METHANE RECOVERY PROJECT HOUBENSTEYN YSSELSTEYN, LIMBURG THE NETHERLANDS

Document Prepared by everi GmbH

Project Title	Methane Recovery Project Houbensteyn Ysselsteyn, The Netherlands
Version	03
Report ID	N/A
Date of Issue	06-January-2023
Project ID	336
Monitoring Period	01-May-2016 to 31-December-2021
Prepared By	everi GmbH
Contact	Grosse Theaterstrasse 14, 20354 Hamburg, Germany +49 176 206 49 79 2, pauline.kalathas@everi-climate.com, www.everi-climate.com

CONTENTS

1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

Methane Recovery Project Houbensteyn Ysselsteyn (hereafter referred to as project Houbensteyn) is a methane recovery project through controlled anaerobic digestion from animal manure as well as from agricultural and industrial waste, that takes place on the estate of the project Houbensteyn Milieu BV located in the Province of Limburg, the Netherlands. The project activity involves power generation using Combined Heat and Power engines (CHP) to produce electricity and heat with the biogas generated. Furthermore, the project activity mitigates GHG emissions by replacing fossil fuels with decentral renewable thermal energy.

The current report monitors emission reductions that have occurred during the second crediting period from May 1st, 2016 to December 31st, 2021. During this period, 4 CHPs with a total electrical capacity of 1,7 MW were in operation and produced around 26 million m^3 of biogas. The project is under continuous operation since the commissioning of the first CHP in 2006.

The heat produced by the biogas plant is used for the own biogas production process, but also to substitute fossil fuels for heating pig stalls and office buildings, for preheating piglet food as well as for hygienization of digestate.

The total GHG emission reductions due to the project activity generated under the current monitoring period starting from 01/05/2016 to 31/12/2021 amounts to 58,034 t CO_2e.

1.2 Sectoral Scope and Project Type

The VCS sectoral scopes applicable to the project activity are 1. “Energy (renewable/non-renewable)” and 13. (Waste handling and disposal).

The project is not a debundled component of a larger project activity.

1.3 Project Proponent

Organization name	Houbensteyn Milieu BV
Contact person	Martin Houben
Title	Owner and Managing Director
Address	Ysselsteynseweg 69, 5813 BK, Ysselsteyn Limburg - The Netherlands
Telephone	+ 31 6 532 11 287

Email	Martin.houben@hgroep.nl

1.4 Other Entities Involved in the Project

Organization name	everi GmbH
Role in the Project	Carbon consultant, author of the Project Description report
Contact person	Pauline Kalathas
Title	Senior carbon project developer
Address	Grosse Theaterstrasse 14, 20354 Hamburg, Germany
Telephone	+49 176 206 49 79 2
Email	pauline.kalathas@everi-climate.com

1.5 Project Start Date

The start of commissioning of the first CHP was May 01st, 2006.

1.6 Project Crediting Period

The start date of the crediting period is set to the 01st of May 2006. The project uses a crediting period of 10 years which ended on 30th of April 2016. In accordance with Verra's approval letter dated July 6th, 2021, requesting the renewal of the project crediting period, the start date of the second crediting period of 10 years is set to May 01st, 2016 and will end on April 30th, 2026.

1.7 Project Location

The project activity takes place on the estate of the project owner Houbensteyn Milieu BV in Ysselsteyn, Limburg, southeastern part of the Netherlands. The geographical coordinates are N 51° 29' 40.633" E 5° 55' 48.705".

Figure 1: Map of The Netherlands with marked project location

Figure 2: Area map with project location

1.8 Title and Reference of Methodology

Three small-scale methodologies according to the PDD Section 3.1 are used in the project:

Type III, other project activities:

- AMS III.AO “Methane recovery through controlled anaerobic digestion” (Version 1.0), referring to the capture of methane gases from biomass or other organic matter.
- AMS III.D *“Methane recovery inanimal manure management systems ”* (Version 21), referring to the capture of methane gases from decomposing manure.

Type I, Renewable Energies:

- AMS I.C, *“Thermal energy for the user with or without electricity”* (Version 21), referring to the utilization of the waste heat to replace fossil energy.

The methodologies also refer to the latest approved version of the following tool:

– Project and leakage emissions from anaerobic digesters, Tool 14 (Version 02)

1.9 Participation under other GHG Programs

The project is not registered under any other GHG program.

Methane Recovery Project Houbensteyn has never applied to any other greenhouse gas program outside of the Voluntary Carbon Standard VCS. The Project Proponent confirms that credits generated in the current monitoring period do not form part of any other national or international scheme.

1.10 Other Forms of Credit

The project does not reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowances trading

Project activity does not claim emission reductions from production of electric energy. In this aspect, it has no influence on projects that have binding emission limits under the EU ETS. Agricultural anaerobic digestion is not considered in the greenhouse gas inventory of the Netherlands, so the emission reductions caused by the avoided uncontrolled decay of waste or manure are not counted towards the greenhouse gas emission inventory of the Netherlands. The net GHG emission reductions from the project are not used for compliance with emission trading programs or to meet binding limits on GHG emissions.

The project is currently not part of any other GHG program, emission trading scheme or environmental credit, that means double counting can be exempted. The project also receives no other form of incentives for the activities that cause the emission reduction.

1.11 Sustainable Development Contributions

The implementation of a biogas installation with manure and co-substrate treatment as well as renewable electricity and thermal energy production helps to avoid the release of methane and CO_2 emissions into the atmosphere. This contributes to the Netherland's targets of reducing GHG emissions by 95% by 2050 and achieving a share of 27% share of renewable energy by 2030, as outlined in the Dutch Climate Act[1].

[1] Integrated National Energy and Climate Plan (2021-2030), p. 7 and p. 9, https://energy.ec.europa.eu/system/files/2020-03/nl_final_necp_main_en_0.pdf

The project also contributes to achieving sustainable development by creating local and green jobs and providing direct and indirect employments during the construction and operational phases[2].

[2] Energieakkoord, p. 11, point 5, https://www.ser.nl/nl/thema/energie-en-duurzaamheid/energieakkoord/-/media/5A6DE312EAB948BEADF43DECF2DF5669.ashx and

https://climate-laws.org/geographies/netherlands/policies/energy-accord-for-sustainable-growth-energieakkoord and

https://www.government.nl/documents/publications/2013/09/06/energy-agreement-for-sustainable-growth (Download "Energy Agreement for Sustainable Growth")

Row number	SDG Target	SDG Indicator	Net Impact on SDG Indicator	Current Project Contributions	Contributions Over Project Lifetime
1)	7.2	7.2.1 Renewable energy share in the total final energy consumption	Implemented activities to increase	The operation of the biogas plant has generated 56 GWh of renewable electricity and at least 58 GWh of renewable heat during the current monitoring period, which increase the share of renewable energy related to the total primary energy supply.	The project will increase the generation of renewable electricity by around 168 GWh and at least 97 GWh of heat over the project lifetime, contributing to Netherland's targets to increase the share of renewable energy in the global energy mix.
2)	8.1	8.1.1 Annual growth rate of real GDP per capita	Implemented activities to increase	Creation of direct employments (1 full-time and 2 part-time jobs for operation and administration of the plant) and indirect employments (4 jobs for substrate transport and the application of digestate on the fields) in order to achieve the goal of sustainable and equitable economic growth for workers and contribute to the Dutch government's goal of creating 15 thousand full-time jobs in the renewable energy sector.	Creation of direct employments (1 full-time and 2 part-time jobs for operation and administration of the plant) and indirect employments (4 jobs for substrate transport and the application of digestate on the fields) in order to achieve the goal of sustainable and equitable economic growth for workers and contribute to the Dutch government's goal of creating 15 thousand full-time jobs in the renewable energy sector.

3)	13.2	13.2.2 Total greenhouse gas emissions per year	Implemented activities to decrease	By running the biogas plant, around 57 thousand tons of GHG emissions were avoided through project activity during the monitoring years 2016-2021	Prevented the release of 225 thousand tons of carbon into the atmosphere.

Table 1: Sustainable Development Contributions

2 SAFEGUARDS

2.1 No Net Harm

The Houbensteyn project has been formally and finally approved by the responsible regional authorities of the Netherlands in accordance with the Dutch building law "Wet op de Ruimtelijke Ordening". This act provides the set of rules which regulates the impact assessment of plants or projects on the environment. The approval covers the installation and operation of the biogas power plant including all components such as storage, feeders, fermenters, CHP modules, etc.

The project activity contributes to a significant higher ecological sustainability compared to a reference scenario without manure's treatment by using biogas plants.

Hence, the Houbensteyn project has no relevant negative environmental and socio-economic impacts and contributes positively by providing environment friendly power generation leading to sustainable development of the region as.

2.2 Local Stakeholder Consultation

The Project is registered with VCS as VCS ID 336. The Local Stakeholder Consultation process was already conducted in line with the requirements during the project registration. As during the authorization process for the project, public stakeholders have the right to litigate against the project at the administrative court during the operation phase of the biogas plant in case the installation have a negative impact on their well-being. In the same way, public stakeholders have the possibility to contact directly and at any time the company of Houbensteyn Milieu BV in case they feel directly or indirectly disturbed by the project activity.

Since the biogas installation impacted positively the region on an economical, environmental and a social level, the stakeholders still give till today positive feedback and consider the project as an example that can motivate other communities to generate renewable energies using the local manure and reducing this way the GHG emissions as well as odor. No complain or litigation has taken place during the first and the second crediting period of the project. Over 10 times a year, Houbensteyn Milieu BV is welcoming various stakeholder groups as companies, children's classes, regional politicians, etc. to visit the biogas plant. Furthermore, the communication with stakeholders as neighbours or business partners takes place in the day-to-day life, in particular via Martin Houben, the owner of the biogas plant who lives in the area.

2.3 AFOLU-Specific Safeguards

Not applicable to the project activity.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

The project activity was in continued operation during the monitoring period 2016-2021.

CHP Units	Electric capacity installed	Thermal capacity installed	Electric efficiency [FT]	Start of operation date
	kWel	kWth	%	
CHP 1 - MAN LE 312	530	627	37.8	2016
CHP 2 - MAN LE 312	530	627	37.8	2016
CHP 3 - MAN LE 312	346	421	37.5	2006
CHP 4 - MAN LE 312	346	421	37.5	2009

Table 2: Data of installed CHP units from Houbensteyn Milieu BV

The biogas plant treats pig manure from the operator's own farm and from external farms located around the project site, which represent at least 50% of the total biomass fed. Co-ferments from agricultural and food industries are also delivered and fed to the biogas plant.

