Terms and Conditions of Sale Of Pentair Water Proces Technologie Holding B.V. and its subsidiaries' apply, filed at the office of the Trade Register of the Chamber of Commerce for East Netherlands, under the number 06032084. Haffmans B.V. expressly rejects the applicability of any of the customer's general terms and conditions.
For download go to:
https://foodandbeverage.pentair.com/en/downloads.
Click on: General Sales Terms and Conditions

3.6. Payment

- 30% down payment at order, balance againstmutually agreedpayment security (to be opened within 30 days of order).
- 30% at Engineering Milestone
- 30% at readiness of shipment
- 5% at mechanical completion(however no later than 16 weeks from readiness for shipment)
- 5% after signing of the acceptance certificate (however no later than 20 weeksfrom readiness for shipment)

Paid within 30 daysof invoice date.
All banking costs outside The Netherlands are care of customer.

3.7. Contact details

Haffmans BV
Marinus Dammeweg 30, 5928 PW Venlo,Netherlands
P.O. Box 3150, 5902 RD Venlo, Netherlands
Chamber of Commerce 12030119 (Venlo) • VAT nr. NL801391490B01
Wire Payment Instructions: Bank of America, Amsterdam, The Netherlands
BIC: BOFANLNX A/C No: 0266508197
IBAN NL 16 BOFA 0266 5081 97

3.8. Currency

All prices stated on this proposal are in EURO.

3.9. Duties

All required duty, excise, VAT etc. payments with respect to this proposal are care of customer.

3.10. Validity

This Quotation is Non –Binding, orders based on this quotation are subject to explicit acceptance byPentair.

3.11. Warranty

The offered parts have a warranty period of 12 months from start-up, however, not longer than 18 months from date of Ex-Works Pentair, Venlo. Parts that are subject to wear and tear (e.g. gaskets, coils) are not covered by this warranty. During the warranty period Pentair will replace defective parts free of charge, however we reserve the right to charge for labor, lodging and traveling costs.Not covered by warranty are liquidated and/or consequential damages due to loss of production.

Parts that are subject to wear and tear (soft goods, wear items, e.g. gaskets, coils) are not covered by this warranty. During the warranty period Pentair will replace defective parts free of charge, however we reserve the right to charge for labor, lodging and traveling costs.
Not covered by warranty are liquidated and/or consequential damages due to loss of production

The Customer is responsible for operating and maintaining the supplied plant according to the instructions and procedures provided by Pentair in the O&M manuals and where necessary the Technical Support department. Should the instructions and procedures described by Pentair not be followed this can have an impact on the provided warranty.

For analyzers, special warranty applies based on "back to back" according the terms of the OEM manufacturer/supplier.

3.12. 24 Months Extended Warranty OPTION

The offered parts have a warranty period of 24 months from start-up, however, not longer than 30 months from date of Ex-Works Pentair, Venlo. The extended warranty only in combination with a minimal 3 year Service LevelAgreement, on site availability of basic onsite spare parts including rotary equipment and local trained/skilled support/responders (care of plant operator).
Parts that are subject to wear and tear (e.g. gaskets, coils) are not covered by this warranty. During the warranty period Pentair will replace defective parts free of charge, however we reserve the right to charge for labor, lodging and traveling costs.
Not covered by warranty are liquidated and/or consequential damages due to loss of production

TheCustomer is responsible for operating and maintaining the supplied plant according to the instructions and procedures provided by Pentair in the O&M manuals and where necessary the Technical Support department. Should the instructions and procedures described by Pentair not be followed this can have an impact on the provided warranty.
For analyzers special warrantee applies based on back to back according the terms of the OEM manufacturer/supplier.

4. Responsibility Matrix

The list below indicates the scope split of the offered installation. Some of the items or services listed below are the responsibility of the Buyer/Customer and are excluded from the scope of supply. In certain cases these exclusions may be due to a lack of information preventing design and costing the items and/or services excluded. Wherever possible we are prepared to submit a quotation for such items upon request.

UTILITIES AND CHEMICALS	Supplier	Buyer
Initial oil supply for compressors	X	
Initial supply of Activated carbon for removing H_2S from Biogas		X
Initial supply of Activated carbon for removing VOC from Biogas		X
Initial supply of media for activated CO_2 system carbon filters and driers	X	
Initial supply of refrigerant for first fill		X
Make-up for process/cooling water (glycol, water or other media specified necessary for first fill)		X
Liquid CO_2 for commissioning and start-up (20-100 Ton) if required		X

DESIGN AND ENGINEERING	Supplier	Buyer
Process Flow Diagram	X	
Above ground foundation details, loads and generic anchoring design requirements	X	
Civil design work		X
Electrical & Instrumentation design	X	
Design & specification for interconnecting piping, safety valves, insulation, and cabling with isometric drawings (excluding pipe supports)	X	
Documentation in English language according to supplier standards	X	
All approvals by local authorities		X
All certificates (except CE/PED or ASME certificates for the press vessels) unless otherwise mentioned		X
Civil engineering to comply to ATEX 153 regulations		X
Risk analyses to comply to ATEX 153 regulations		X
ATEX compliant condensate drain pit for condensate drainage from the Biogas upgrader plant		X
All on-site non-destructive (pressure) tests and approval by authorities		X

PROCUREMENT	Supplier	Buyer
FCA Packing preparation	X	
Local permits		X
HAZOP Interfaces on site		X
Health & Safety coordinator		X
All health and safety certificates		X
All local approvals, technical translations		X

SUPPLY OF MATERIALS AND EQUIPMENT	Supplier	Buyer
Process skids fabricated based on PFD equipment lineup	X	
Unloading / positioning on site		X
Disposal of packing/filling materials		X
On site insulation of piping and vessels (as necessary)	(O)	
Ladder and platform installation (design/fabrication is scope dependent)		X
Piping, cables, instrumentation, valves, and insulation for skid-mounted equipment	X	
Design of piping, piping insulation and cabling between skic between skids and field equipment	X	
Supply and fabrication of piping and cabling between skids and between skids and field equipment based on supplier design within the scope of supply	(O)	
Installation of prefabricated piping, piping insulation (if applicable) ar cabling between skids and between skids and field equipment based on supplier design within the scope of supply	(O)	
Paint touch up on-site		X
Raw gas analyzer	(O)	X
Biomethane analyzer		X
Grid entry unit / Odorisation unit		X
Grid entry unit / Outlet Biomethane flow metering		X
Grid entry unit / Biomethane analyzer		X
Biogas piping connection to and from the biogas digester to the biogas upgrading plant		X
Biogas piping connection to/from the gate keeper to the biogas upgrading plant		X
Biogas piping connection to and from the flare to the biogas upgradin plant		X
Heat tracing outside piping and condensate lines		X
Inert gas for on-site pressure testing		X
Inert gas to inert the system		X
All utilities including raw biogas, reject gas to/from connecting points i biogas installation (skid enclosure wall is taken as boundary of turnke definition)		X
Calibration gas		X
Compressed dried instrument air	(O)	X
Hand-held gas analysis equipment Biogas		X

INSTRUMENTATION AND CONTROL SYSTEM	Supplier	Buyer
On-skid piping, cables, instrumentation and valves, Remote IO boxes	X	
Field Instrumentation and valves (within scope)	X	
Siemens S7 control system with UPS/HMI and programming acc. Pentair standard	X	
Control and integration of offered parts with customer's system exce mentioned items		X
Gas/fire/alarm detection system		X

ELECTRICAL EQUIPMENT	Supplier	Buyer
Electrical power supply and transformers (as applicable)		X
Electrical power and water on site		X
Power distribution and cabling		X
400 V MCC panel (per scope agreement) for installation in condition MCC/PLC area	X	
Lighting, earthing, lightning protection		X
Electrical grounding grid (earth connection nearby each unit)		X
Electrical main incoming cable from the customers distribution board Pentair MCC / Control Panel / Compressors etc.		X
Measures to reduction of harmonics from 6 pulse variable speed drives		X
Internet connection for offsite support		X

OTHERS	Supplier	Buyer
Buildings		X
Enclosure	X	
Civil design, foundation, buildings, and approval		X
All civil works and mounting/support constructions, platforms, ladders walkways		X
Mechanical and electrical installation works and materials	X	
Supervision during mechanical and electrical installation works	X	
Commissioning including training of local operators after completion of mechanical and electrical installation works	X	
Platforms and stairs, noise attenuation, waste disposal		X
Spare parts	(O)	
Commissioning spare parts	(O)	
Firefighting equipment		X
Toilet facilities, office		X
Waste disposal of materials		X
Permission to Operate		X
Any item not specifically mentioned in the quotation		X

WORKSHOP FABRICATION	Supplier	Buyer
Fabrication of equipment in supplier scope	X	
FAT	X	
Pressure testing/NDT according to applicable requirements (e.g. CE/ASME)	X	

4.1. Design, Approvals & Certification

Unless otherwise specified, the offered solution is designed and produced inaccordance with the following EU Directives:

- Machinery Directive 2006/42/EC
- Electromagnetic Compatibility -EMC2014/30/EU
- Pressure Equipment Directive 2014/68/EU
- ATEX 114 Equipment Directive 2014/34/EU
- ATEX153 Workplace Directive 99/92/EC

Unless specifically specified otherwise:

- All pressure vessels will be designed according to CE-PED and approved by a Notified Body. This does not include any special national requirements in addition to those specified in the mentioned directive.
- Electrical design & approvals will be in accordance with IEC 60204-1
- Standard for controls NEN-EN 60204-1
- Standard for safety NEN 3140
- EMC standard EN 61000-6-2 and EN61000-6-4
- NEN-EN-IEC 60079

Notes & recommendations:

- Built according to the **Pentair standard** to be installed under Pentair supervision and in accordance to Pentair P&ID's, general arrangement, instruction and manuals
- Pentair reserves the right to adapt specifications for engineering purposes.
- All expenses and materials for the fulfillment of local requirements that go beyond the measures required to obtain the CE mark for the delivered plant are not included.
- All expenses and materials required to obtain the operator's approval to operate the plant on the basis of local regulations are not included.

