METHANE RECOVERY PROJECT PRINCEPEEL WILBERTOORD NORTH BRABANT, THE NETHERLANDS

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Document Prepared by everi GmbH

Project Title	Methane Recovery Project Princepeel Wilbertoord, North Brabant, the Netherlands
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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

Methane Recovery Project Princepeel Wilbertoord (hereafter referred to as project Princepeel) 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 Landgoed de Princepeel BV located in Wanroij, Province of North Brabant, 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 June 1st, 2017 to December 31st, 2021. During this period, 6 CHPs with a total electrical capacity of 6 MW were in operation and produced around 73 million m^3 of biogas. The project is under continuous operation since the commissioning of the first CHP in 2007.

The heat produced by the biogas plant is used for the biogas production process of the plant, but also to substitute fossil fuels with fertilizer production and hygienization of digestate.

The total GHG emission reductions due to the project activity generated under the current monitoring period starting from 01/06/2017 to 31/12/2021 amounts to 89,415 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	B.V. Landgoed de Princepeel
Contact person	Pieter Smits
Title	Owner and Managing Director
Address	Molenstraat 40, 5446 PL Wanroij North Brabant - The Netherlands
Telephone	+ 31 06 101 42 404

Email	pieter@princepeel.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
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1.5 Project Start Date

The start of commissioning of the first CHP was the 01st of June 2007.

1.6 Project Crediting Period

The start date of the crediting period is set to the 01st of June 2007. The project uses a crediting period of 10 years which ended on 31st of May 2017. 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 the 01st of June 2007 and will end on 31st of May 2027.

1.7 Project Location

The project activity takes place on the estate of the project owner B.V. Landgoed de Principeel. The project is located in Wilbertoord in North Brabant, southeastern part of the Netherlands. The geographical coordinates are N51°39' 20.988" E5°46 '30".