The plant has produced around 26 million m³ biogas during the current monitoring period.

Year	Electricity produced [kWh]	Biogas produced [m³]	Weighted average Methane content [%]	Efficiency
	EEP	BGP	x_{CH4}	ETA_{CHP-el}
2016	9.659.956	4.676.815	54,9	0,377
2017	10.080.797	4.473.649	59,9	0,377
2018	9.591.854	3.978.582	64,0	0,377
2019	9.056.247	4.254.470	56,5	0,377
2020	8.995.784	4.254.040	56,2	0,377
2021	8.786.015	4.352.065	53,6	0,377
Total	**56.170.653**	**25.989.621**	**57,5**	**0,377**

Table 3: Biogas and electricity production (2016-2021)

Since the beginning of the crediting period, the waste heat of the CHPs has been used for space heating of the adjacent pig stalls and office building, as well as for preheating piglet food. Furthermore, since January 2007, heat is used for hygienization of the digestate.

During this monitoring period, the biogas plant has been running without any significant event that would have affected the GHG emission reductions and monitoring.

3.2 Deviations

3.2.1 Methodology Deviations

Deviations as per section 3.6 of the registered PD

1. Methodology deviations under AMS-III.D

Quantity of animal manure ($Q_{manure,j,LT,y}$)

Deviant from the Methodology AMS-III.D, the manure input is not measured on a dry basis but on the amount of fresh manure, as it is the practice in the Netherlands. The fresh manure produced on the farms is transported directly to the biogas plant, where it is first weighed and then treated in the plant.

The reason for measurements on fresh basis is that fresh manure is the main data on which are based the subsidies for the power generation. It is mandatory for co-digestion projects in the Netherlands to treat at least 50% of feedstock with manure. This is verified by CertiQ, the Dutch issuing body for guarantees of origin and certificates of origin for heat and electricity generated from sustainable sources[3]. CertiQ is part of TenneT TSO B.V., the national electricity grid operator in the Netherlands and has been commissioned by the Dutch government (Minister of Economic Affairs and Climate Policy) as issuing body.

Mass balance of feedstock based on fresh manure and co-products have to be submitted monthly to CertiQ in order to get the certification for the subsidies. Hence, both biogas farmers as well as authorities operate with fresh manure.

In order to have the equivalent value of the manure on a dry basis as required in the methodology, the measured amount of fresh manure has to be multiplied by the values for dry matter content of animal manure (dm_{LT}), depending on the livestock type and the animal manure management system:

$$Q_{manure,j,LT,y} = Q_{fm,j,LT,y} \cdot dm_{j,LT}$$

Where :

$Q_{manure,j,LT,y}$	Quantity of manure treated from livestock type LT and animal manure management system j (t/y, dry basis)
$Q_{fm,j,LT,y}$	Measured quantity of fresh manure treated from livestock type LT and animal manure management system j (t/y, fresh basis)
$dm_{j,LT}$	Average dry matter content from manure of livestock type LT and animal manure management system j (t dry matter/ t fresh matter)

[3] https://www.certiq.nl/about-us/profile/about-certiq/

The average dry matter content from manure will be measured by accredited laboratories specialized in that field, as is already carried out on farms to analyse the composition of the manure. Since the project is a co-digestion project with many manure suppliers, samples for analysing the dry matter content of manure will only be taken at the 4 of the 6 different farms from Houbensteyn Ysselsteyn BV in order to obtain an average dry matter content value for each animal category, but not for each of the 15 supplier farms. The efforts and costs to carry out manure analyses from 15 different suppliers is out of all proportion to the project size (micro-scale project as defined under Tool 19[4]) and the achieved amount of emission reductions from manure digestion. Also, the manure suppliers are changing from time to time, depending on their own manure availability and use. Therefore, the annual average value for $dm_{j,LT}$ from the 4 Houbensteyn farms will be used as the basis for the value for $dm_{j,LT}$ for the other farms. In order to follow the principle of conservativeness as required in Section 2.2.1 of the VCS Standard, only 90% of the measured $dm_{j,LT}$ value will be used for dry matter content of manure coming from external farms.

The methodology deviation for obtaining manure values based on dry matter content have no negative impact on the quantification of GHG emission reductions as all derived values are based on measured project specific data. Accuracy can thus be ensured, and an overestimation of emission reductions can be excluded, since a conservative approach is used to calculate the manure dry matter content from external farms.

Furthermore, in the project activity, manure delivered to the biogas plant ($Q_{fm,I,LT,y}$) is either from the company's own farms or external farms. Manure coming from external farms is measured by truck weighing scale on the biogas site. Manure coming from the own farms is calculated based on animal numbers, since this is the base for mandatory registration for the farm's production (livestock, manure and crop) under the responsible agency RVO (Netherlands Enterprise Agency), the governmental agency which operates under the auspices of the Ministry of Economic Affairs and Climate Policy[5]. Registration is mandatory in order to control the Dutch application standards for manure and fertilizers and to regulate the nutrients surplus of the country[6].

This methodology deviation also has no negative impact on the quantification of GHG emission reductions since the calculated number of animals and manure amounts are based on registrations required by the government and subject to very strict controls and can thus be considered as accurate.

2. Methodology deviations under AMS-I.C

[4] Tool 19: Demonstration of additionality of microscale project activities, https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-19-v9.pdf, p.3

[5] Manure, a valuable resource, https://edepot.wur.nl/498084 , p. 17

[6] Livestock identification and registration, RVO, https://business.gov.nl/regulation/livestock-identification-registration/

Baseline emissions from heat production are calculated according to paragraph 34 of the AMS-I.C with the following equation:

$$BE_{thermal,CO2,y} = \left(\frac{EG_{thermal,y}}{\eta_{BL,thermal}} \right) \cdot EF_{FF,CO2}$$

Where:

$BE_{thermal,CO2,y}$	Baseline emissions from thermal energy displaced by the project activity during the year y (t CO_2)
$EG_{thermal,y}$	Net quantity of thermal energy supplied by the project activity during the year y (TJ)
$EF_{FF,CO2}$	CO_2emission factor of the fossil fuel that would have been used in the baseline plant obtained from reliable local or national data if available, alternatively, IPCC default emission factors can be used (t CO_2/TJ)
$\eta_{BL,thermal}$	Efficiency of the plant using fossil fuel that would have been used in the absence of the project activity determined as per paragraph 40 or 40 below

In the project activity, the waste thermal energy going to the 3 external heat consumers (space heating, pre-heating piglet food and hygienization unit) is measured with only 1 heat meter, so that a calculative approach has to be used to determine the heat use for the space and piglet food as well as for the hygienization unit.

The total baseline emissions from external heat use will be calculated as follows:

$$BE_{thermal,CO2,y} = BE_{thermal,CO2,SH,PF,y} + BE_{thermal,CO2,HYG,y}$$

Where

$BE_{thermal,CO2,y}$	total baseline emissions from waste thermal energy use during the year y (Tj)
$BE_{thermal,CO2,SH,PF,y}$	baseline emissions from heating space and pre-heating piglet food during the year y (Tj)
$BE_{thermal,CO2,HYG,y}$	baseline emissions from hygienization of digesate during the year y (Tj)

Since the total thermal energy consumption is directly measured and since the heat used from hygienization can be calculated according to the verified equation already used for the previous crediting period and approved in the previous PD, the thermal energy consumption from heating space and pre-heating piglet food will be calculated as follows:

$$EG_{thermal,CO2,SH,PF,y} = Heat_{tot,y} - Heat_{HYG,y}$$

Where:

$EG_{thermal,CO2,SH,PF,y}$ the net quantity of heat supplied by the project activity to the livestock space (SH) and to the piglet food heating system (PF) during the year y (TJ)

$Heat_{tot,y}$ total quantity of external heat use by the project activity during the year y (Gj), measured

$Heat_{HYG,y}$ net quantity of heat supplied by the project activity to the hygienization unit (HYG) during the year y (Tj), calculated

As for the first crediting period, a calculative approach will be used to calculate the thermal energy used for hygienization ($Heat_{HYG,y}$) based, this time, on the quantity of digestate. The energy demand for heating up a liquid from a given temperature can easily be calculated by means of physical equations. Only the heat capacity of the liquid and the inlet and outlet temperatures need to be known. The heat capacity of manure is set to the one for water. The inlet temperature is fixed to the average digestate temperature in the fermenter and the outlet temperature is fixed to the minimum temperature required for pasteurization process:

$$Heat_{HYG,y} = Digestate \cdot Cap_{heat,PR} \cdot \left(T_{HYG,PR} - T_{inlet,PR}\right) \cdot 1/Eff_{ex,PR}$$

Where:

Digestate quantity of digestate produced by the biogas plant in the year y (kg)

$Cap_{heat,PR}$ heat capacity of the digestate to be heated, set to the capacity of water 1,16 kWh/t

T_{Hyg} needed hygienization temperature, set to 75 °C

$T_{Inlet,PR}$ digestate inlet temperature to the hygienization system in the project scenario, set to the 37 °C

Eff_{Hex} heat exchanger efficiency, set to 87 %

The fixed values for hygienization and digestate temperatures are conservative since the required temperature of hygienization is at 70°C for 1 hour and the temperature range for operating the biogas fermenters is about 37°C to 41°C. These values ensure that the heat quantity calculated with the above equation correspond to the lowest thermal energy use for hygienization. Hence, the quantity of GHG emission is not overestimated, as it is calculated according to conservative assumptions. Moreover, according to AMS-I.C, Appendix 1, a default value for the heat exchanger efficiency of 87% was set, which corresponds to the efficiency of an old natural gas fired boiler and can be considered as conservative. Therefore, the calculation approach described has no negative impact on the quantification of the emission reductions and can be evaluated as accurate and conservative.

Deviations as per section 3.2 of the VCS Monitoring Report

In this monitoring period, the methodologies are applied as described in the PDD under section 4, including the deviations mentioned in section 3.6., except for the parameters BGP (biogas production), x_{CH4} (methane content) and the calculation of the distance between external manure suppliers' location and the biogas site.