Note regarding UKCA (UK Conformity Assessed)

The UKCA marking is a new product marking that is used for goods being placed on the market in Great Britain (England, Wales and Scotland). It covers most goods which previously required the CE marking. The UKCA marking regime came into effect on the 1st of January 2021. However, to allow businesses time to adjust to the new requirements, CE marking is valid until the 1st of January 2023 in most cases.
Pentair is currently continuing to supply goods in accordance with EU CE regulations.
Pentair will, if applicable, apply UKCA marking from on or before 1 January 2023. Pentair reserves the right to modify its delivery schedule and pass on any additional costs associated with UKCA marking compliance.
This quotation takes into account compliance with EU CE regulations only.
While Pentair will use reasonable endeavours to ensure compliance with UKCA, we do not guarantee the same
Any cost/delay (including downstream sub-supplier delays) in connection with UKCA compliance will be passed on to the customer.

5. Design & Performance Specification

5.1. Design data

The following design data is based on experience in combined biogas upgrading and carbon dioxide recovery plants. Pentair strongly recommendsto conduct araw biogas analysis to confirm compliance with the specified compositionin this proposal. Unless the composition of the raw biogas coming into the upgrading system meets or exceeds (is lower in contaminants) the composition specification, Pentair cannot warrantythe performance of the plant, the produced biomethane and/or liquid CO_2 purity and/or the life of plant consumables.

Notes & recommendations:

- Built according to the Pentair standard, to be installed under Pentair supervision, and in accordance to Pentair P&ID's, general arrangement, instruction and manuals
- Pentair reserves the rightto adapt specifications for engineering purposes.

5.1.1. Incoming Raw Biogas

The offered plant design is based on 24/7 continuous digester operation with the following limitations:

Incoming Raw Biogas			
Biogas source		1680	
Biogas flow	min.	50% of max	
	max.	1680 Nm^3/h	
max. variation over a 30 min. period: ± 10% of minimal capacity			
Inlet pressure	min.	3	mbar (g)
	max.	120	mbar (g)
Inlet temperature	min.	10	˚C
	max.	45	˚C
Methane	range	52-60	% v/v
Methane	design min.	55	% v/v
CO_2	design max.	44	% v/v
N_2	max.	0.8	% v/v
O_2	min.	0.1	% v/v
	max.	0.2	% v/v
H_2S	design	<50	ppm v/v
NH_3	design	<1	ppm v/v
Relative humidity	100 % saturated, free of liquid		
Foam & liquid in biogas	foam & liquid free		
Particles		< 3	µm

Notes & Recommendations:

- Pentair standard values are applicable, until project specificparameters are agreedand defined.
- Nm^3/h based on 0 ˚C and 1013 mbara
- The above inlet parameters are expected at the inlet Flange connection of the skid enclosure.
- During the digestion of the bio-mass other (example; Siloxanes, Terpenes, Hexanes etc) can be formed that are not mentioned in the list above. The detection and separation of these components are not included in thescope of supply. If such contamination is found, Pentair will work together

with the Customer to find the best possible solution. Such additional works and eventual solutions considered as contract variations and are subject to revised quotation.

- Any changes as a consequence of revised inlet conditions, site location etc. will be reviewed and offered separately.

5.1.2. Utilities

Utilities	
Water for adiabatic spay dry-cooler	According OEM specification
Main Electrical Power Supply	3x 400VAC (± 5%) + PE, 50Hz, 20kA max.
Electrical Supply Compressor(s)	3x 400VAC (± 5%) + PE, 50Hz, 20kA max.
Safety Electrical Power Supply	3x 400VAC (± 5%) + N + PE, 50Hz, 20kA max.
Compressed air (acc.to ISO 8573-1: 2010 [3:3:3])	clean, oil & NH_3-free, 6-8 barg, -10…+50°C

Notes & Recommendations:

- Utilities Care of customer

5.1.3. Environmental Site Conditions

Environmental Site Conditions			
Ambient temperature outside	min.	-10	˚C
	max.	+35	˚C
Design Dry bulb temperature		28.7	˚C
Design Wet bulb temperature		19.8	˚C
Altitude above sea level		0	m
Environment & utilities incl. CO_2 raw gas	Not Aggressive to carbon & stainless steel eg. AISI 304		

Notes & Recommendations:

- Seismicity : not in a seismic relevant zone.
- Outdoor site conditions are determined from ASHRAE 2017 figures.
- In freezing conditions, the system may not be able to perform a “cold start” without assistance and may require manual intervention by the operator.

5.2. Performance

The Biogas upgrading plant is designed on the basis of the following information:

Outlet Biomethane (CH_4)			
Capacity gas outlet	952	Nm^3/h	
Maximum Outlet Pressure	8.0	bar (g)	
CH_4 purity	97	% v/v	
CO_2 purity	~1.2	% v/v	
N_2 purity	~1.4	% v/v	
O_2 purity	~0.3	% v/v	
Methane slippage	**~ 0**	% CH_4	[1])

Outlet CO_2 Recovery			
Capacity gas outlet	1281	Kg/h	
Temperature	-24	˚C	
CO_2 purity	> 99.9	% v/v	
CO_2 specification	AccordingtoEIGAor ISTB whatever is applicable		
Storage conditions	17.5 bar(g)@-24˚C)		

Notes & Recommendations:

[1]) Slippage down to 0%, raw gas composition conditions apply @ full load and stable operation

- Pentair standard values are applicable, until project specifics have been agreed.All mentioned values and performances are subjected to detailed engineering
- Nm^3/h based on 0 ˚C and 1013 mbara
- Specification for GAS Quality (See appendix for details)
  The biogas upgrading system produces biomethane with a CH_4 quality of >97%, increasing "Calorific Value" to meet the GSM(R) specification for grid entry by e.g. propane dosing is not included in the scope if supply
- Optional LiquiVap CO_2 vent gas utilization @6 barg (add cost apply).
  Higher CO_2 gas pressures are available on request and subjected to re-engineering.

5.3. Total Cost of Ownership (TCO)

The provided electrical energy consumption figures are provisional and subject to detailed engineering. The provided figures assume 24 hour per day continuous operation at full plant design capacity at 9 bar operating pressure.

Power		
Specific Power consumption	360	Wh/Nm^3 ±5%
Estimated Average Power Consumed*	605	kW
Based on 15°C outside temp, 55% CH_4, 44% CO_2		

*) Not installed power.

Including:

- Blower
- Pre-treatment system
- Biogas compressor(s)
- Glycol circuit – ambient air heated
- Glycol circuit 1°C
- CO_2 -compressor(s)
- ACF/D unit
- Reboiler heating
- CO_2 liquefaction system
- CO_2 pump
- Control Panel

Excluding Skid Enclosed Housing Services:

- Room ventilation
- Lighting
- Ventilation and/or air conditioning of cabinets
- Room sockets

Notes & Recommendations:

- The provided electrical energy consumption figures are provisional and subject to detailed engineering. The provided figures assume 24 hour per day continuous operation at full plant design capacity.

6. APPENDIX

6.1. Service Proposal

Pentair can provide the following additional services. These services are divided into the four options mentioned below.

6.1.1. Preventive Maintenance:

For maintaining the installation, a preventive maintenance service is offered. This service includes:

- Accommodation costs for the service team
- Traveling costs for the service team
- Labor for executing the preventive maintenance
- Preventive maintenance parts

Description	Yearly cost
Based on 1 service visit and 1 inspection visits per year	TBD*

Approx. 3.5% of Capex (Consignment stock option available)

6.1.2. Basic Onsite Spares Parts:

During normal operation, it is advised to have a basic spares stock onsite, which enables the customer to replace basic components in case of a breakdown.

Description	One off cost
Basic onsite spare parts	TBD*

6.1.3. Consignment stock parts

Critical parts for corrective maintenance may be held in consignment stock, these parts will be available within 24 hours for the customer in case of a breakdown against a 10% consignment fee for the held stock

Description	Yearly fee
Consignment stock parts	EUR TBD (*)

Approx. 2% of Capex (Consignment stock option available)

6.1.4. 24/7 Service:

The 24/7 Service gives the unlimited access to the head office, located in the Netherlands via a telephone help/support line. Further, this service offers availability of a Pentair Service engineer onsite within agreed timeframe of registered request.

- A special 24/7 telephone service number with within the hour response time
- Availability of a Pentair Service Engineer onsite within agreed timeframe

Description	Yearly cost
24/7 service	[redacted]

6.1.5. Online Support & Performance Analysis:

The Online Support service works closely with the 24/7 service helpdesk. This online service allows our support team to remote view the plant via internet connection and as required monitor and track the installation. The Online & Performance Analysis option includes:

- Logging of all relevant process parameters at the head office server

- Weekly reporting of uptime/downtime of the plant including related support calls.
- Online/remote support to analyze online the performance and/or find the causes of any failure of the plant

Description	Yearly cost
Online Support & Performance Analysis	[redacted]

Notes & Recommendations:

- The above-mentioned costs are indicative and depends on customer requirements.

*) TBD= to be determined, depends per customer

6.1.6. Consumables

To remove H_2S and other Sulphur components the unit is equipped with activated carbon filters. The activated carbon is selected on the most cost efficient basis.
The amount of Activated Carbon required is a direct result of the amount of Sulphur in ppm/Nm^3 Biogas.