1992 MAGELLAN Geographix SM Santa Barbara, CA (800) 929-4627

Figure 1: Map of The Netherlands with marked project location

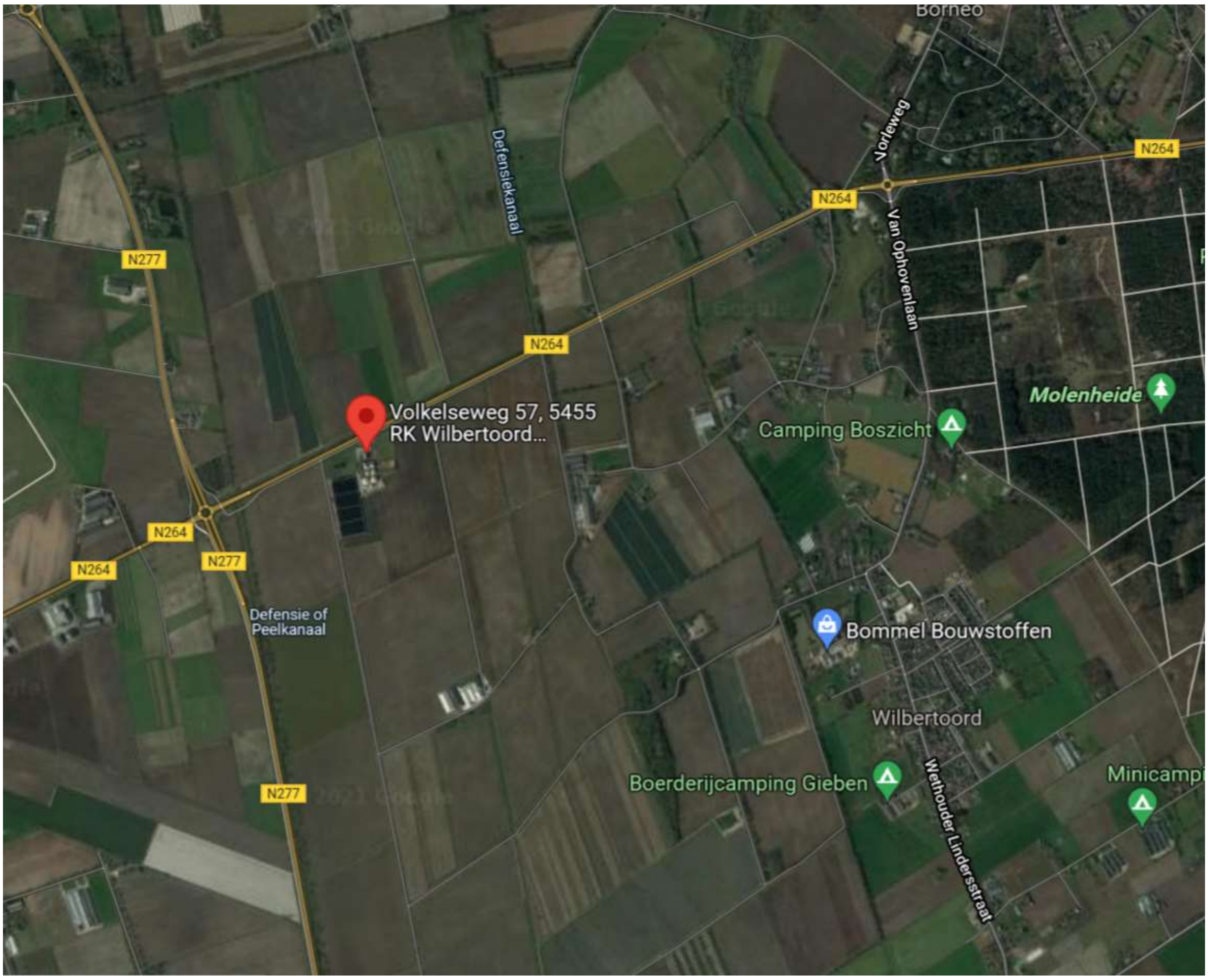


Figure 2: Area map with project location

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 in animal 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 Princepeel Wilbertoord 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 148 GWh of renewable electricity and at least 266 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 662 GWh and at least 347 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 (8 full-time and 5 part-time jobs for operation, maintenance and administration of the plant) and indirect employments (16 jobs for substrate transport) 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 (8 full-time and 5 part-time jobs for operation, maintenance and administration of the plant) and indirect employments (16 jobs for substrate transport) 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, at least 92 thousand tons of GHG emissions were avoided through project activity during the monitoring years 2017-2021	Prevented the release of 483 thousand tons of carbon into the atmosphere.

Table 1: Sustainable Development Contributions

2 SAFEGUARDS

2.1 No Net Harm

The Princepeel 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 Princepeel 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 337. 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 Landgoed de Princepeel 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 project’s lifetime.

No special meetings have been organized since the communication with the stakeholders takes place in the day-to-day life due to the neighborhood or a working relationship and the impact of the installation in operation on the stakeholders is positive. Six to seven times a year, B.V. Landegoed de Princepeel 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 Pieter Smits, 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 2017-2021.

CHP Units	Electric capacity installed	Thermal capacity installed	Electric efficiency [FT]	Start of operation date
	kWel	kWth	%	
CHP 1 - Waukesha 475	475	695	35.2	2006
CHP 2 - Waukesha 550	550	865	37.6	2006
CHP 3 -Jenbacher 320	1065	1339	40.9	2006
CHP 4 - Jenbacher 320	1065	1339	40.9	2006
CHP 5 - Jenbacher 420	1416	1405	42.0	2008
CHP 6 - Jenbacher 420	1485	1709	41.7	2014

Table 2: Data of installed CHP units from Landgoed de Princepeel 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 82 million m³ biogas during the current monitoring period.

Year	Electricity produced [kWh]	Biogas produced [m³]	Weighted average Methane content [%]	CHP efficiency
	EEP	BGP	x_{CH4}	$ETA_{CHP\text{-}el}$
2017	35,078,778	14,846,800	59.5	0.397
2018	33,295,450	14,933,933	56.1	0.397
2019	36,212,197	18,687,519	48.8	0.397
2020	34,667,028	17,077,096	51.1	0.397
2021	39,474,117	16,680,156	59.6	0.397
Total	**178,727,570**	**82,225,504**	**55.0**	**0.397**

Table 3: Biogas and electricity production (2017-2021)

Since the beginning of the crediting period, the waste heat of the CHPs has been used for ammonia stripping, digestate drying, thermal evaporation and hygienization of 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)

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 all 5 different farms from B.V. Landgoed de Princepeel in order to obtain an average dry matter content value for each animal category, but not for each of the many suppliers. The efforts and costs to carry out manure

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

analyses from many 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 5 Princepeel 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

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. This can be explained as follows: while the baseline scenario does require only the manure to be heated up from storage (10,8 °C = ambient temperature) to 70 °C, the actual installed apparatus does heat up the complete digestate from fermenter exit temperature of about 37 °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/

As for the first crediting period, a calculative approach will be used. 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 temperature need to be known. The heat capacity of manure was set to the one for water. The inlet temperature was fixed to the average annual ambient temperature. According to paragraph 42. c) of the AMS-I.C and for conservativity reasons, a default value of 100% of efficiency of the baseline unit has been chosen.