1. Biogas production

Deviant from the calculation method described in the PDD, the amount of biogas is not calculated as described in section 3.6. on page 47 of the PDD but calculated based on the biogas production of each substrate treated in the plant. This calculation was carried out by a third-party company Eqwadraat, which is the author of the mandatory electricity and heat measurement reports (see for example Appendix B "Meetrapport 2021 – Houbensteyn" on page 3). Since the biogas production is not relevant for the quantification of GHG emission reductions, this deviation has no impact on their conservativeness.

2. Methane content

Regarding the methane content in the biogas, the calculation method presented in the PDD used for calculating the biogas production is applied instead of using literature values of methane content from all substrates treated in the plants. As described in the PDD under section 5.2 for parameter BGP, the calculation method used is:

$$BGP = \frac{EEP}{(ETA_{CHP-el}) * HV_{Biogas}}$$

Where:

BGP	Biogas produced [m³]
EEP	Electrical energy produced [MWh]
ETA_{CHP-el}	Electric efficiency of the CHP engines
HV_{Biogas}	Calorific value of biogas [kWh/m³]

With

$$HV_{Biogas} = 0,01 \frac{MWh}{m^3} \cdot x_{CH4}$$

Where:

0,01 Stoichiometric combustion calculation of CH4 [MWh/m³]:

802,6 kJ/mol /0,02241 m³/mol = 35.814,37 kJ/m³ = 0,01 MWh/m³

x_{CH4} CH4 volume content of biogas flow [%]

Since EEP is measured, BGP is calculated and ETA_{CHP-el} is given (see Appendix B "Data sheet MAN LE [no]"), the CH_4 content in the biogas can be calculated as per calculation method above. Since the biogas production is not relevant for the quantification of GHG emission reductions, this deviation has no impact on their conservativeness.

3. Manure transport distance

Regarding manure transported from external farms to the biogas plant, a different calculation method than the one described in the PDD in section 5.2 has been chosen to calculate the average distance from manure transportation from external farms. The postcodes and the number of manure transports from the respective postcodes are used to calculate the average incremental transport distance (see Appendix A under "PE – Transport"). Since the work effort to gather the addresses of many different manure suppliers is very high and the project emissions from transport represent only <1% of the emission reductions achieved through manure fermentation, the alternative calculation method presented above and applied for the current monitoring period is considered as accurate and appropriate. There is no significant impact on the conservativeness of the quantification of GHG emission reductions, since the project emissions from transport are less than 1% of the total emission reductions from manure treatment.

3.2.2 Project Description Deviations

No project description deviations have occurred.

3.3 Grouped Projects

Project activity is not a grouped project.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data and parameter from the AMS-III.D

Data / Parameter	GWP_{CH4}
Data unit	t CO_2e / t CH_4
Description	Global warming potential of methane applicable to the crediting period
Source of data	IPCC Fifth Assessment Report (AR5)
Value applied	28
Justification of choice of data or description of measurement methods and procedures applied	As per VCS Standard, Version 4.1, paragraph 3.14.4
Purpose of Data	Calculation of baseline emissions and project emissions
Comments	-

Data / Parameter	D_{CH4}
Data unit	t CH_4/m^3
Description	Density of Methane
Source of data	UNFCCC
Value applied	0.00067
Justification of choice of data or description of measurement methods and procedures applied	Density of methane at room temperature (20°C) and at 1 atm pressure
Purpose of Data	Calculation of baseline emissions and project emissions
Comments	-

Data / Parameter	U_{fb}
Data unit	-
Description	Model correction factor to account for model uncertainties
Source of data	AMS-III.D, Version 21.0; Reference: FCCC/SBSTA/2003/10/Add.2, page 25.
Value applied	0.94

Justification of choice of data or description of measurement methods and procedures applied	As per AMS-III.D, Version 21.0
Purpose of Data	Calculation of baseline emissions and project emissions
Comments	-

Data / Parameter	MCF_j
Data unit	%
Description	Annual methane conversion factor (MCF) for baseline pig manure management system j
Source of data	National Inventory Report 2021- Annex 7 Van der Zee (2021) – Methodology for estimating emission from agriculture in the Netherlands – Section 4.2.3, p. 54
Values applied	Manure type: Liquid pig manure; MCF_j: 36%
Justification of choice of data or description of measurement methods and procedures applied	A country specific value is available for pig manure. This value is used in the NIR for GHG emission calculations of the Netherlands.
Purpose of Data	Calculation of baseline emissions and project emissions
Comments	-

Manure type	MCF_j
Liquid pig manure	36%

Data / Parameter	$B_{0,LT}$
Data unit	m^3 CH_4/kg dm
Description	Maximum methane producing potential of the volatile solid generated for animal type LT
Source of data	National Inventory Report 2021- Annex 7 Van der Zee (2021) – Methodology for estimating emission from agriculture in the Netherlands – Section 4.2.3, p. 54 (for liquid pig manure).
Values applied	Manure type: Liquid pig manure; Bo_{LT}: 0.31
Justification of choice of data or description of	A country specific value is available for pig manure. This value is used in the NIR for GHG emission calculations of the Netherlands.

Manure type	Bo_{LT}
Liquid pig manure	0.31

measurement methods and procedures applied	
Purpose of Data	Calculation of baseline emissions and project emissions
Comments	-

Data / Parameter	$MS\%_{i,y}$
Data unit	-
Description	Fraction of manure handled in system i in year y
Source of data	AMS-III.D
Values applied	100%
Justification of choice of data or description of measurement methods and procedures applied	The project activity does not involve sequential manure management systems. Hence, all manure will be handled in system i and a value of 100% is applied.
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	CT_y
Data unit	Tonnes/truck
Description	Average truck capacity for transportation
Source of data	Standard specifications, D-TEC, Manure tank trailer FV-2006
Values applied	36
Justification of choice of data or description of measurement methods and procedures applied	The load capacity of this model of manure tank trailer is described in the corresponding specifications
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	$EF_{CO2,transport}$
Data unit	g CO_2/km
Description	CO_2 emissions factor from fuel use due to manure transportation
Source of data	TNO Report, "Dutch CO_2 emission factor for road vehicles", 2016, p. 3
Values applied	1.028

Justification of choice of data or description of measurement methods and procedures applied	Country specific CO_2 emission factor from fuel use for heavy duty vehicles on rural roads.
Purpose of Data	Calculation of project emissions
Comments	-

Data and parameter from AMS-I.C

Data / Parameter	$EF_{FF,CO2}$
Data unit	t CO_2/TJ
Description	CO_2 emission factor for natural gas
Source of data	The Netherlands: list of fuels and standard CO2 emission factors version of January 2022, Netherlands Enterprise Agency, p. 4, https://english.rvo.nl/sites/default/files/2022/05/The%20Netherlands%20list%20of%20fuels%20and%20standard%20CO2%20emission%20factors%20January%202022.pdf
Value applied	56.4
Justification of choice of data or description of measurement methods and procedures applied	Country specific values for natural gas are available and published on the governmental website from RVO (Netherlands Enterprise Agency)
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	$\eta_{BL,thermal}$
Data unit	%
Description	Efficiency of the plants using natural gas
Source of data	As per AMS-I.C, paragraph 42. c)
Value applied	100
Justification of choice of data or description of measurement methods and procedures applied	No data concerning the operational efficiency of the baseline units are available. Hence, a default efficiency value is used as per AMS-I.C
Purpose of Data	Calculation of baseline emissions
Comments	-

CapHeat	$Cap_{Heat,PR}$
Data unit	kWh/tonne
Description	Specific heat capacity of digestate
Source of data	"Biogashandbuch Bayern, 17.05.2007 (Trad: *Biogas manual Bavaria*), Section 1.7.8, p. 22.
Value applied	1.16
Justification of choice of data or description of measurement methods and procedures applied	The heat capacity of digestate to be heated up is set to the capacity of water. As described in the biogas manual, the specific heat capacity of water is set for biogas substrate.
Purpose of Data	Calculation of baseline emissions
Comments	-

CapHeat	$Cap_{Heat,BE}$
Data unit	KJ / kg K
Description	Specific heat capacity of manure
Source of data	Wikipedia
Value applied	4.18
Justification of choice of data or description of measurement methods and procedures applied	The heat capacity of the manure to be pre-heated is set to the capacity of water 4,18 kJ/kg K
Purpose of Data	Calculation of baseline emissions
Comments	-

CapHeat	$T_{Hyg,PR}$
Data unit	°C
Description	Outlet temperature of digestate in the project activity
Source of data	
Value applied	75
Justification of choice of data or description of measurement methods and procedures applied	The special treatment process to sanitize digestate for export needs for 1 hour a temperature above 70°C
Purpose of Data	Calculation of baseline emissions

Comments	For conservativity reasons, a temperature of 75°C was set as the sanitization process is set to 73°C and it does not exceed 75°C.

CapHeat	$T_{Hyg,BE}$
Data unit	°C
Description	Outlet temperature of manure in the baseline scenario
Source of data	-
Value applied	70
Justification of choice of data or description of measurement methods and procedures applied	The special treatment process to sanitize manure for export needs for 1 hour a temperature above 70°C
Purpose of Data	Calculation of baseline emissions
Comments	For conservativity reasons, a temperature of 70°C was set as 70°C represents the lowest temperature required for the sanitization process.

CapHeat	$T_{Inlet,PR}$
Data unit	°C
Description	Inlet temperature of digestate to the hygienization system in the project activity
Source of data	-
Value applied	37
Justification of choice of data or description of measurement methods and procedures applied	The temperature in the digesters varies between 37°C – 41°C to guarantee the survival of the bacterial cultures. For conservativity reasons, the digestate temperature is set to 37°C.
Purpose of Data	Calculation of baseline emissions
Comments	For conservativity reasons, a temperature of 37°C was set as this represents the lowest temperature for digestate, since the usual temperature in the fermenter fluctuates between 37°C - 41°C.