6.1.7. Corrective Maintenance

For corrective maintenance purposes, the Contractor has a technical support team that is guaranteed to be available around the clock for the Client. Such availability consists of:

- Telephone response by the technical support team within 2 hours after the malfunction report by the Client to the Contractor.
- Online analysis of the malfunction within 3 hours after the malfunction report by the Client to the Contractor.
- Mechanic present at Plant location within 8 hours after the need for on-site support has been presented in writing by the Client

6.1.8. Plant availability

With a full service level agreement in place like mentioned in paragraph 1.1 until 1.6, Pentair could guaranty a 96% plant availability. Higher plant availability >97% are achievable. This service concept is in principal based on the following pillars:

- Plant in operation 51 weeks a year and able to produce the required bio methane
- One week a year plant out of operation for mayor annual maintenance, by highly experienced Pentair maintenance engineers.
- 365 days a year 24/7 service engineer availability for (visual) remote support & emergency breakdowns with full plant data analyses.
- Daily structured 1ste line support according operator log-list from the customer side.
- Critical parts availability based on a customer dedicated consignment stock, defined on more than 10 years' experience in servicing biogas-upgrading systems worldwide.
- High level Technical Support engineers available around the clock for dedicated on-line support, to sort out issues quick and effectively what will improve the availably significant

6.1.9. Corrective Maintenance Costs

According our T&C 2022 for service:

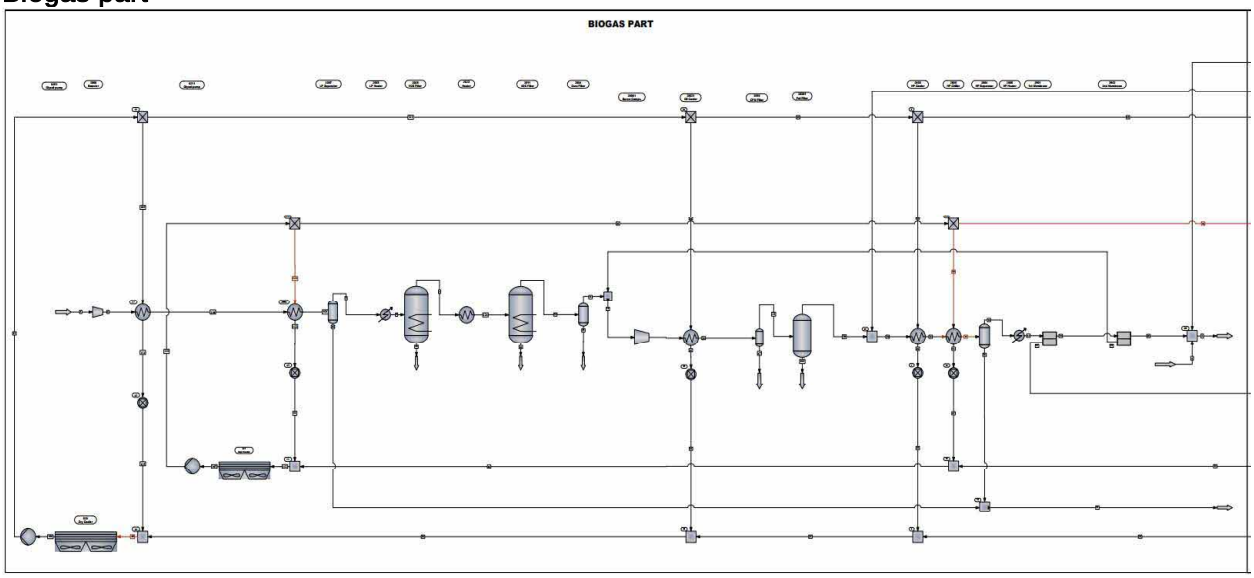
Service Prices & Conditions Europe 2022

Onsite service work	
Hourly Rate	[redacted]
Based on 9 hours per day for working, travelling and waiting hours based on a 6-day workweek. All additional working hours will be charged as overtime.	
Additional charge for overtime	[redacted]

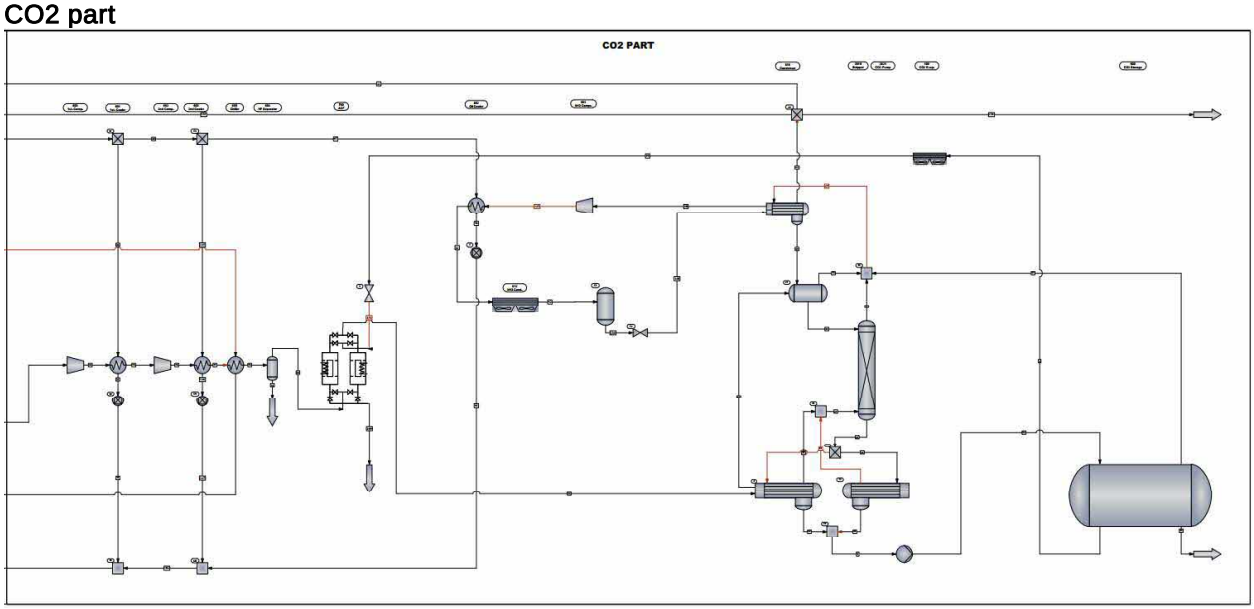
General conditions:
Travel Cost: All cost for travelling will be charged against actual costs increased with 15% handling fee. This includes: flight tickets, rental car, Visa, V.A.T. and the costs for carrying excess tools and luggage as far as necessary for the installation/service activities planned. For the use of a Pentair company car for traveling we will charge € 1,00 per km.
Overnight stay: In case Pentair should arrange a hotel, we will charge you for the actual hotel rates increased with 15% handling fees. If the customer will arrange the hotel, the hotel should be according western European standard.
Cancellation fee: In the event that the customer cancels the service visit after it has been confirmed by Pentair, Pentair shall be entitled to invoice the buyer for all costs related to the preparation of the visit such as airplane tickets, hotel bookings, etc.
Limitation of liabilities: Customer shall not be entitled to, and Pentair shall not be liable for, loss of profits and revenue, incidental or consequential damages of any nature. Customer's recovery from Pentair for any claim shall not exceed the purchase price paid for the affected products.
Taxes, Customs Duties and Import/Export licenses All taxes (incl. possible WHT), customs duties, contributions and costs of any such kind shall be borne by the customer. Income Tax on Supplier's representative shall be borne by the Supplier.
Law and jurisdiction: Any dispute that may arise out of the delivery or the agreement between the parties or in some connection herewith shall be governed by the substantive law of the country the Pentair entity is located, including the Convention on the International Sales of Goods (CISG). The jurisdiction in legal proceedings shall be the proper jurisdiction of the Pentair. The language shall be English.
Payment: During all service visits the service engineer will write a time sheet, which has to be signed by an authorized person. Pentair will charge according time sheet. On this time sheet the on-site working hours are mentioned as well as possible spare parts delivered by the engineer. A copy will be send together with the final invoice.