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

<u>Where:</u>

$EG_{thermal,y}$	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_{Hex}	heat exchanger efficiency, set to 100 %

The calculation approach described has no negative impact on the quantification of the emission reductions and can be evaluated as accurate and conservative.

Furthermore, the exhaust gases released from the gas engines are fed directly into the inlet of the digestate dryer. The exhaust gas supply is registered per CHP by means of an open-close signal with an end contact. For each quarter of an hour, it is registered how many seconds the exhaust gas valve has been open. The thermal energy used for drying digestate out of exhaust gases is calculated using the equation given in the Appendix of this document (based on measured gross electricity production, and electric and thermal efficiency of the CHPs). The measurements and calculations are done monthly by an external independent company Fudura B.V., which 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 meters. Therefore, the calculated values for thermal energy use from exhaust gas are considered as very accurate and have no negative impact on the quantification of GHG emission reductions.

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) and x_{CH4} (methane content).

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 Kroes, which is the author of the mandatory electricity and heat measurement reports (see for example Appendix B “2021 Assurance Rapport – Princepeel” 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 JMS [no]" and "Meetprotocol Landgoed de Princepeel BV" on pages 4 and 11), 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.

3.2.2 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	$EF_{NG,CO2}$
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	$T_{Hyg,BE}$
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	$T_{Inlet,BE}$
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	-

Data / Parameter	Eff_{ex}
Data unit	%
Description	Heat exchanger efficiency of the hygienization unit
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	-
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

<table>
<tr><td>Value applied</td><td>
<table>
<tr><th>CHP Units</th><th>Electric efficiency</th></tr>
<tr><td></td><td>%</td></tr>
<tr><td>Waukesha 475</td><td>35.20</td></tr>
<tr><td>Waukesha 550</td><td>37.60</td></tr>
<tr><td>Jenbacher 320</td><td>40.90</td></tr>
<tr><td>Jenbacher 320</td><td>40.90</td></tr>
<tr><td>Jenbacher 420</td><td>42.00</td></tr>
<tr><td>Jenbacher 420</td><td>41.70</td></tr>
</table>
</td></tr>
<tr><td>Justification of choice of data or description of measurement methods and procedures applied</td><td>-</td></tr>
<tr><td>Purpose of Data</td><td>To cross-check the biogas produced and destroyed by the CHP engines</td></tr>
<tr><td>Comments</td><td>-</td></tr>
</table>

4.2 Data and Parameters Monitored

This Monitoring Report comprises approx. 4,5 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 registered in the annual electricity and heat measurement reports (Appendix B "[year] Assurance Rapport – Principeel").

<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 the Princepeel farms is calculated as the difference between the total amount of manure (registered in the measurements reports and based on animal numbers) and the amount of manure from external farms (registered in the RVO database).</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Annually, based on daily measurements</td></tr>
<tr><td>Value applied</td><td>
<table>
<tr><td>Liquid pig manure from Princepeel farms</td><td>Quantity [kg/y]</td></tr>
<tr><td>June -December 2017</td><td>26,904,000</td></tr>
<tr><td>2018</td><td>49,043,200</td></tr>
<tr><td>2019</td><td>60,048,000</td></tr>
<tr><td>2020</td><td>49,859,000</td></tr>
<tr><td>2021</td><td>49,998,000</td></tr>
</table>

<table>
<tr><td>Liquid pig manure from ext. farms</td><td>Quantity [kg/y]</td></tr>
<tr><td>2017</td><td>1,178,440</td></tr>
<tr><td>2018</td><td>622,800</td></tr>
<tr><td>2019</td><td>-</td></tr>
<tr><td>2020</td><td>-</td></tr>
<tr><td>2021</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Specifications of the weighing scale on the installation:
<table>
<tr><td>Type/Model, Type/Model:</td><td>VS125 18x3m</td></tr>
<tr><td>Fabrikant, Manufacturer:</td><td>PRECIA MOLEN</td></tr>
<tr><td>Serienummer, Serial number:</td><td>VS125 18x3m</td></tr>
<tr><td>Weegvermogen, Weighing capacity:</td><td>60.000 kg</td></tr>
<tr><td>Indeling, Division:</td><td>20 kg</td></tr>
<tr><td>Nauwkeurigheidsklasse, Accuracy class:</td><td>III</td></tr>
<tr><td>Toelatingsnummer, No of type approval certificate:</td><td>T2177</td></tr>
<tr><td>Bouwjaar, Year of construction:</td><td>2008</td></tr>
</table>
</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>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions and project emissions</td></tr>
</table>