CapHeat	$T_{Inlet,BE}$
Data unit	°C

Description	Inlet temperature of manure to the hygienization system in the baseline scenario
Source of data	World Weather Online, https://www.worldweatheronline.com/lang/es/wanroij-weather-averages/north-brabant/nl.aspx
Value applied	10.8
Justification of choice of data or description of measurement methods and procedures applied	Value set to the average annual ambient temperature in the region of Wanroij, North Brabant
Purpose of Data	Calculation of baseline emissions
Comments	-

CapHeat	$Eff_{ex,PR}$
Data unit	%
Description	Heat exchanger efficiency of the hygienization unit in the project activity
Source of data	As per AMS-I.C, Appendix 1
Value applied	87
Justification of choice of data or description of measurement methods and procedures applied	No data concerning the operational efficiency of the hygienization unit is available. Hence, a default efficiency value is used as per AMS-I.C
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	ETA_{CHP-el}
Data unit	%
Description	CHP electrical efficiency
Source of data	Technical specification of the CHP

Value applied	<table><tr><th>CHP Units</th><th>Electric efficiency</th></tr><tr><td></td><td>%</td></tr><tr><td>CHP 1 - MAN LE 202</td><td>37.8</td></tr><tr><td>CHP 2 - MAN LE 202</td><td>37.8</td></tr><tr><td>CHP 3 - MAN LE 312</td><td>37.5</td></tr><tr><td>CHP 4 - MAN LE 312</td><td>37.5</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	To cross-check the biogas produced and destroyed by the CHP engines
Comments	-

4.2 Data and Parameters Monitored

This Monitoring Report comprises approx. 5,5 years of monitored data. In order to keep the Monitoring Report clear, only the values for the year 2021 are given below for each parameter if it is not possible to display the values of all monitored years. The values of the other monitored years are represented in the annexed spreadsheet with the details of all calculation steps for each year (see Appendix A).

Data / Parameter	$Q_{fm,j,LT,y}$
Data unit	kg/y, fresh basis
Description	Quantity of fresh manure treated from livestock type LT at animal manure management system j
Source of data	Manure quantities from external farms are recorded in the company's database as well as in the official software of the government Dutch National Service for Enterprise (Rijksdienst voor Ondernement RVO), that records all the nutrients shifts and flows between farms under mijn.rvo.nl. Manure quantities from own farms are calculated as the difference between the amount of digestate sold and the amount of co-ferment inputs. Digestate and co-ferments amounts are also registered in the RVO database.

<table>
<tr><td>Description of measurement methods and procedures to be applied</td><td>Quantity of manure supplied by external farms is weighed when delivered by a truck weighing scale.

Quantity of manure supplied by Houbensteyn Ysselsteyn are calculated as the difference between the amount of digestate sold and the amount of co-ferment inputs. The amounts of digestate and co-ferment inputs are measured by weighing scale and recorded daily in operation manual and in electronic databases.</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Annually, based in daily measurements</td></tr>
<tr><td>Value applied</td><td>
<table>
<tr><td>Liquid pig manure from Houbensteyn farms</td><td>Quantity [kg/y]</td></tr>
<tr><td>May 2016 to Dec 2016</td><td>13,316,000</td></tr>
<tr><td>2017</td><td>29,833,782</td></tr>
<tr><td>2018</td><td>25,067,570</td></tr>
<tr><td>2019</td><td>60,741,315</td></tr>
<tr><td>2020</td><td>51,312,670</td></tr>
<tr><td>2021</td><td>38,323,950</td></tr>
</table>

<table>
<tr><td>Liquid pig manure from ext. farms</td><td>Quantity [kg/y]</td></tr>
<tr><td>May 2016 to Dec 2016</td><td>18,321,000</td></tr>
<tr><td>2017</td><td>17,538,440</td></tr>
<tr><td>2018</td><td>8,517,780</td></tr>
<tr><td>2019</td><td>15,077,810</td></tr>
<tr><td>2020</td><td>12,794,720</td></tr>
<tr><td>2021</td><td>18,947,510</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Specifications of the weighing scale on the installation:

KEURINGS / CONTROLE RAPPORT
Serienummer(s): 3550
Type: sca1c1
Fabrikaat BWT Klasse: III
Ordernummer 10910 Tnr. : T2992 cem-cy 01/0025-5.2
Max: 70000 kg min: 400 kg e= 20 kg d= 20 kg</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>Weighing scales are precise and belong to the accuracy class III. Calibration occurs when the devices need maintenance or repairs. Since substrates are not only weighed when being delivered on the biogas plant but also at the supplier's location, the PP controls continuously the accuracy of the weighed substrates by comparing both weighing results. This practice ensures for both parties that substrate measurements are accurate. In case of deviations, the PP gets in contact with the manufacturer so that the weigh bridge can be repaired and calibrated.</td></tr>
</table>

Purpose of data	Calculation of baseline emissions and project emissions
Calculation method	Manure from own farms [t/y] = Digestate sold [t/y] - Co-ferment inputs [t/y]
Comments	Manure amounts treated in the biogas plant vary from year to year, depending on the manure availabilities in the region. The calculation method for the quantities of manure delivered by Houbensteyn Ysselsteyn is the same as in the first crediting period and is considered to be very conservative, as it does not take into account the weight loss due to dissolved biogas.

Data / Parameter	$dm_{j,LT,y}$
Data unit	Kg dm/kg fresh manure
Description	Dry matter content of animal manure from livestock type LT and animal manure management system j in year y
Source of data	Dry matter content analyses from specialized accredited laboratories as Eurofins and Normec Robalab
Description of measurement methods and procedures to be applied	For manure delivered by the Houbensteyn farms: Pig manure samples from all Houbensteyn farms, Aben farms (VCS Project ID 335) and Princepeel farms (VCS Project ID 337) have been sent to laboratories to measure the respective dry matter content. For manure delivered by external farms: The average dry matter content of the annually aggregated measured dm values from the Houbensteyn, Aben and Princepeel farms is multiplied by 90% in order to obtain the value used for dry matter content.
Frequency of monitoring/recording	Twice a year
Value applied	(see tables below)

Manure from Houbensteyn farms	Average dry matter content [kg dm/kg]
Pig manure	0,117

Manure from ext. farms	Average dry matter content [kg dm/kg]

	Pig manure | 0,105
Monitoring equipment	Laboratories analyses
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions and project emissions
Calculation method	For manure delivered by the Houbensteyn farms: Average annual dm value calculated based on all dm results from manure measurements on Houbensteyn farms, Aben farms (VCS Project ID 335) and Princepeel farms (VCS Project ID 337). For manure delivered by external farms: Average annual dm value [kg dm/kg] x 90%
Comments	Since the 2nd crediting period already started in May 1st, 2016, $dm_{j,LT,y}$ is based on recent measurements (2021/2022). The feeding of animals is the same since 2016. Therefore, the composition of manure has not changed since then and the current average value for $dm_{j,LT,y}$ applies for the monitoring years 2016 – 2021.

Data / Parameter	$SVS_{j,LT,y}$
Data unit	Kg SVS/kg dm
Description	Organic dry matter content (odm=specific volatile solids content) of animal manure from livestock type LT and animal manure management system j in year y
Source of data	Organic dry matter content analyses from specialized accredited laboratories as Eurofins and Normec Robalab
Description of measurement methods and procedures to be applied	For manure supplied by the Houbensteyn farms: Pig manure samples from all Houbensteyn farms, Aben farms (VCS Project ID 335) and Princepeel farms (VCS Project ID 337) have been sent to laboratories to measure the respective organic dry matter content. For manure supplied by external farms:

<table>
<tr><td></td><td>The average organic dry matter content of the annually aggregated measured odm values from Houbensteyn, Aben and Princepeel farms is multiplied by 90% to obtain the value used for organic dry matter content.</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Twice a year</td></tr>
<tr><td>Value applied</td><td><table><tr><td>Manure from Houbensteyn farms</td><td>Organic dry matter content [kg/kg]</td></tr><tr><td>Liquid pig manure</td><td>0.773</td></tr></table>
<table><tr><td>Manure from ext. farms</td><td>Organic dry matter content [kg/kg]</td></tr><tr><td>Liquid pig manure</td><td>0.696</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td>Laboratories analyses</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>-</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions and project emissions</td></tr>
<tr><td>Calculation method</td><td>For manure delivered by the Houbensteyn farms:
Average annual odm value calculated based on all odm results from manure measurements on Houbensteyn farms, Aben farms (VCS Project ID 335) and Princepeel farms (VCS Project ID 337)

For manure delivered by external farms:
Average annual odm value [kg SVS/kg dm] x 90%</td></tr>
<tr><td>Comments</td><td>Since the 2nd crediting period already started in May 1st, 2016, $SVS_{j,LT,y}$ is based on recent measurements (2021/2022). The feeding of animals is the same since 2016. Therefore, the composition of manure has not changed since then and the current average value for $SVS_{j,LT,y}$ applies for the monitoring years 2016 – 2021.</td></tr>
</table>