6.2. Indicative PFD

Biogas part

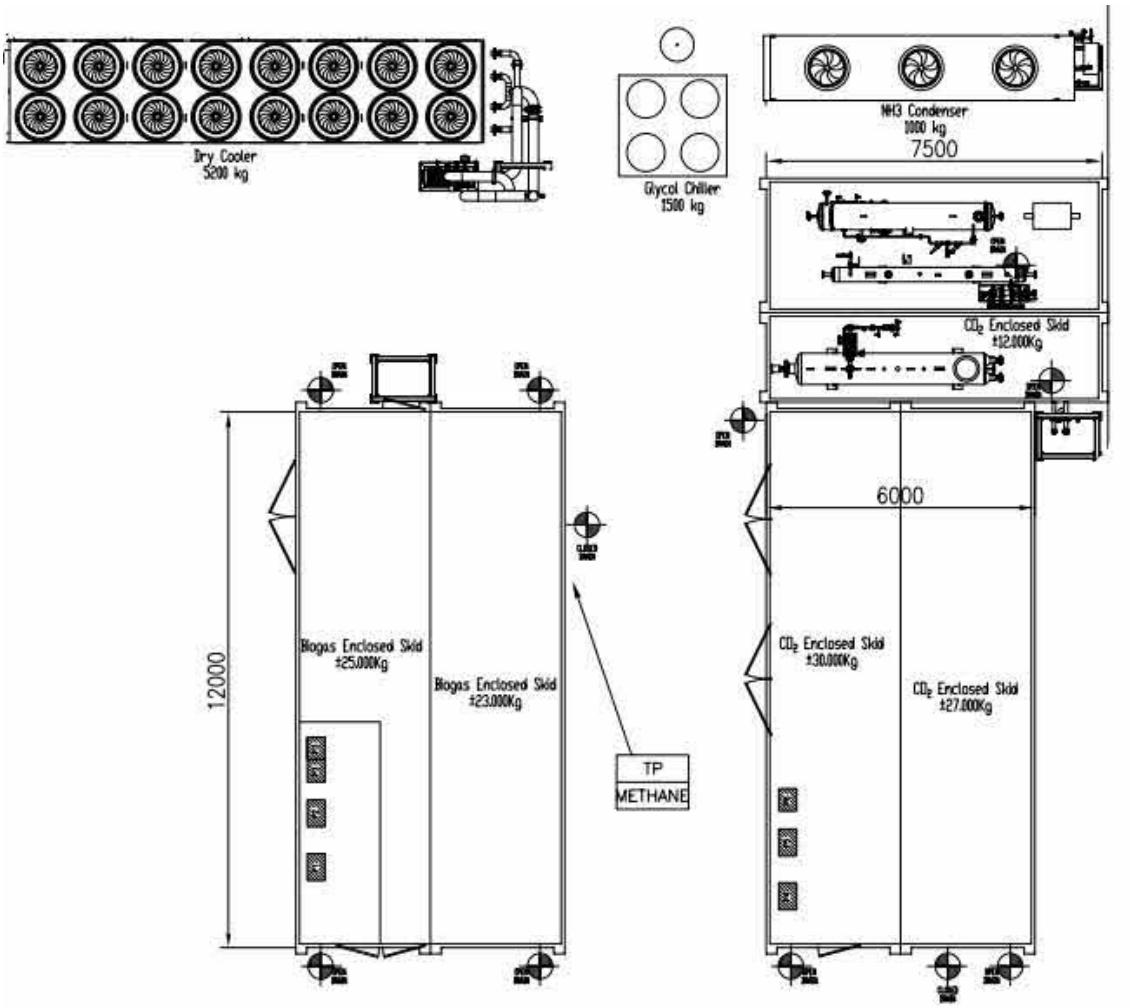


CO2 part



6.3. Indicative Lay-out

A provisional layout drawing of the systemto be updated during detailed design stage:



6.4. BioSENSE - Rental & Purchase Agreement

This agreement is for the BioSENSE described above which will supplied to you for a rent & purchase period; the period is set for a minimum of 6 months (with a maximum of 8 months). This agreement will start after a signed agreement has been handed over to Pentair. The rent & purchase period is effective from the date of EXW delivery of the BioSENSE.

After 8 months this rent & purchase agreement will automatically end, and the purchase of the BioSENSE will be finalized by a last invoice of the remaining purchase price of the BioSENSE. This invoice will be the purchase price of the BioSENSE of [redacted] minus the rent already paid.

The rent & purchase agreement can be terminated by returning the BioSENSE to Pentair. A written notification to: NLVENQCSupport@Pentair.com with the agreement number and BioSENSE serial number has to be sent 7 days before the end of the month, with the request to terminate the agreement.

Pentair will send a notification and will make an appointment to de-commission the device and return it to Pentair. When returning the equipment, this equipment should be returned undamaged and in a good working condition. During the de-commissioning an RMA (Return Material Authorization) will be supplied to you and needs to be signed off. If the BioSENSE is returned damaged than this will be noted on the RMA, a surcharge cost for the repair will be forwarded later to you. De-commissioning will be charged at standard Pentair service rates

Monthly rental rate:
The monthly rental price [redacted],- which will be invoiced in advanced at the beginning of each month.

Installation costs
The BioSENSE system Installation costs will be charged a minimum of [redacted] with payment at order, if the installations works takes longer than one day, then a day rate of [redacted] will be charged (expected installation duration max 2 days)

6.5. Specification for GAS Quality

Thetable below shows the limits for the biomethane to be injected into the grid including Caloric Value and Wobbe.

The biogas upgrading system produces biomethane with a CH_4 quality of >97%, increasing "Calorific Value" to meet the GSM(R) specification for grid entry by e.g. propane dosing is not included in the scope if supply.

Parameter	Grid Entry Limits
Temperature	1-38 °C
Pressure	9barg to allow 7 barg after Grid Entry Unit
Odor	No uncharacteristic odor or masking of odour
Hydrogen sulfide(H_2S)	<= 5mg/Sm3
Hydrogen (H_2)	< 0.1 % vol
Carbon dioxide(CO_2)	≤ 2.5% vol
Oxygen (O_2)	≤ 1.0% vol
Nitrogen (N_2)	No limit
Hydrocarbon dew temperature	≤ - 2°C at up to 85 barg
Water dew temperature	≤ - 10°C at up to 10 barg
Incomplete Combustion Factor (ICF)	≤ 0.48
Sooting Index (SI)	≤ 0.6
Wobbe Number (WN)	47.2 – 51.41 MJ/Sm3
Gross Calorific Value (CV)	Biomethane around 36.6-37MJ/Sm^3 after clean up FWACV = around 39.0 MJ/Sm^3 in EM LDZ
GSMR Contaminants	No significant solids or liquids shall be introduced by the upgrading system which may interfere with the operation of the grid.
Total Sulphur	≤ 30 mg/Sm3
Organo Halides	≤ 1.5 mg/Sm^3
Hydrogen chloride	≤ 1.5 mg/Sm^3
Hydrogen fluoride	≤ 5 mg/Sm^3
Ammonia	≤ 20 mg/Sm^3
Xylenes (all isomers)	≤= 100 mg/Sm^3
Arsenic	≤ 0.1 mg/Sm^3
Radioactivity	≤ 5 Bq/g
Siloxanes	≤ 5 mg Si/Sm^3 ** expected – not yet finalised

6.6. EIGA Limiting Characteristics for Carbon Dioxide for Foods and Beverages

Component	Concentration
Assay	99.9% v/v min.
Moisture	50 ppm v/v max. (20 ppmw/w max.)
Ammonia	2.5 ppm v/vmax.
Oxygen	30 ppm v/v max.
Oxides of Nitrogen (NO/NO_2)	2.5 ppm v/vmax. each
Non-volatile residue(particulates)	10 ppm w/w max.
Non-volatile organic residue (oil and grease)	5 ppm w/w max.
Phosphine ***	0.3 ppm v/vmax
Total volatile hydrocarbons (calculated as methane)	50ppmv/vmax.ofwhich20ppmv/v max non-methane hydrocarbons.
Acetaldehyde	0.2 ppm v/vmax.
Benzene	0.02 ppm v/v max.
Carbon Monoxide	10 ppm v/v max.
Methanol	10 ppm v/v max.
HydrogenCyanide*	0.5 ppm v/vmax
Total Sulphur (as S) **	0.1 ppm v/vmax.
Taste and Odor inWater	No foreign taste or odor

* Analysis necessary only for carbon dioxide from coalgasificationsources

** If the total Sulphurcontent exceeds 0.1ppm v/v as Sulphur then the species must be determined separately and the following limits apply:

Carbonyl Sulphide	0.1 ppm v/vmax.
Hydrogen Sulphide	0.1 ppm v/vmax.
Sulphur Dioxide	1.0ppm v/vmax.

***Analysis necessary only for carbon dioxide from phosphate rocksources

Wherecarbon dioxide complieswith the specification then by definition the requirements foracidity and reducingsubstances as required by European Law are met.

Inline KI (Key Indicators), which are not included in the scope of supply have to be determined with CO_2 off taker.

APPENDIX-Technical Description

BIOGAS PART – Bio-methane Production

For the Biogas part the following steps are offered:

1. Gas Monitoring

1.1. Oxygen Sensor

As safety device to protect against a potentially dangerous oxygen-biogas mixture, dual oxygen sensors are installed when vacuum operation is expected. In the case positive pressure is supplied to the installation only one (1) oxygen sensor is required.

1.2. H2S Sensor

The H_2S Sensor can satisfy H_2S measurement applications on a single platform. It meets compliance requirements, as well as the high specification requirements of customized solutions.

The instrument converts the measured gas concentration into an electrical signal for further processing. Frequency of the measured value calculation: 1 c per second (updating of the display, the 4-20 mA interface and the relays.

1.3. Raw Biogas Analyzer OPTION

A raw biogas analyzer is installed to monitor the incoming methane content. While optional this sensor is a recommended inclusion when the 24/7 and remote monitoring package is included as it is a key diagnostic parameter.

Benefits & advantages:

- Modular system
- Latest sensor technologies.
- Pre-calibrated plug and play sensor modules for ease of use

Scope:

- Gas analyzer installed in a housing IP42
- Gas inlet including automated pneumatic valves for sample taking
- Calibration gas inlet (calibration gas excluded CH_4 + 25% H_2S)
- ATEX /EX Flame arrester
- Pressure regulator
- Sample gas cooler
- Profinet connection

Technical specifications (measurements):

CH_4	0-100	v/v (±1% FS)
CO_2	0-100	v/v (±1% FS)
H_2S	0-10000	± 3 ppm v/v
H_2	0-4,000	ppm (± 5 % FS)
O_2	0-25	± 0.1% v/v

Notes & recommendations:

- Calibration gas to be supplied by customer

- Insulation and heat tracing sample piping excluded.

2. Pre-Treatment Process OPTION

The pre-treatment system dehumidifies, dries and cleans the gases prior entering the compression stage.

2.1. Biogas Fan Blower

A fan blower is included to pressurize the biogas from the digester in order to lead the raw gas through the first cleaning steps.