Data / Parameter	$Heat_{tot,y}$
Data unit	Gj

<table>
<tr><td>Description</td><td>Quantity of thermal energy consumption for total external heat use during the year y</td></tr>
<tr><td>Source of data</td><td>Heat meter</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>The heat use is measured by a heat meter and recorded digitally in annual measurement reports (Appendix B “Meetrapport [year] – Houbensteyn”). The daily measurements are recorded and send both monthly and annually to CertiQ (the Dutch issuing body for guarantees of origin and certificates of origin for heat and electricity generated from sustainable sources) for certification.</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Annually, based on monthly reports</td></tr>
<tr><td>Value applied</td><td>
<table>
<tr><th>Year</th><th>Heat consumption [Gj/y]</th></tr>
<tr><td>2016</td><td>16,562</td></tr>
<tr><td>2017</td><td>33,768</td></tr>
<tr><td>2018</td><td>36,092</td></tr>
<tr><td>2019</td><td>37,476</td></tr>
<tr><td>2020</td><td>38,048</td></tr>
<tr><td>2021</td><td>37,225</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Specifications of the heat meters and their technical devices (Source: App B – 7 – on page 14):
<table>
<tr><th colspan="10">Warmtemeters</th></tr>
<tr><th>Benaming meter</th><th>Warmtesoort</th><th>Serienummer</th><th>Typenummer</th><th>merk</th><th>type</th><th>Meten van</th><th>Eenheid</th><th>Onnauwkeurigheid</th><th>Voldoet aan eis</th></tr>
<tr><td>SDE 2010 - Stoom</td><td>Stoom</td><td>D110000000259296</td><td>nvt</td><td>Krohne</td><td>Optiswhirl 4070C</td><td>Temperatuur, Debiet</td><td>GJ</td><td>± 1,0% of measured value (Re ≥ 20000)
Pressure and temperature compensation:
± 1,5% of measured value (Re ≥ 20000)</td><td>Ja</td></tr>
<tr><td>SDE 2010 - HT</td><td>Warm water</td><td>7158606</td><td>67C6107B1285</td><td>Kamstrup</td><td>Multical 601 / Ultraflow 65</td><td>Debiet, Temperatuur heen, Temperatuur retour</td><td>GJ</td><td>Rekenmodule: ± 0,14%
Flow sensor: ± 0,28%
Temperatuur sensor: ± 0,45%</td><td>Ja</td></tr>
<tr><td>SDE 2014 - HT</td><td>Warm water</td><td>65057885</td><td>602C71070C1285</td><td>Kamstrup</td><td>Multical 602 / Ultraflow 65</td><td>Debiet, Temperatuur heen, Temperatuur retour</td><td>GJ</td><td>Rekenmodule: ± 0,12%
Flow sensor: ± 0,83%
Temperatuur sensor: ± 0,79%</td><td>Ja</td></tr>
<tr><td>SDE 2014 - LT</td><td>Warm water</td><td>65068629</td><td>602C71070C1285</td><td>Kamstrup</td><td>Multical 602 / Ultraflow 54</td><td>Debiet, Temperatuur heen, Temperatuur retour</td><td>GJ</td><td>Rekenmodule: ± 0,07%
Flow sensor: ± 0,57%
Temperatuur sensor: ± 0,42%</td><td>Ja</td></tr>
<tr><td>SDE 2017 - HT</td><td>Warm water</td><td>78204179</td><td>67GU2070285</td><td>Kamstrup</td><td>Multical 801 / Ultraflow 54</td><td>Debiet, Temperatuur heen, Temperatuur retour</td><td>GJ</td><td>Rekenmodule: ± 0,13%
Flow sensor: ± 0,27%
Temperatuur sensor: ± 0,48%</td><td>Ja</td></tr>
<tr><td>SDE 2017 - LT</td><td>Warm water</td><td>5370634</td><td>67GU207B1285</td><td>Kamstrup</td><td>Multical 801 / Ultraflow 54</td><td>Debiet, Temperatuur heen, Temperatuur retour</td><td>GJ</td><td>Rekenmodule: ± 0,05%
Flow sensor: ± 0,45%
Temperatuur sensor: ± 0,36%</td><td>Ja</td></tr>
<tr><td>SDE 2017 - Stoom*</td><td>Stoom</td><td>D110000000259296</td><td>nvt</td><td>Krohne</td><td>Optiswhirl 4070C</td><td>Temperatuur, Debiet</td><td>GJ</td><td>± 1,0% of measured value (Re ≥ 20000)
Pressure and temperature compensation:
± 1,5% of measured value (Re ≥ 20000)</td><td>Ja</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>The electric and heat meters are supplied, installed, and operated by a recognized measuring company Fudura B.V. Fudura reads, collects and validates the necessary measurement data and send the data to the grid operator. Fudura also takes care of the control and maintenance of the</td></tr>
</table>

	meter. The meters are operated, maintained and calibrated according to the manufacturer's instructions. Heat measurements are carried out in accordance with the applicable rules described in the regulations in the Standards Framework for Metering Companies and the Meter Pool Regulations. Fudura has a certified data collection, validation and distribution system EDS (data management system). EDS is certified according to the ISO 9001-2008 standard. The values are checked against historical data, key figures and related to the operation mode. In case measurement data is not plausible after checking, the measurement data is re-collected and validated. In case a measurement fails, it is reported to the malfunction department, which identifies the cause and fixes the problem (see App B – 7 – Meetprotocol Houbensteyn BV").
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	The operator has not the possibility to access or manipulate the meters as they are sealed by officials (Fudura B.V.).

Data / Parameter	Digestate
Data unit	kg
Description	Quantity of digestate (output substrate from the biogas plant) during the year y
Source of data	Electronic database provided by the governmental agency RVO under mijn.rvo.nl. and measurements reports certified by CertiQ
Description of measurement methods and procedures to be applied	Measured by truck weighing scale after digestion process
Frequency of monitoring/recording	At collection
Value applied	(see table below)

Year	Digestate quantity [kg/y]
2016	41,711,580
2017	62,100,222
2018	47,794,350

	2019	90,683,125 2020	79,702,390 2021	73,091,460
Monitoring equipment	Specifications of the truck weighing scale on the installation: **KEURINGS / CONTROLE RAPPORT** Serienummer(s): 3550 Type: sca1c1 Fabrikaat BWT Klasse: III Ordernummer 10910 Tnr. : T2992 cem-cy 01/0025-5.2 Max: 70000 kg min: 400 kg e= 20 kg d= 20 kg
QA/QC procedures to be applied	Calibration occurs when the devices need maintenance or repairs. Since substrates are not only weighed when being delivered on the biogas plant but also at the supplier's location, the PP controls continuously the accuracy of the weighed substrates by comparing both weighing results. This practice ensures for both parties that substrate measurements are accurate. In case of deviations, the PP gets in contact with the manufacturer so that the weigh bridge can be repaired and calibrated.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

Data / Parameter	DAF_w
Data unit	km/truck
Description	Average incremental distance for manure transportation from farm locations to the biogas plant
Source of data	Farm location of manure suppliers
Description of measurement methods and procedures to be applied	Houbensteyn farms: Since the quantity of manure delivered by each farm of the Houbensteyn company is not directly measured and in order to be conservative, the distance from the furthest farm to the

	biogas plant (10.6 km) has been taken for the monitoring years 2016-2021. External farms: Since there are multiple external manure suppliers located in about different regions around the biogas plant (characterized by their postcodes), an average distance between the external farms and the biogas plant was calculated based on the postcodes and the number of manure transports coming from the respective postcodes
Frequency of monitoring/recording	Annually
Value applied	Average transport distance for manure from Houbensteyn farms: Year: 2016 - 2021 — Average distance [km/truck]: 10.6 Average transport distance for manure from external farms: Year / Average distance [km/truck]: 2016: 22 2017: 22 2018: 19 2019: 11 2020: 10 2021: 12
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	The average distance between each region (based on the 2 first numbers of the postcodes) and the biogas plant, as well as the number of transports from each region are calculated. Based on these data, the weighted average transport distance from the external manure suppliers to the biogas plant is calculated (see Appendix A under “PE – Transport”)
Comments	-

Average transport distance for manure from Houbensteyn farms:

Year	Average distance [km/truck]
2016 - 2021	10.6

Average transport distance for manure from external farms:

Year	Average distance [km/truck]
2016	22
2017	22
2018	19
2019	11
2020	10
2021	12

Data / Parameter	EEP
Data unit	kWh
Description	Electrical energy produced
Source of data	Power meter
Description of measurement methods and procedures to be applied	Electric power meter at each CHP measures the produced electric energy.
Frequency of monitoring/recording	Continuously
Value monitored	see table below
Monitoring equipment	Specifications of the power meters at the different CHP units: (see table below)
QA/QC procedures to be applied	Precision is very high (uncertainty < 0,5%). The electric meters are sealed and maintained by the grid operator. Calibration is done by authorized service providers.
Purpose of the data	To cross-check the biogas produced and destroyed by the CHP engines
Calculation method	N/A
Comments	-

Value monitored:

Year	Electrical energy produced [kWh/y]
2016	9,659,956
2017	10,080,797
2018	9,591,854
2019	9,056,247
2020	8,995,784
2021	8,786,015

Monitoring equipment:

CHP	Type	Description	Unit	Accuracy class
CHP 1 - WKK 1	kWh1	Gross production meter WKK1	kWh	Class 1
CHP 2 - WKK 2	kWh3	Gross production meter WKK2	kWh	Class 1
CHP 3 - WKK 3	kWh4	Gross production meter WKK3	kWh	Class 1
CHP 4 - WKK 4	kWh5	Gross production meter WKK4	kWh	Class 1

Data / Parameter	BGP

Data unit	Nm^3
Description	Biogas produced
Source of data	Calculated
Description of measurement methods and procedures to be applied	Calculated by the amount of biogas produced per ton of substrate input and recorded in the measurement reports (see Appendix B “Meetrapport [year] - Houbensteyn)
Frequency of monitoring/recording	Monthly or annually
Value monitored	see table below
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of the data	To cross-check the methane produced and destroyed by the CHP engines
Calculation method	∑ (substrate input [t/a] x biogas production of substrate input [m^3/t]) = total biogas production [m^3/a]
Comments	

Year	Biogas produced [m^3]
2016	4,676,815
2017	4,473,649
2018	3,978,582
2019	4,254,470
2020	4,254,040
2021	4,352,065

Data / Parameter	MC
Data unit	Vol-%
Description	Methane content of the biogas
Source of data	Calculated
Description of measurement methods and procedures to be applied	Calculated by the amount of electricity produced (EEP), the biogas produced (BGP) and the efficiency of the CHP engines (ETA_{CHP-el}).

Frequency of monitoring/recording	Annually
Value monitored	Year: 2016 – Methane content [%]: 54.9 2017 – 59.9 2018 – 64.0 2019 – 56.5 2020 – 56.2 2021 – 53.6
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of the data	To cross-check the methane produced and destroyed by the CHP engines
Calculation method	The equation used to calculate the methane content is based on the validated formula in the PDD for calculating the biogas production (where MC = x_{CH4}): $$BGP = \frac{EEP}{(ETA_{CHP-el}) * HV_{Biogas}}$$ Where: BGP: Biogas produced [m³] EEP: Electrical energy produced [MWh] ETA_{CHP-el}: Electric efficiency of the CHP engines HV_{Biogas}: Calorific value of biogas [kWh/m³] With $$HV_{Biogas} = 0,01 \frac{MWh}{m^3} \cdot x_{CH4}$$ Where: 0,01: Stoichiometric combustion calculation of CH_4 [MWh/m³]: 802,6 kJ/mol /0,02241 m³/mol = 35.814,37 kJ/m³ = 0,01 MWh/m³ x_{CH4}: CH_4 volume content of biogas flow [%]
Comments	-

Year	Methane content [%]
2016	54.9
2017	59.9
2018	64.0
2019	56.5
2020	56.2
2021	53.6

<table>
<tr><td></td><td>$B_{Biomass,y}$</td></tr>
<tr><td>Data unit</td><td>t</td></tr>
<tr><td>Description</td><td>Net quantity of co-ferments i fed into the digester</td></tr>
<tr><td>Source of data</td><td>Scale recordings</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>Each co-ferment is weighed at delivery. The mass of the co-ferment is noted on the delivery receipt and electronically logged in the computer-based program Optimad from the Bright Company. The records are also logged in the RVO system.</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>At delivery</td></tr>
<tr><td>Value monitored</td><td><table>
<tr><th>Year</th><th>Co-substrate input [t/y]</th></tr>
<tr><td>2016</td><td>15,180</td></tr>
<tr><td>2017</td><td>14,728</td></tr>
<tr><td>2018</td><td>14,209</td></tr>
<tr><td>2019</td><td>14,864</td></tr>
<tr><td>2020</td><td>15,595</td></tr>
<tr><td>2021</td><td>15,820</td></tr>
</table></td></tr>
<tr><td>Monitoring equipment</td><td>Specifications of the weighing scale on the installation:
KEURINGS / CONTROLE RAPPORT
Serienummer(s): 3550
Type: sca1c1
Fabrikaat BWT Klasse: III
Ordernummer 10910 Tnr. : T2992 cem-cy 01/0025-5.2
Max: 70000 kg min: 400 kg e= 20 kg d= 20 kg</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>Weighing scales are precise and belong to the accuracy class III. Calibration occurs when the devices need service or repair.</td></tr>
<tr><td>Purpose of the data</td><td>To cross check the biogas produced and destroyed by the engines</td></tr>
<tr><td>Calculation method</td><td>N/A</td></tr>
<tr><td>Comments</td><td>-</td></tr>
</table>

4.3 Monitoring Plan

The person responsible for collecting all data relevant for monitoring GHG emission reductions is Martin Houben, managing director of Houbensteyn Milieu BV. He has taken over the responsibility for monitoring and recording all data. The operation and maintenance of the biogas plant is carried out by the operating staff of the company. Generally, all the relevant data needed for the calculation and monitoring of emission reductions are also requested by the government for usual business operation and must be collected and recorded. Data is needed for controlling and accountancy, but also to meet the requirements for the feed-in tariff for energy production. The operating staff keep operation manuals which contain the input and output quantities of substrates, the power and heat generation of the plant as well as the runtime hours of the CHPs. These data are also logged electronically.

Substrate inputs and outputs

As for the last crediting period, the total amount of manure delivered to the biogas plant is determined through a calculative method, as the difference between the digestate sold, which is measured and recorded for the monitoring years 2016-2021 (see Appendix B "[year] uitgaande mest hys") and the co-ferments inputs (see Appendix B "Meetrapport [year] – Houbensteyn"). This method is considered to be very conservative, as it does not take into account the weight loss due to dissolved biogas. The digestate leaving the biogas plant is weighed and the weighed amounts are logged in the official software of the government Dutch National Service for Enterprise (Rijksdienst voor Ondernement RVO), that records all the nutrients shifts and flows between farms under mijn.rvo.nl.

Manure delivered by external farms is transported by trucks to the biogas site and measured on site by means of a truck weighing scale (see Appendix B "Technical specifications weighing scale"). Each manure delivery is recorded via a delivery receipt in the company's folder and logged digitally in the software of RVO (see Appendix B "[year] aangevoerde mest hys"), as for the digestate. In these excel files, manure coming from the farms "Heidelveld varkens BV", "Meterik" or "Houbensteyn Heidelveld BV" are excluded, since these farms are belonging to the Houbensteyn group.

Manure delivered by the Houbensteyn farms is calculated as the difference between the total amount of manure delivered minus the amount of manure delivered by external farms (see the calculation steps in Appendix B "[year] uitgaande mest hys").

The co-ferment substrates entering the biogas plant are weighed at delivery by a weighing scale. The delivery notes of each substrate delivered are stored as hard copies in folders on the plant's site. The amounts of co-substrates are electronically logged in the computer-based program Optimad from the Bright Company. The data is recorded in the monthly and annual measurement reports (see Appendix B "Meetrapport [year] – Houbensteyn).

Dry matter (dm) and Organic dry matter (odm) from manure

Pig manure samples from Houbensteyn farms, Aben farms (VCS Project ID 335) and Princepeel farms (VCS Project ID 337) were sent to laboratories to measure the respective dry matter and organic dry matter contents. The sample analyzes were carried out by accredited companies

(Normec Robalab[7] and Eurofins[8]). Each of the 3 companies has taken 9 samples on the different livestock locations at different periods of time, in order to obtain representative results. The measurement results with confidence and precision levels of 90/10 are presented in Appendix B "Measurements_dm-odm". The results show that over 95% of the dm/odm values are situated within the defined range.

For manure delivered by the Houbensteyn farms, average dm and odm contents are calculated based on the representative measurements mentioned above.

According to section 4.1 of the PDD, 90% of the average measured dm and odm contents from the 3 above mentioned projects are taken for manure deliveries from external farms (see Appendix A under "BE Manure – AMS-III D"). This approach is found to be conservative, since none of the results from dm/odm measurements are below the lower limit applies (90% of the mean value).

Manure transport

During the project activity, manure is transported from the Houbensteyn farms to the biogas plant as well as from external farms to the biogas plant. Manure is delivered by trucks with tank trailers with a transport capacity of 36 tons. The technical specifications of the trucks are provided under Appendix B "Type plate – Tank trailer".

For manure transported from the Houbensteyn farms to the biogas plant, the distance from the furthest farm location to the biogas plant (10.6 km) has been taken as transport distance for the monitoring years 2016-2021 (see Appendix A under "PE – Transport"), as the quantity of manure delivered by each farm of the Aben company is not directly measured and in order to be conservative.

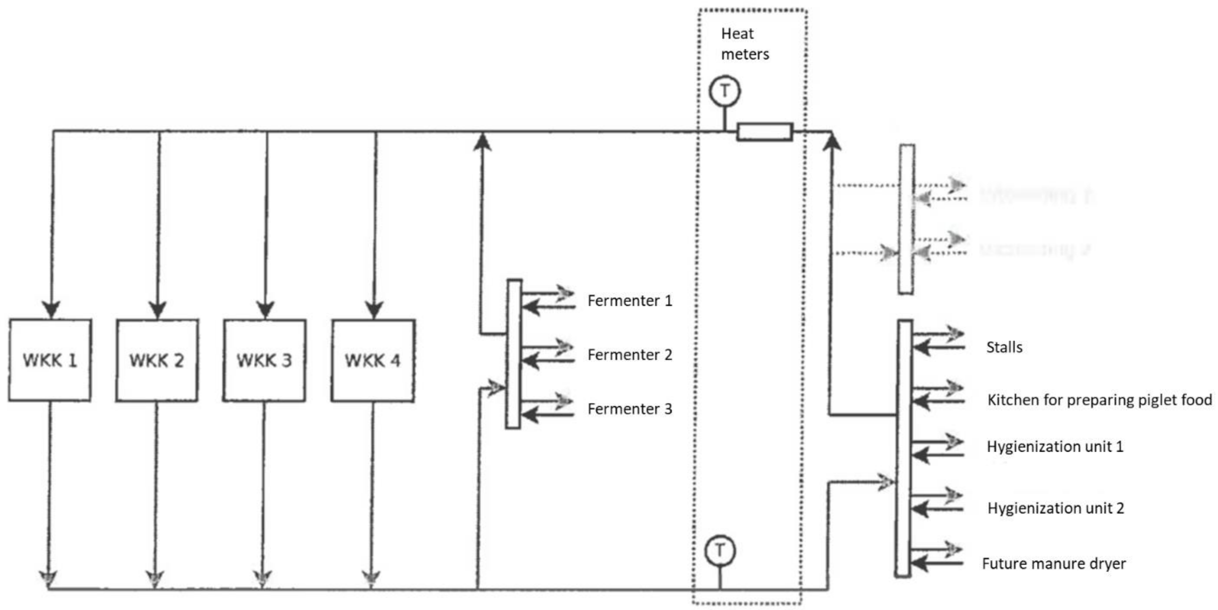
Regarding manure transported from external farms to the biogas plant, a simple method has been chosen to calculate the average distance, as project emissions from transport represent only <1% of the emission reductions achieved through manure fermentation. The postcodes and the number of manure transports from the respective postcodes were used to calculate the average incremental transport distance (see App C under "PE – Transport"). The postcodes of the external manure suppliers are recorded in Appendix B "[year] aangevoerde mest hys" (displayed in green) from 2017 onwards.

Heat production

[7] https://normecfoodcare.com/nl-en/accreditations-and-recognitions/

[8] https://www.eurofinsfoodtesting.com/accreditations-certifications

The heat produced by the biogas plant has been used since 2006 for the company's own process (fermenter 1-3) as well as for heating the pig stalls and office buildings, preheating piglet food and for digestate hygienization.



Figuur 3 Stroomschema warmtetoepassing Houbensteyn

Figure 3: Translated schematic representation of heat flow, including heat meters and users (Source: Appendix B "Meetprotocol Houbensteyn Milieu BV", p. 6)

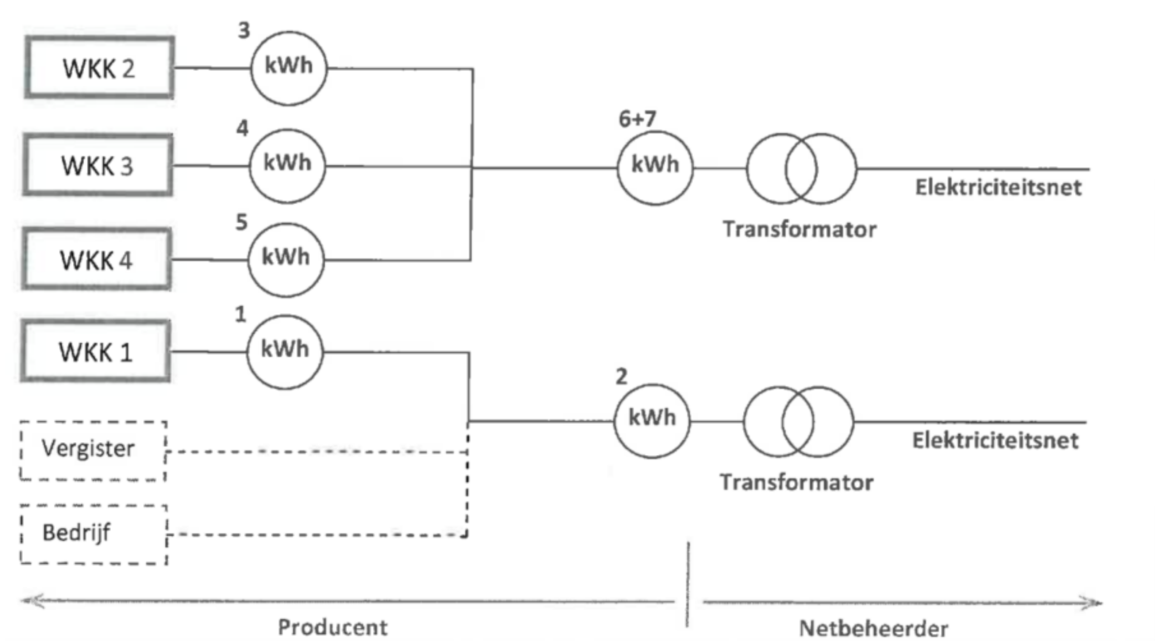
The thermal energy used externally has been officially measured by Fudura since June 2012 by means of heat meters and is recorded electronically in files named "Meetrapport [year] - Houbensteyn" (see Appendix B). Calibration is regularly performed by an authorized service provider called Kamstrup. The official measurements are used to calculate heat consumption from space heating and for preheating piglet food (see Appendix A under "BE Heat – AMS-I C").