Scope:

- Centrifugal blower including motor and drive guard
- Cooling disc
- Ducted inlet & outlet
- Vibration eliminators at inlet & outlet
- Variablespeed drive

Technical specifications:

Location	:	Outside in close proximity of Skid Enclosure

2.2. Gas Conditioning

2.2.1. Gas Cooling

Gas cooling is required for optimal conditioning of the process gas prior entering the activatedcarbon filter. Dehumidification of the process gas is performed according the condensation drying principle. The first step is to cool down the incoming biogas via a dry-cooler removingmost of the heat energy. After this first cooling step a second cooling step is installed to chill the gas further for optimization which is done by a water-cooled shell-and-tube heat exchanger. Accumulated condensate is discharged from the collection vessel based on a level control. This to achieve the optimum gas conditions,which increasesthe absorption capacity of the activated carbon,a heater is also installed.

Scope:

- Gas Cooler (Shell-and-Tube Heat exchanger: Glycol cold)
  - Parts in contact with process gas made of stainless steel
- Base Frame for gas dehumidifier
  - Stainless steel beam frame
  - Plug and play/pre-fabricated piping/insulation
- Demister Cabin
  - Up to 99% removal of condensate drops
- Condensate Collection Vessel
  - Vessel of stainless steel
  - Level control alarms
  - Strainer, solenoid valve and non-return valve
- Gas Heater
  - Prior entering the carbon beds, and to optimize the gas humidity an electrical heater is installed

Technical specifications:

Material of construction (parts in contact with biogas)	:	1.4301 / AISI 304
Location	:	Outside in close proximity of SkidEnclosure

2.2.2. Integration of Active Carbon Filters – H2S Removal and VOC

To guarantee the plant performance and protect the membranes, the provided filter(s) remove the biogas impurities - mainly H_2S.
There will be 2 filters in operation. One vessel in filled with activated carbon for H_2S removal and one vessel in filled with activated carbon for VOC removal.
Optional: Provisions for a second, parallel, H_2S and VOC filter enabling vessel change "during" operation.
Pentair has foreseen that the Customer will enter into a leasing contract for rental of the carbon filter vessels and supply contract for the replacement of activated carbon. The H_2S break-through is detected by online measurement.

Benefits & advantages:

- Filter saturation alarm
- Specifically developed activated carbon for optimal H_2S adsorption
- Easy access for quick active carbon exchange

Scope:

- In & outlet butterfly valve valves with interlock
- Inertisation valves
- In & outlet sample points
- H_2S sensor (Option)

Execution:

- Total amount of vessel installation slots: 2
  - 1x H_2S Vessel
  - 1x VOC Vessel
- Carbon vessels can be exchanged during operation
- Dust filter
- Heater to for relative humidity correction prior to VOC vessel for optimized carbon load

Specification:

Vessel type	:	Vertical
H_2S inlet	:	≤500 ppm v/v
H_2S outlet	:	< 5 ppm v/v
VOC outlet	:	< 1 ppm v/v

Notes & recommendations:

The Desotec leasing arrangement is care of the customer. The vessel system integration is part of the scope of supply of Pentair.

2.3. BioSENSE – Online VOC SENSOR OPTION

Pentair's BioSENSE is a new and unique sensor with which the VOC (Volatile Organic Compounds) load of biogas in biogas upgrading plants can be continuously determined by means of optical absorption spectroscopy. BioSENSE provides a robust and cost-effective way of measuring the contaminants before and after pre-treatment of the raw biogas. This also includes the detection of H_2S and NH_3 breakthroughs to the purified raw biogas in case of saturated activated carbon filter fillings. Your overall plant operation is optimized and the cost for biogas purification are minimized.

Benefits & advantages:

- Developed specifically for biogas applications
- Delivers accurate, reliable and validated results
- Robust (light source and sensor not in contact with gas sample)
- Easy operation without expert knowledge
- Low maintenance
- No need for calibration gas
- No on-site calibration required
- Onlyone service interval per year

Scope:

- Gas analyzer installed in a stainless steel housing IP41
- Gas inlet including automated pneumatic valves for sample taking
- HMI display: 155 mm x 86 mm, English
- Datablock exchange of measurement results
- Software integration into Pentair biogas system
- Ethernet / PROFINET connection
- Setof manuals:
  - BioSENSE quick start guide (hard copy)
  - BioSENSE installation & commissioning manual (digital, English)
  - BioSENSE operating manual (digital, English)
  - BioSENSE annual field service guide (digital, English)
  - BioSENSE reactive field service guide (digital, English)

Measurement ranges and accuracy*:

Total ketones	:	0.5 -350	v/v ppm ± 10%**
Total terpenes	:	0.5 -350	v/v ppm ± 10%**
H_2S	:	1 -500	v/v ppm***
NH_3	:	1 -200	v/v ppm***
Measurement speed	:	Up to 6 samples per hour	
Location	:	Skid Enclosure, Non ATEX Zone	

*) For further details see also: *Pentair_biosense_leaflet_1806.pdf*
**) Accuracy: of measured value or detection limit, whichever is larger
***) Breakthrough detection

2.3.1. Sampling Valve Management System

The sampling valve management system allows you to measure up to five different points in the pre-treatment process. One sample per hour is typically taken at one of the sampling points. The system includes the following items:

Scope:

- Mounting frame
- Isolated/protected software block to be integrated in customers S7

- Sampling preparation block with:
  - Flush system & Condensate trap
  - Sampling solanoid valves
- Sampling & recirculation lines and interconnecting materials (max. 30 meter line length between BioSENSE and sampling points)
- Valve system with up to 5 sampling points: this enable you to measure contaminants in the raw biogas and pre-treated biogas in configurations with up to two parallel streets and separate vessels for H_2S and VOC removal in each street.
- Set of manuals:
  - Installation & commissioning manual (digital, English)
  - Reactive field service guide (digital, English)

Technical specifications:

Amount of sampling points	:	Up to 5 valves
Location	:	Skid Enclosure, ATEX Zone II

3. Biogas compression

3.1. Biogas Oil Lubricated Screw Compressor

The screw compressor is a twin shafted rotary machine of positive displacement design operating with internal compression. The raw Biogas is compressed on its way from the intake socket to the discharge socket in ever diminishing chambers, finally being discharged into the discharge pipe. During the compression process oil is injected into the conveyance chambers. The injected oil fulfils the following functions during this operation; lubrication of bearings and rotors, dealing of the clearances between the rotors themselves, and between these and the cylinder walls, conduction away the heat generated compression process and reducing sound. The oil must subsequently be extracted from the biogas by means of an oil separator installed after the compressor, it is then cooled. The bearings and the rotors are lubricated via injection passages of optimum dimensions at an oil pressure that depends on the discharge pressure; this eliminates need for an oil pump. The quantity of oil injected is controlled by the temperature in such a way as to ensure that the final compression temperature will adjust itself to the required specification.

Benefits & advantages:

- High operational reliability
- Long Working Life
- Low maintenance costs
- Excellent efficiency
- Smalloverall dimensions
- Low weight
- No reciprocating parts, rotary movement only, all rotating parts dynamically balanced, no special foundations required, easy to install within the confines of the compressor plant unit.
- All stages suitable for frequency converter-operation.
- Few wearing parts, no inlet or exhaust valves requiring maintenance
- Rotors work in a non-contact way
- Injected oil ensures adequate lubrication and cooling, and provides the sealing between the rotors themselves and between these and the walls of the housing. All this warrants the highest efficiency.

Scope:

- Booster included
- Oil separator
- Oil cooler
- Variable speed drive for capacity control

Furthermore the screw compressor unit is equipped with the following oil filtering system:

3.2. Oil Filtering System

During compression of the biogas oil vapors could occur which will affect the lifetime of the membranes. To prevent oil vapors entering the membranes each outlet of a compressor is equipped with a special design Pentair CPM filter.

If in a case oil vapor breaks through the CPM filters, for example as it is not noticed that the filters should be replaced, a large guard filter is installed in the common line to ensure never oil breaks through. Also if a break-down of the screw compressor occurs and liquid oil comes through the CPM filter the guard filter will absorb the oil.
The oil filtering system is built as a pre-fabricated unit and includes the following:

3.2.1. Coalescer Filter (CPM-Filter)

The CPM® coalescence filter, type PSMF, is a validated filter for the removal of residual oil, water and solid particles. In the filter element, liquid droplets and particles are captured, coalesced and drained to the bottom of the filter housing for easy removal through the condensate drain.

The coalescence filter element is graded 0.01 micron, delivering a class 1 gas quality on particle size and oil content according ISO 8573-1:2001(E). This results in a gas with a residual oil content <0.01 mg/m^3, free of water and solid particles down to 0.01 µm. The stainless steel filter element is resistant to all mineral and synthetic oils.

Benefits & advantages:

- Robust stainless steel construction, including stainless steel filter elements, results in no damage or aging of the filter element
- High filter capacities possible
- Effective pre-treatment of compressed air, CO_2 and other gases
- Prevention of product loss, contamination and spoilage
- Increased service life of gas supply network and gas consuming system components

3.2.2. Common Polishing "Guard" Oil Filter

As the biogas separation membranes represent a significant portion of the total capitalinvestment, secure protection is essential. The largely dimensioned polishing filter is designed to remove oil to low ppb levels.

Benefits & advantages:

- Robust stainless steel construction, no damage or aging
- High temperature resistance
- Long lifetimeof biogas separationmembranes

4. Gas Seperation

4.1. High Pressure Biogas Conditioning Unit

The performance of the biogas membrane separation process is greatly affected by pressure, temperature and moisture content. For optimal membrane performance, a gas pre-cooling, water separator and gas pre-heating system is included in the scope of supply.

Benefits & advantages:

- Fully automated controls
- Better membrane performance
- Longer/optimized lifetime of membranes

Scope:

- Two (2) stage Biogas chiller & cooler
- Automatic condensate drain for water separator by pneumatic maintenance free valves
- System with:
  - Automated temperature controllers
  - Strainer
  - Stop valves
- Biogas heater

Technical specifications:

Location : Skid Enclosure, ATEX Zone II

4.2. Biogas Separation Membrane Unit

The biogas membrane unit will be delivered as a full prepared package which is completely executed in stainless steel piping to provide the highest quality and long lifetime. Further the unit is in-house packaged with cabling, cable trays, air hoses, valves, heat exchanger and metering equipment. As the unit is pre-packaged and FAT testing, this enables short installation and start-up time.