Electricity production

The electricity production is continuously recorded at the processing unit of the CHP (measurements every 15 minutes). The daily production is recorded by a data logger. The records of the daily electricity production rates measured by Fudura can be found since 2012 in the mandatory measurement reports provided by Eqwadraat (see Appendix B "Meetrapport [year] - Houbensteyn"). These reports are compiled and checked by Eqwadraat, as can be read on the last page of each of the reports. These mandatory measurement reports are sent to CertiQ (the Dutch issuing body for guarantees of origin and certificates of origin for heat and electricity generated from sustainable sources) for certification. CertiQ then send the certified documents to Rijksdienst voor Ondernement (RVO, government Dutch National Service for Enterprise), which is the decision-making authority regarding renewable energy subsidies".

The electric meters are supplied, installed, and operated by this recognized measuring company Fudura B.V. Fudura reads, collects and validates the necessary measurement data and send the data to the grid operator. Fudura also takes care of the control and maintenance of the meter. According to Fudura, the electricity measurements fully comply with the European CE-Directive Measuring Instrument Directive (MID). That means, that the meters are operated, maintained and calibrated according to the manufacturer's instructions. The installation and operation of the electrical meter is regulated by law. The operator has not the possibility access or manipulate the meters as they are sealed by officials (Fudura B.V.). This is a common fact in EU countries. Authorities require meters to be initially qualified (DU: "Eichung") which is similar to a calibration but can only be conducted by a competent authority. Accuracy is provided and safeguarded by law through the competent authority .

The accuracy class of the CHPs' power meters is given in a report named "Meetprotocol Houbensteyn Milieu B.V.", p. 8 ("Nauwkeurigheid = accuracy class", see Appendix B). This report contents also the data regarding electricity (and heat) production, their technical description and the monitoring methods. This report has to be submitted to the government and serves as basis for the subsidies.



Figuur 2. Schematische weergaven elektriciteitsstromen inclusief systeemgrens en meters

Figure 4: Schematic representations of electricity flow, including system boundary and meters (Source: Appendix B - "Meetprotocol Houbensteyn Milieu BV", p. 5.)

Methane content

The methane content has been continuously measured, but the data has not been regularly recorded. Only an estimation of the average annual methane content is possible. Therefore, as explained under section 3.2.1. of this monitoring report, the calculation method presented in the PDD used for calculating the biogas production is applied instead of using literature values of methane content from all substrates treated in the plants. The calculation bases on the biogas production, the electricity production, and the efficiency of the CHPs.

The biogas production is calculated by Eqwadraat and recorded in the measurement reports (see Appendix B “Meetrapport [year] – Houbensteyn”). The electricity production is measured by Fudura and is also recorded in the measurement reports. The efficiency of the CHPs is given in the technical specification sheets of the CHPs (see Appendix B “Data sheet MAN LE [no]”).

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

1. Baseline Emissions from Manure Management

The methane emission reduction through the project activity is calculated according to the small-scale Methodology AMS-III.D, as per section 4.1 of the registered PDD with following equation:

$$BE_{y,ex-post} = GWP_{CH_4} \cdot D_{CH_4} \cdot Uf_b \cdot \sum_{j,LT} MCF_j \cdot B_{0,LT} \cdot Q_{manure,j,LT,y} \cdot SVS_{j,LT,y}$$

Where:

$BE_{y,ex\ post}$	Baseline emissions in year y using ex-post monitored values (t CO_2e)
GWP_{CH4}	Global Warming Potential of CH_4 applicable to the crediting period (t CO_2e/t CH_4)
D_{CH4}	CH_4 Density (0.00067 t/m³ at room temperature (20 °C) and 1 atm pressure)
UF_b	Correction factor to account for model uncertainties (0.94)
j	Index for animal manure management system
LT	Index for all types of livestock
MCF_j	Annual methane conversion factor (MCF) for the baseline animal manure management system j
$B_{0,LT}$	Maximum methane producing potential of the volatile solid generated for animal type LT (m³ CH_4 / kg dm)
$Q_{manure,j,LT,y}$	Quantity of manure treated from livestock type LT and animal manure management system j (t/y, dry basis)
$SVS_{j,LT,y}$	Specific volatile solids content of animal manure from livestock type LT and animal manure management system j in year y (t/t, dry basis)

The data and parameter used for ex-post baseline emission calculation are presented below.

Global Warming Potential (GWP_{CH4})

According to the VCS Standard v4.1, section 3.14.4, all ex-ante estimates and ex-post calculations may be converted to CO_2e using either the GWP values from the IPCC Fourth Assessment Report (AR4) or those from AR5.

For the project activity, the GWP value for methane of 28 established in AR5 has been chosen.

Methane Conversion Factor (MCF_j)

The MCF represents the percentage of manure's maximum methane-producing capacity that is actually achieved during manure management, i.e. part of organic matter actually converted into methane. In the Netherlands, liquid animal manure is stored in pits underneath the slatted floors of animal housing facilities[9]. Against this practice background and as part of the preparation of the National Inventory Report (NIR), country specific MCF values were calculated for liquid manure since the manure management systems are different from the circumstances on which the IPCC default is based[10].

The MCF value for pig manure is 36%.

Maximum methane producing potential of volatile solid ($B_{0,LT}$)

The value of B_0 depends on the degradability of the organic components in the manure. As for the MCF value, a country specific B_0 value is taken for liquid manure and used for ex-post emission calculation from manure management[11].

The B_0 value for pig manure is 0,31.

Quantity of animal manure ($Q_{manure,j,LT,y}$) and average dry matter content (dm_{LT})

As described in the PDD under section 3.6, the measured amount of fresh manure has to be multiplied by the values for dry matter content of animal manure (dm_{LT}) in order to have the equivalent value of manure on a dry basis, as required in the methodology:

$$Q_{manure,j,LT,y} = Q_{fm,j,LT,y} \cdot dm_{j,LT}$$

Where :

$Q_{manure,j,LT,y}$	Quantity of manure treated from livestock type LT and animal manure management system j (t/y, dry basis)
$Q_{fm,j,LT,y}$	Measured quantity of fresh manure treated from livestock type LT and animal manure management system j (t/y, fresh basis)

[9] "Greenhouse gas emissions in the Netherlands 1990-2019, National Inventory Report 2021", Section 5.3.2, p. 174.

[10] "Methodology for estimating emissions from agriculture in the Netherlands, Calculation from CH4, NH3, N2O, NOx, NMVOC, PM2.5 and CO2 using the National Emission Model Agriculture (NEMA) – Update 2021", Section 4.2.3, p. 54.

[11] "Methodology for estimating emissions from agriculture in the Netherlands, Calculation from CH4, NH3, N2O, NOx, NMVOC, PM2.5 and CO2 using the National Emission Model Agriculture (NEMA) – Update 2021", Section 4.2.3, p. 54.

$dm_{j,LT}$ Average dry matter content from manure of livestock type LT and animal manure management system j (t dry matter/ t fresh matter)

The average dry matter content (dm) from manure has been measured by accredited laboratories specialized in that field. According to the PDD section 5.2, samples for analysing the dry matter content of pig manure have been taken on each farm from Houbensteyn Ysselsteyn BV. In order to have a representative sample size, the dry matter content from pig manure from farms located in the same region (Aben farms, VCS Project ID 335, and Princepeel farms, VCS Project ID 337), have been measured and an average dm value of 0,117 was calculated from all dm results (see Appendix B "dm odm measurements").

Since the project is a co-digestion project with many external manure suppliers and according to section 3.6 of the PDD, the value for dry matter content from pig manure coming from external farms is 0,105, which represents 90% of the measured average value mentioned above.

Specific volatile solids content ($SVS_{j,LT,y}$)

Specific volatile solids content (SVS) of animal manure is the organic dry matter in livestock manure consisting of biodegradable and nonbiodegradable fractions. Together with the $dm_{j,LT}$ described above, $SVS_{j,LT,y}$ has been measured by accredited laboratories in accordance with section 5.2 of the PDD. As for the calculation of the average dm value, SVS from pig manure has been measured on Houbensteyn farms, as well as on Aben und Princepeel farms, in order to obtain an average SVS value. As a result, the average SVS value for pig manure from project's farms is 0,773.

Since the project is a co-digestion project with many external manure suppliers and according to section 3.6 of the PDD, the value for specific volatile content from pig manure coming from external farms is 0,696, which represents 90% of the measured average value mentioned above.

As a result, and using the formula above, the ex-post baseline emissions from pig manure treated in the monitoring years 2016-2021 are presented in the table below and the emission calculation is detailed for the year 2021:

$BE_{pig,own,2021}$ = 28 x 0.00067 x 0.94 x 36% x 0.31 m³ CH_4/kg-dm x 38,324 t/y x 0.117 dm/fm x 0.773 svs/dm

= 6,791 t CO_2e/a

$BE_{pig,ext,2021}$ = 28 x 0.00067 x 0.94 x 36% x 0.31 m^3 CH_4/kg-dm x 18,948 t/y x (0.105 dm/fm x 90%) x (0.696 svs/dm x 90%)

= 2,720 t CO_2e/a

$BE_{ex\ post,2021}$ = 6,791 + 2,720

= 9,510 t CO_2e/a

BASELINE EMISSIONS	**CH_4 emission from manure management**
Unit	t CO_2e
2016	4,989
2017	7,804
2018	5,664
2019	12,927
2020	10,929
2021	9,510
Total emissions	**51,824**

Table 4 : Calculation of ex-post baseline emissions from manure management (2016-2021)

2. Baseline Emissions from external heat use

As explained in the PDD under section 3,6, the waste thermal energy produced by the biogas plant used by 3 external heat consumers (space heating, pre-heating piglet food and hygienization unit) is measured with only 1 heat meter, so that a calculative approach has been adopted to determine the heat use for the space and piglet food as well as for the hygienization unit.

The total baseline emissions from external heat use are:

$$BE_{thermal,CO_2,y} = BE_{thermal,CO_2,SH,PF,y} + BE_{thermal,CO_2,HYG,y}$$

Where

$BE_{thermal,CO2,SH,PF,y}$ baseline emissions from space heating and preheating piglet food during the year y (Tj)

$BE_{thermal,CO2,HYG,y}$ baseline emissions from substrate hygienization during the year y (Tj)

a) **Heating pig stalls and pre-heating piglet food** ($BE_{thermal,CO2,SH,PF,y}$)

As described in section 4.1 of the PDD, the calculative approach to determine the thermal energy required for space heating (SH) and pre-heating piglet food (PF) used is:

$$BE_{thermal,CO_2,SH,PF,y} = \left(EG_{thermal,CO_2,SH,PF,y}/\eta_{BL,thermal}\right) \cdot EF_{FF,CO_2}$$

where

$$EG_{thermal,CO2,SH,PF,y} = Heat_{tot,y} - Heat_{HYG,y}$$

with:

$EG_{thermal,CO2,SH,PF,y}$ the net quantity of heat supplied by the project activity for space heating (SH) and for pre-heating piglet food (PF) during the year y (TJ)

$Heat_{tot,y}$ total quantity of external heat use by the project activity during the year y (Gj), measured

$Heat_{HYG,y}$ net quantity of heat supplied by the project activity to the hygienisation unit (HYG) during the year y (Tj), calculated

And with:

$$Heat_{HYG,y} = Digestate \cdot Cap_{heat,PR} \cdot \left(T_{HYG,PR} - T_{inlet,PR}\right) \cdot 1/Eff_{ex,PR}$$

Where:

Digestate quantity of digestate produced by the biogas plant in the year y (kg)

$Cap_{heat,PR}$ heat capacity of the digestate to be heated, set to the capacity of water 1,16 kWh/t

$T_{Hyg,PR}$ needed hygienization temperature, set to 75 °C

$T_{Inlet,PR}$ digestate inlet temperature to the hygienization system in the project scenario, set to the 37 °C

Eff_{Hex} heat exchanger efficiency, set to 87 %

As a result, the ex-post baseline emissions from space heating and pre-heating piglet food in the monitoring years 2016-2021 are represented in the following tables and the emission calculation is detailed below for the year 2021:

$Heat_{HYG,2021}$ = 73,091,460 kg x 1.16 kWh/t x (75°C – 37°C) x 1 / 87%

= 3,703,301 kWh

$EG_{thermal,CO2,SH,PF,2021}$ = 37,225 Gj / 1,000 Gj/Tj – (3,703,301 kWh x 0.0000036 kWh/Tj)

= 37 Tj – 13 Tj

= 24 Tj

$BE_{thermal,CO2,SH,PF,2021}$ = (24 Tj / 100%) x 56.40 t CO_2/Tj

= 1,348 t CO_2e

The different steps to calculate the ex-post baseline emissions from space heating and pre-heating piglet food are also detailed in Appendix A under “BE Heat - AMS-I C”.

b) Heat use for hygienization unit ($BE_{thermal,CO2,HYG,y}$)

Since the amount of heat required in the project activity does not correspond to that used in the baseline scenario, direct measurements of $EG_{thermal,CO2,HYG,y}$ cannot be used for the calculation.

As for the first crediting period, a calculative approach is used:

$$BE_{thermal,CO_2,HYG,y} = \left(EG_{thermal,CO_2,HYG,y} / \eta_{BL,thermal}\right) \cdot EF_{FF,CO_2}$$

Where

$$EG_{thermal,CO_2,HYG,y} = Q_{fm,i,LT,y} \cdot Cap_{heat,BE} \cdot \left(T_{HYG} - T_{inlet,BE}\right) \cdot 1/Eff_{ex}$$

with

$EG_{thermal,CO2,HYG,y}$	Net quantity of thermal energy supplied by the project activity during the year y (TJ)
$Q_{fm,j,LT,y}$	annual manure excreted from the animals in kg during the year y
$Cap_{Heat,BE}$	heat capacity of the manure to be pre-heated, set to the capacity of water 4,18 kJ/kg K
T_{Hyg}	needed hygienization temperature, set to 70 °C
$T_{Inlet,BE}$	manure inlet temperature to the hygienization system in the baseline scenario, set to the average ambient temperature 10.8 °C

Eff_{ex} heat exchanger efficiency, set to 100 %

Applying the above equations, the ex-post baseline emissions from hygienization in the monitoring years 2016-2021 are presented in the following tables and the emission calculation is detailed below for the year 2021:

$EG_{thermal,CO2,HYG,2021}$ = 57,271,460 kg * 4.18 KJ/kg K * (70°C – 10.8°C) * 1 /100%

= 14 TJ

$BE_{thermal,CO2,HYG,2021}$ = (14 TJ / 100%) * 56.40 t CO_2/TJ

= 799 t CO_2

Therefore, emission reductions from fossil fuel displacement due to the project Methane Recovery Project Houbensteyn Ysselsteyn during the monitoring period 2016-2021 are, with example below for the monitoring year 2021:

$BE_{thermal,CO2,tot,2021}$ = 1,348 t CO_2 + 799 t CO_2

= 2,147 t CO_2

BASELINE EMISSIONS	**CO_2 emission from thermal energy production**
Unit	t CO_2
2016	947
2017	1,927
2018	2,013
2019	2,239
2020	2,221
2021	2,147
Total emissions	**11,493**

Table 5: Total ex-post baseline emissions from thermal energy consumption (2016-2021)

5.2 Project Emissions

1. Project emissions – Manure management

According to the PDD, emissions due to physical leakage of biogas and to incremental transportation of manure have to be considered.

a) $PE_{PL,y}$ - Emissions from physical leakage of biogas

Project emissions from physical leakage are based on the total baseline emissions from manure management (BE_y) and are calculated as follows:

$$PE_{PL,y} = 0.10 \cdot BE_{y,ex-post}$$

The application of the formula above results in project emissions from physical leakage from the project activity Methane Recovery Project Houbensteyn Ysselsteyn during the monitoring years 2016 to 2021, with a calculation example below for the monitoring year 2021, of:

PE_{PL2021} = 0.10 x 9,510 t CO_2e

= 951 t CO_2e

BASELINE EMISSIONS	Project emissions - Physical leakage
Unit	t CO_2e
2016	499
2017	780
2018	566
2019	1,293
2020	1,093
2021	951
Total emissions	**5,182**

Table 6: Project emissions from physical leakage (2016-2021)

b) $PE_{transp,y}$ - Emissions from incremental transportation of manure

In the project activity, emissions from manure transported from the farms to the biogas plant are calculated with help of following equation:

$$PE_{transport,y} = (Q_y / CT_y) \cdot DAF_w \cdot EF_{CO2,tranport}$$

Where:

Q_y Quantity of manure treated in the year y (tonnes)

CT_y Average truck capacity for transportation (tonnes/truck)

DAF_w Average incremental distance for manure transportation (km/truck)

$EF_{CO2,transport}$ CO_2 emission factor from fuel use due to transportation (kgCO_2/km, IPCC default values or local values may be used)

The calculation is applied once for the manure transported from the Houbensteyn farms to the biogas plant and once from the external farms to the biogas plant.

Using the formula above, project emissions from manure transported from the farms to the biogas plant are presented in the tables below and the calculation steps are detailed for the year 2021 as example:

$PE_{transp,2021}$ = (38,324 t / 36 t/truck) x 10.6 km/truck x 1,028 g CO_2/km +

(18,948 t / 36 t/truck) x 12 km/truck x 1,028 g CO_2/km

= 11,6 t CO_2 + 6,7 t CO_2

= 18 t CO_2

BASELINE EMISSIONS	Project emissions - Manure tranportation
Unit	t CO_2e
2016	7
2017	20
2018	12
2019	23
2020	19
2021	18
Total emissions	**100**

Table 7: Project emissions from incremental transportation of manure (2016-2021)

5.3 Leakage

According to the PDD section 4.3., there is no leakage due to the project activity.

5.4 Net GHG Emission Reductions and Removals

The project activity reduces GHG emissions due to methane recovery through controlled anaerobic digestion and to the displacement of fossil fuel by using the produced renewable thermal energy.

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
01.05.2016 - 31.12.2016	5,936	506	0	5,430
01.01.2017 - 31.12.2017	9,731	800	0	8,930
01.01.2018 - 31.12.2018	7,677	579	0	7,098
01.01.2019 - 31.12.2019	15,166	1,316	0	13,850
01.01.2020 - 31.12.2020	13,149	1,112	0	12,038
01.01.2021 - 31.12.2021	11,657	969	0	10,688
Total	63,316	5,282	0	58,034

APPENDIX A: SPREADSHEET WITH CALCULATION OF EMISSION REDUCTIONS

APPENDIX B: MONITORING PLAN - DOCUMENTATION

1. Records of the electricity and heat production rates for the year 2016 till 20216 certified by Fudura BV named “Meetrapport [year] – Houbensteyn”
2. Electric efficiency of the CHPs under “Data sheet MAN LE 312” and “Data sheet MAN LE 202”
3. Annual quantities of digestate produced and recorded under “[year] uitgaande mest hys”
4. Technical specifications of the weighing scale named “Technical specifications weighing scale”
5. Manure provided by external suppliers recorded under “[year] aangevoerde mest hys”
6. Analyse of manure measurements’ results for dry matter and organic dry matter content recorded under “Measurements_dm-odm”
7. “Technical specifications of the tanks transporting manure to the biogas plant named “Technical specification – Tank trailer”
8. Reports containing information about electricity (and heat) production, their technical description, the monitoring methods as well as calibration reports named “Meetprotocol Houbensteyn Milieu B.V.”