Benefits & advantages:

- Compact pre-packaged unit
- Short installation time
- Stainless steel piping

The unit includes the following items:

4.2.1. Micro Filtration Coalescer(s)

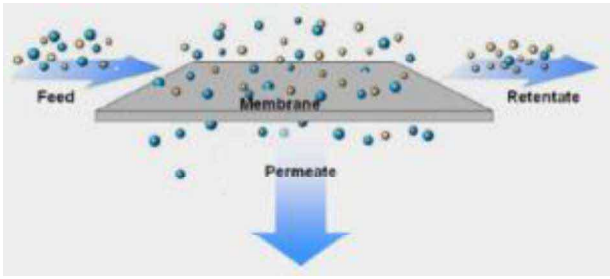
After conditioning the biogas and prior entering the separation membranes, a high efficiency micro filtration coalescer is installed which further protects the separation membranes. These micro filtration coalescers are installed together on the membrane unit asa package.

Benefits & advantages:

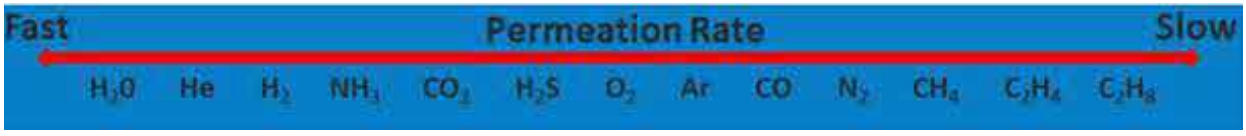
- The interior of the housing has a chromate coating to protect against effloresce and corrosion.
- The externalsurfaces are protected with an impact-resistant powder coating.
- Easy serviceability

4.2.2. Biogas Membrane Set

The specially selected separation membranes split the biogas into a CO_2 and CH_4 rich gas. The working principle of membrane separation is that gas components are separated by the difference of solution-diffusion through the polymer. The effective ratio of separation is determined by the flux of CO_2 passing through the membrane.



Using this special technique a difference can be made between slow and fast diffusing components. Fast diffusing components are e.g. water, ammonia, carbon dioxide, sulfide and oxygen. Slow components are e.g. nitrogen and methane.



The control system, measures operating pressure, methane content and flow and automatically adjusts the system to the optimum operating conditions, ensuring, maximum CH_4 recovery and minimal electrical energy consumption.

For each application, gas composition, the best membrane setup is custom engineered. The design of the membrane installation is done in such a way that the most energy efficient configuration is ensured.

Benefits & advantages:

- Customer sized membrane configuration for optimum flow and purity
- Customer sized membrane configuration for lowest CAPEX costs
- Sized in a way to optimize low operating cost (OPEX)
- Fullyautomated (on/off) membrane streets for optimized process operation

Scope:

- Automatic pressure control valve
- Flowmeter
- Methane measurement
- Automatic block in/shut of valves
- Sampling points
- Skid mounted

4.3. Temperature Conditioning Unit

The resulting purified biomethane must comply to the specifications of the grid owner. As there are different requirements of each grid owner the design is in such a way that either the bio-methane can be heated or cooled down. The outlet temperature controller is executed in such a way it is capable of delivering the biomethane at higher or lower temperatures.

The cooling will be done with the glycol water circuit 7°C or in case of heating with the cooling water circuit of 35°C which is part of the biogas upgrading system.

Benefits & advantages:

- No additional investment to control the biomethane temperature prior entering the grid
- Stainless steel execution
- Control valve to adjust the temperature

Scope:

- One (1) Chiller/heater to comply to specific grid requirements
- Temperature control valve
- Temperature transmitter

CO_2 PART – Cryogenic Separation

This system is designed to recover 100 % of the methane by producing 100% pure CO_2 and sending all impurities back to the membrane system instead of reducing methane emissions by burning/venting the CO_2 rich stream coming from the membrane system. Pentair has aimed for recovery of the methane slip from the membrane unit and the possibility to produce a second product: liquid CO_2.

The CO_2 recovery system is designed to separate the CO_2 cost efficiently from the CO_2 rich gas stream. There are two results in achieving this goal: 100 % recovery of methane and production of liquid CO_2.

The CO_2 system is designed to compress, purify, de-humidify and liquefy the CO_2. When the CO_2 is ejected to the atmosphere the liquid CO_2 can be re-used within the system to save energy. This will result in a cost efficient separation of methane and CO_2. Whenthe CO_2 is sold as liquid CO_2 an extra cooling unit and a liquid CO_2 storage tank is required. The whole system will use more electric energy but will gain a second product to cover these costs.

The CO_2 that is produced in the recovery installation can reach high specifications and can be used in the beverage industry, green houses and food freezing applications. The CO_2 recovery installation is an important advantage in a sustainable operation and a methane yield of 100%.

For the CO_2 part the following steps are offered:

5. CO_2 Compression

5.1. Dry-Running CO_2 Gas Compressor Unit

The 2 stage, dry-running CO_2 compressor unit is specifically designed for the compression of wet CO_2 gas.

Benefits & advantages:

- Fully automatic unloaded start, stop and level controlled condensate removal.
- Below-mentioned parts are skid mounted, pre-assembled, pre-piped and pre-cabled
- CO_2 piping, coolers and condensate separators in stainless steel.
- Drive assembly with slide mounted motor
- Modulating temperature control valve to maintain a constant CO_2 discharge temperature

Scope:

- Dry running CO_2 – compressor
- Electric motor with drive guard
- **Stainless steel** inter cooler
- Temperature transmitterafter each stage
- Pressuretransmitter after each stage
- Temperature / pressure indicators on both stages
- Safety valve protecting each stage
- Cooling utility circulationsystem with:
  - Stop valves
  - Temperature control valves
- Variable speed drive for capacity control

5.2. High Pressure CO_2 Conditioning Unit

The CO_2 conditioner is designed to reduce the water content in the CO_2 gas through condensation. This will reduce the water load onto the driers, lowering the chance that the CO_2 condenser will freeze and thus improve the CO_2 recovery and liquefaction efficiency.

Benefits & advantages:

- Fully automatic
- Reduces energy consumption of activated carbon filters and driers
- Reduces CO_2 consumption of activated carbon filter and driers.

Scope:

- After cooler for CO_2 compressor
- After chiller for CO_2 compressor
- Condensate separator with automatic drain by pneumatic maintenance free valves
- System with:
  - Temperature indicator
  - Stop valves
  - Temperaturetransmitter after each cooler

6. Cleaning & Conditioning

6.1. Regenerative Activated Carbon Filter & Dryer Unit

The Activated Carbon Filter and Drier is a fully automatic CO_2 deodorizing and drying system. This system will clean the CO_2 gas of undesired impurities that affect the quality of the food grade CO_2 and also will remove the moisture of the CO_2 gas. This system will be executed dual mode; one unit is running and the other unit will be regenerated.

Benefits & advantages:

- Fully automatic operation and regeneration cycle
- Below-mentioned parts are skid mounted, pre-assembled, pre-piped, pre-cabled and pre-insulated
- Fully stainless steel vessels and piping
- Specially developed activated carbon for optimal odor removal
- No contamination with external media (steam or hot air)
- No additional utilities required to be brought into the engine room
- Simple construction with two 4-way valves
- Low maintenance system e.g. no check valves, no steam valves, no air blower
- Unique heating system for heating during regeneration
- Energy saving system: temperature control based regeneration
- Easy access for filling exchange
- Easy access to external heaters: no process interruption such as decompressionis required

Scope:

- Activated carbon filter / dryer vessels each with in-and outlet filter
- 2x 4-way actuated ball valves with valve position confirmation
- 2x Pressure gauges
- 2x Safety valves
- Purge gas connection with flow indicator and control valve
- Actuated purge valve with valve position confirmation
- Particulate filter after drier
- Heating elements

- Temperature switches
- Insulation with aluminum cladding
- Pressure transmitter
- 1st filling of Activated Carbon & Desiccant
- Inline dew point transmitter
- MASS flow meter.

Notes & recommendations:

- Refreshment of Activated Carbon required during start-up and commissioning is excluded.

6.2. CO_2 Evaporator

The regeneration gas for the Active Carbon Filter Dryer Unit is made through a CO_2 evaporator. The fully automated CO_2 evaporator vaporizes liquid.

Scope:

- CO_2 evaporator comes with:
  - Integrated CO_2 circuit
- CO_2 inlet including:
  - Safety valve
  - Safety valve with drain valve for liquid supply line
  - Stop valve
  - Strainer and orifice
  - 2x Pneumatic ball valves
- CO_2 outlet including:
  - Safety valve
  - Stop valve
  - Overload protection by means of temperature switch

7. Methane Recovery / Liquid CO_2 System

The purpose of the liquefaction system is to provide sufficient condensing capacity to liquefy the dry CO_2 gas in the CO_2 condenser. The extracted heat will be transferred to the refrigerant that dissipates the heat directly to an evaporative condenser.

The refrigeration system is operating at approximately -36 ºC, and is completely pre-fabricated. This design is selected to reach the best possible functionality needed for this type of system.

Notes & recommendations:

- Refrigerant calculations are based on above mentioned wet bulb temperature which customer is to confirm. Any changes as a consequence of revised local conditions will be reviewed and offered separately.

7.1. Refrigerant compressor (NH_3)

The compressor compresses the low pressure and low temperature refrigerant gas into a high pressure and high temperature gas.

Scope:

- Compressor incl. electric motor with drive assembly and drive guard mounted on base frame
- Oil separator with oil return and lubrication system
- Oil cooler
- Oil strainer
- Variable speed drive for capacity control

- PLC controlled
- Stop valve on suction and discharge side
- Suctionand discharge pressure switch

7.2. Refrigerant Condenser – Air-cooled

The refrigerant condenser is designed to liquefy the high pressure refrigerant gas coming from the compressors.

Scope:

- Refrigerant condenser comes with:
  - Fan with frequency controlled motor
  - Stop valves
  - Safety valve
  - Pressure transmitter
  - HP float
  - NH_3 buffer vessel

7.3. Refrigerant evaporator / CO_2 Condenser

The refrigerant evaporates in the CO_2 condenser (refrigerant evaporator) and produces the required cooling capacity to liquefy the incoming CO_2 gas. The system is optimally designed to separate the non-condensable gasses (N_2, O_2 and CH_4) from the liquefied CO_2 meaning less CO_2 is lost from the system during automatic purging.

Scope:

- Refrigerant evaporator / CO_2 condenser
- Shut off valves on CO_2 and refrigerant side
- Safety valves CO_2 and refrigerant
- Pressure gauge
- Actuated and injection valve refrigerant
- Oil drain vessel
- Drain valve

Notes & recommendations:

- At sufficient height to enable gravity feed into stripping system.

7.4. Bleed System

Any hydrogen (a non-condensable component that can be generated in the anaerobic digester) entrained in the raw biogas will accumulate in the CO_2 condenser of the biogas upgrading plant. If the H_2 value exceeds 8ppm on the inlet of CO_2 capture system a bleed system should be installed which prevents hydrogen accumulation so that the CO_2 condenser operates within ATEX design specification..

The bleed system is mounted in the slip return line of the CO_2 condenser where it will bleed a controlled flow from the slip return line to:

- The bio-methane production line;
- OR feed the onsite CHP plant (subject to suitability of CHP to receive varying bleed-flow and bleed-composition). Suitability of executing this option will be reviewed during engineering phase**;
- OR atmosphere. Suitabilityof executing this option will be reviewed during engineering phase**.

Benefits & Advantages:

- Fully automatic

- Prevention of hydrogen build up
- Optimal CO_2 liquefaction

Scope:

- Control valve
- Manometer with stop valve
- 2x sample point stopvalve

Bleed to bio-methane production line or existing CHP:

- Actuated valve
- Orifice
- Safety valve
- Check valve
- Stop valve

Purge to atmosphere:

- Actuated valve
- Orifice

Add services and materials to integrate abovementioned parts into biogas upgrading plant:

- Interconnecting materials : piping & cabling
- Welder with tools
- ** Piping materials, related works etc. from bleed point (at slip return line) to onsite CHP or to suitable blow offpoint (to atmosphere) is care of customer.

Notes & recommendations:

- H_2 accumulationin CO_2 condenser < 4% v/v

7.5. CO_2 Stripper – Reboiler

The stripper/reboiler will remove the last non condensable impurities (N_2, O_2 and CH_4) in the liquid CO_2. These non-condensable components will be moved to the CO_2 condenser where they will be purged to the membrane unit. By this stripping technology Pentair is able to return all of the CH_4 to the membrane unit and produce almost 100% pure liquid CO_2.

This Liquid Stripping System type is designed to increase the end purity of the liquefied gas. The automatic Stripping system includes an integrated management system to optimize CO_2 recovery.

Benefits & advantages:

- Fully automatic operation
- Enhances CO_2 purity
- Energy neutral system: CO_2 gas to the CO_2 condenser is pre-cooled in the re-boiler to generate the required stripping gas.
- Heating element to compensate during start/stops and partial load
- Special stainless steel packing for optimal stripping of N_2, O_2 and CH_4

Scope:

- Stripping & management system
- Stripping column with packings
- Reboiler
- Heating element
- Safety valve
- Level measurement reboiler
- Pressure indicator

7.6. CO_2 Liquid Transfer Pump

The CO_2 Liquid transfer pump transfers the purified liquid CO_2 from the Reboiler to the CO_2 storage tank.

Scope:

- CO_2 liquid pump with motor
- Non-return valve
- Overflow valve
- Pressure gauge
- Ball valve in CO_2 inlet
- Strainer in CO_2 inlet
- Ball valve in CO_2 outlet
- Safety valves
- Vent valves
- Base frame on which the above-mentioned parts are mounted.
- All parts on this base frame are completely piped and wired.
- Counter flanges & bolts
- Pre-insulated.

8. Internal Cooling Circuit Utilities

The purpose of the internal utilities is to provide sufficient cooling medium to cool down the various positions in the biogas upgrading system.

The system contains the following items:

8.1. Glycol Circuit -Ambient Air Cooled

The fully automatedcooling circuit is designed to cool the following Biogas upgrading parts:

- Oil cooler of the biogas compressor
- HP cooler of the biogas compressor
- Inter cooler of the CO_2 compressor
- After cooler of the CO_2 compressor
- Oil cooler of the NH_3 compressor
- Superheater LiquiVap (if supplied)
- Biogascooler (if pre-treatment is included)

The collected heat is rejected to environment through a dry cooler which is located outside.

Benefits & advantages:

- Fully automatic stand alone operation
- Low operational costs
- Fan capacity control for reduced energy consumption in winter

Scope:

- Glycol pump
- Dry cooler
- Valves, accessoriesand instruments.

8.2. Glycol Circuit (+1ºC)

The fully automated cooling circuit is designed to cool the following Biogas upgrading parts:

- Inlet biogas chiller (if pre-treatment is included)
- HP chiller of the biogas compressor
- After chiller CO_2 compressor

The collected heat is rejected to environmentthrough an air-cooled condenser which is located outside.

Benefits & advantages:

- Fully automatic stand-alone operation
- Low operational costs
- Fan capacity controlfor reduced energy consumption in winter

Scope:

- Glycol pump
- R32cooling system
- AutomatedValves andaccessories

9. Liquid CO_2 Storage Tank OPTION

The CO_2 storage tank is designed to provide dry liquid CO_2 storage capacity on site.

Scope:

- CO_2 tank and (weld) connections for:
  - Liquid & gas – CO_2 recovery plant
  - Liquid & gas – CO_2 transfer pump / road tanker
  - Drain
- Lifting lugs
- Pre-insulated
- Tank accessories:
  - All necessary shut-off valves for the above mentioned connections
  - Pressure gauge
  - 2x Safety valves with change-over valve
  - 1 Content measurement by means of differential pressure (Δp)

Technical specifications:

Gross volume	:	80 tonne
Net volume (@ 95% filling)	:	78,8 tonne
Storage conditions	:	-24°C & 17.5 barg
Execution	:	Vertical
Dimensions un-insulated (Ø x L)	:	3,200 x 9,000 mm
Empty weight (un-insulated)	:	19,500 kg
Material-tank	:	Carbon steel
Insulation	:	PU, vapor barrier & aluminum cladding

10. Road Tanker Pump OPTION

The road tanker pump is designed to transfer liquid CO_2 between the CO_2 storage tank and the road tanker.

Benefits & advantages:

- Simple, safe and manual operation
- Pump
- Compact and robust pre-mounted unit

Scope:

- Pump with motor
- Bypass valve
- 2x Pressure gauge
- Ball valves and strainers
- Safety valves and drains
- Operator panel
- Pump release contacts.

11. Air Compressor OPTION

The offered plant is equipped and operated with pneumatic valves. An air compressor built according industrial standard and designed for a 24/7 operation for start-up is offered separately if no air is available.

Scope:

- Hour counter
- Vibration eliminators
- Manual Drain valve

12. Electrical Hardware & Control System

The electric control panel is executed according to the Pentair standard and thus designed for the automatic control of the offered parts if not specifically mentioned otherwise. The control panel is equipped with a control system including a Human Machine Interface (HMI) for control, status and alarm messages of the system.
As this system will operate as a stand alone unit, Pentair has fully automated the controls up to the highest standard. The bases of this system will be a Siemens S7 PLC . The system can be controlled on site by a touch screen. The control system includes all motor starters and variable speed drives.

Benefits & advantages:

- Full automatic operation of the controlled parts
- Motor-starters: Direct On Line ≤ 7.5 kW, Star-Delta > 7.5 kW
- Electrical drawings are according Pentair standard in EPLAN which is AutoCAD compatible
- Panel layout with main voltage segregated from control voltage
- Pre-wired and pre-tested

Scope:

- Control panel with internal lighting and power outlet
- Lockable door on which easy accessible HMI, emergency stop and main switch are mounted
- Frequency drives for:
  - Biogas Booster (if applicable)
  - Biogas Compressor(s)
  - CO_2 Compressor(s)
  - Refrigeration Compressor(s)
- PLC based control system consisting of:
  - CPU
  - HMI
  - All necessary digital-inputs + outputs
  - All necessary analogue input + outputs
- Digitally stabilized 24VDC control voltage supply
- Communication with Digester and BTG-unit
- All necessary software for the control of the offered parts
- All necessary (automatic) fuses for control voltage, in/outlets and instruments
- Provisions for remote control/monitoring (excluded local PC)

Technical specifications:

HMI Control Panel	:	Siemens TP 1500
PLC in Control Panel	:	Siemens S7
Control voltage (common)	:	24 VDC
Design	:	IEC 60204-1
Ingress Protection	:	IP 54
Name plates	:	English
HMI text	:	English
Material panel	:	Coated steel
Location of main panel	:	Skid Enclosure

Notes & recommendations:

Customer must provide measurements/signals “handshakes” with Pentair control system in order to ensure safety aspects and/ or operation & monitoring. A list of required signal exchange will be provided at the time of engineering, eg. standby/release of digester to start upgrading. Signals for communication purposes e.g start/stops signals including communication via profinet from the gate keeper with Wobbe-index, CH_4, CO_2, Caloric value etc., are to be provided to the Pentair control panel.

13. Skid Enclosed Housings

The skid enclosed housing, wherein the offered biogas upgrade and CO_2 recovery system will be installed, consists of a steel structure and prefabricated components. As the concept is a "one piece flow" method short production/delivery times are achieved. Before the complete unit is shipped, an internal quality and FAT-test is being executed on the total system which enables a short installation period onsite.

By using a skid-enclosure solution instead of a standard container solution size, more maintenance space is being created which results in a faster and more effective maintenance activities.

Benefits & advantages:

- Fast and modular design
- Reduced footprint
- Easy operation and maintenance
- Plug and Play

Scope:

- Skid enclosure, including:
  - Maintenance doors
  - Building drawings and construction calculations
- Construction of building

Technical specifications:

Dimension (W x L x H) [1] – Biogas part	:	6 x 12 x 3.5 mtr.
Dimension (W x L x H) [1] – CO_2 part	:	6 x 12 x 3.5 mtr.
Color - building, doors and roller door	:	RAL (to be defined)
Zoning (Biogas part)	:	Atex153EXZone2/G IIA /T1
Zoning (CO_2 part)	:	Non-Atex
Indication noise level	:	75dBA@10 mtr.

Exclusions:

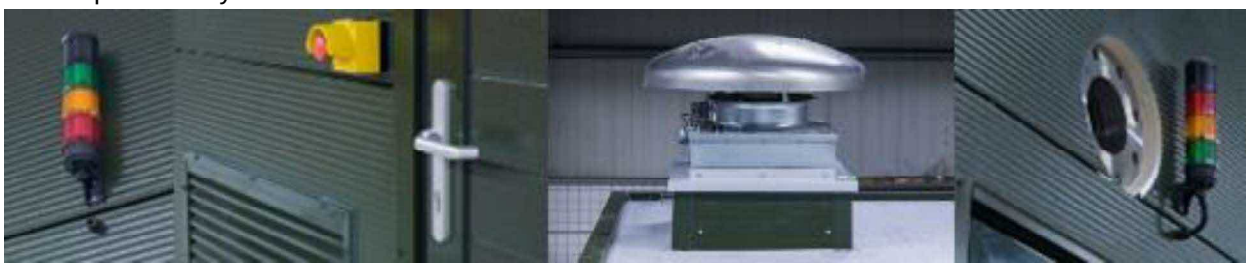
- Building permit
- Integrated cranes for maintenance purposes
- All civil works including but not limited to:
  - Foundations & grouting
  - Sewer, drains (open and closed) and gullies
- In ground electrical earthing & lightning protection

Notes & recommendations:

- [1]) Final dimensions are subject to scope of supply and defined during detailed engineering stage of the project.
- All stainless steel piping and bridge materials where applicable is executed in SS304 (or equal).

13.1. Skid Enclosed Housing Services

In order to comply to ATEX EXZone2/G IIA /T1 the following is offered. Housing services are foreseen and controlled in a separate control panel which is provided with power coming from the Pentairmain control panel. To comply to the ATEX regulations this separate control panel must be executed with a redundant power supply. One isalready foreseen, coming from the Pentairmain control panel, the other power supply is to be provided by the customer.



Scope:

- Safety PLC with Siemens Safety IO cards
- Gas detection (CO_2, CH_4 and NH_3)
- Warning lights (mounted above doors outside)
- Emergency stop (mounted next to doors outside)
- Forced ventilation fans
- Lighting (inside)
- Electrical power sockets (in non Atex zone)
- Control panel
- Housingheating (electrical heating and thermostat)

Exclusions:

- Smoke and/or fire detection system
- Emergency and evacuation plan
- Firefighting installation e.g. sprinkler system
- Powersupply to offered scope
- Lightning protection
- Lighting outside.

14. Interconnecting Materials -Pipes, Cables & Insulation ESTIMATION

Pentair will deliver Turnkey materials(Pipes, Cables, Insulation) for the installation of the offered biogas upgrade plant & CO_2 recovery plant based on the assumed footprint information and/or provisional layout.

For the successful realization of on site works:

- Mounting of goods is to be done directly when goods arrive
- Customer to provide on site a secure and lockable area for offered parts
- The plant will be set up in a skid enclosure (closed layout, with suitable ATEX Zone II area)
- Available space/foundation slab is free of obstacles and easily accessible especially for the installation of the offered parts and its connections
- Interconnecting materials of offered parts outside the skid enclosure are excluded from the scope
- Offered parts outside are to be installed in close proximity of the skid enclosure
- All utilitiesare available and ready to be connected.

Piping for the exterior installed equipment, within the scope of supply, is pre-fabricated and broken down for transport.

14.1. On Site Piping Materials

The following piping materials (pipes, elbows, tees and reducers) are included in the scope of supply:

- Interconnecting piping between the offered parts within the boundary of the skid enclosure
- Utility piping from one point in to offered parts within the boundary of the skid enclosure
- Pipe clamps and pipe supports for the piping within the boundary of the skid enclosure
- Special “insulation” clamps for cold piping
- Biogas, CO_2 and utility piping are executed in stainless steel
- Piping materials not specified, to/from not offered parts and to/from parts located outside skid enclosure are not included. Specifically the main biogas supply line from the digester and pretreatment to the skid enclosure, blow off lines, drains and the CO_2 piping to/from the storage tanks arenot included.
- All stainless steel piping and bridge materials where applicable is executed in SS304 (or equal).

14.2. On Site Insulation Materials

For the following units insulation materials will be supplied:

- Dehumidification unit (cold)
- HP Water separator (cold)
- CO_2 condensers (cold)
- Stripper & re-boiler (cold)
- CO_2 & refrigerant piping (cold)
- Glycolpiping (cold).

14.3. On Site Electrical Materials

This includes the following:

- Interconnecting cable materials between the offered parts within the boundary of the skid enclosure
- Cabletrays (zinc coated steel) and protection pipes for the offered cable materials

Cabling materials not specified, to/from not offered parts and to/from parts located outside skid enclosure are excluded. Specifically the power supply cable from the site plant power distribution to the Pentair control panels is excluded.

15. Onsite Labor, Tools & Equipment ESTIMATION

Pentair offers all necessary onsite labor, tools and equipment for the installation of the offered scope of supply.

This includes all related works within the boundary limits of the scope of the supply such as:

- Welders with tools
- Fitters with tools
- Insulators with tools
- Electricians with tools

On site labor is based on using Pentair sub contractors. Should the customer wish to use their preferred local suppliers we will review the costs and re-quote this part of the offer.

16. Supervisor for Mounting, Installation, Commissioning & Training

Pentair provides qualified engineer/supervisor for a period of 9 weeks for mounting and installation works and 8 weeks for commissioning (6 days per week, 50 on site workings hours per week). Works:

- Supervise mounting and erection of all delivered items
- Supervise installation of interconnecting piping, cabling and insulation
- Commission (start-up) the offered parts, directly after erection
- Test run and fine tune the system for acceptance
- Train the local personnel (during commissioning) in English or German (translation in other languages are care of customer).

Scope:

- One (1) round-trip per supervisor incl. all travel costs

In case the supervision of the installation and commissioning takes longer than the above mentioned period of time due to no fault of Pentair, the additional supervision costs will be charged separately according to Pentair Service Department terms and conditions.

Should there be conditions where in the Pentair engineer/supervisor assigned and on site for installation supervision and start up is deemed not qualified to execute certain job/task according to local regulations, laws or customer rules then the customer is to and will be responsible to arrange/pay for a qualified specialist to meet this requirement at no expense to Pentair.

To prevent any unnecessary project delays the customer will provide and put at the disposal of the Pentair engineer/supervisor

- All necessary utilities such as compressed air, water, electricity, etc.
- On site internet connection of suitable industrial standard to allow remote PLC changes to be made as necessary with 24/7 availability.

Pentair will provide a schedule for the onsite works indicating necessary labor, crane etc.

It is assumed that supervision of the installation works and commissioning of the offered parts will take place within 1 year after readiness for shipment Pentair/Manufacturer.

17. Engineering, Design & Project Management

Above mentioned scope is subject to a more detailed description at order and engineering after order. Pentair reserves the right to adapt specifications for Engineering purposes.

This includes:

- Management and coordination of the project
- Engineering of the offered parts
- Preparation and supply of an agreed Project Planning
- Detailed list of requirements to the customerbefore sending the supervisor for installation and commissioning
- Documentation(2x digital, EnglishorGerman) according to Pentair standardand OEM availability:
  - Parts, Accessories and Instrument schedule
  - Operation Instructions, Maintenance Manuals & Spare parts Lists
  - Project drawings:
    - Engineering diagrams (PID)
    - Layout& above ground foundation drawings
    - Electricaldiagrams + panel layout drawings (in EPLAN)
    - General assembly drawings.

Notes & recommendations:

The documentation will be prepared according to relevant Good Engineering Practice. Differences or specifications requested by the customer will be charged according to expenses.

Additional site visits will be charged separately according to Pentair terms and conditions.

17.1. Project Manager On Site Visit (5days)

To discuss the project with the local project team and review the local conditions we offer an on site visit by the Project Manager.

This includes costs for:

- Tickets
- Visa (if applicable)
- Hotels
- Local transportation
- Travel hours
- Working hours

17.2. Interface Hazop Participation (2 days/2 persons)

Based on all involved parties being present in one location for a common Hazard and Operability study (on line).

17.3. Health & Safety Participation(2 days/2 persons)

To comply of the UK registrations, the following is foreseen(on line)in support of:

- H&S Plan incl. off-site Risk Assessment Analysis
- RAMS.