Calculation method	Manure from own farms [t/y] = Total manure amount [t/y] – Manure from external farms [t/y]
Comments	-

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 Princepeel farms: Pig manure samples from all Princepeel farms, Aben farms (VCS Project ID 335) and Houbensteyn farms (VCS Project ID 336) 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	<table><tr><td>Manure from Princepeel farms</td><td>Average dry matter content [kg dm/kg]</td></tr><tr><td>Pig manure</td><td>0,117</td></tr></table> <table><tr><td>Manure from ext. farms</td><td>Average dry matter content [kg dm/kg]</td></tr><tr><td>Pig manure</td><td>0,105</td></tr></table>
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 Princepeel farms: Average annual dm value calculated based on all dm results from manure measurements on Princepeel farms, Aben farms (VCS Project ID 335) and farms Houbensteyn (VCS Project ID 336). For manure delivered by external farms: Average annual dm value [kg dm/kg] x 90%
Comments	Since the 2nd crediting period already started in June 1st, 2017, $dm_{j,LT,y}$ is based on recent measurements (2021/2022). The feeding of animals is the same since 2017. 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 2017 – 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 Princepeel farms: Pig manure samples from all Princepeel farms, Aben farms (VCS Project ID 335) and farms Houbensteyn (VCS Project ID 336) have been sent to laboratories to measure the respective organic dry matter content. For manure supplied by external farms: 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.
Frequency of monitoring/recording	Twice a year

Value applied	<table><tr><td>Manure from Princepeel 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>
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 Princepeel farms: Average annual odm value calculated based on all odm results from manure measurements on Princepeel farms, Aben farms (VCS Project ID 335) and Houbensteyn farms (VCS Project ID 336) For manure delivered by external farms: Average annual odm value [kg SVS/kg dm] x 90%
Comments	Since the 2nd crediting period already started in June 1st, 2017, $SVS_{j,LT,y}$ is based on recent measurements (2021/2022). The feeding of animals is the same since 2017. 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 2017 – 2021.

Data / Parameter	$EG_{thermal,AS,y}$
Data unit	Gj
Description	Quantity of thermal energy consumption for the ammonia stripping process during the year y
Source of data	Heat meter (WM 1)

<table>
<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. The daily measurements are recorded and send by Fudura both monthly and annually to CertiQ 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>2017</td><td>20,652</td></tr>
<tr><td>2018</td><td>46,662</td></tr>
<tr><td>2019</td><td>53,830</td></tr>
<tr><td>2020</td><td>62,316</td></tr>
<tr><td>2021</td><td>1,128</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Technical specification of heat meters:
<table>
<tr><th>WM</th><th>Heat type</th><th></th><th>Make, type</th><th>Measuring</th><th>Accuracy</th><th>Meet require-ments</th></tr>
<tr><td>1</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN100 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,07%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>2</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN150 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,22%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>3</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN100 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,11%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>4</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN125 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,0,04%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>5</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN125 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,18%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>6</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN125 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,06%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
</table>
Serial number of WM1: 5341738</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 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 “Electricity Measuring Code”. Fudura Meetbedrijf B.V. has a certified data collection, validation and distribution system EDS. Fudura Meetbedrijf B.V. is certified in accordance with the ISO 9001-2008 standard. Concerning heat measurements, limited validation takes place on the basis of</td></tr>
</table>

	checking completeness. Correction takes place by using reference electricity measurements. If measurement data are incomplete after checking, they are recollected and validated. If the measurement fails, it is reported to the producer who must resolve the failure in consultation with his supplier.
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	

Data / Parameter	$EG_{thermal,DD,y}$
Data unit	Gj
Description	Quantity of thermal energy consumption for the digestate drying process during the year y
Source of data	Heat meter (WM 2)
Description of measurement methods and procedures to be applied	The heat use is measured by a heat meter and recorded digitally. The daily measurements are recorded and send by Fudura both monthly and annually to CertiQ for certification.
Frequency of monitoring/recording	Annually, based on monthly reports
Value applied	<table><tr><th>Year</th><th>Heat consumption [Gj/y]</th></tr><tr><td>2017</td><td>3,996</td></tr><tr><td>2018</td><td>12,333</td></tr><tr><td>2019</td><td>7,238</td></tr><tr><td>2020</td><td>11,338</td></tr><tr><td>2021</td><td>46,096</td></tr></table>
Monitoring equipment	Technical specification of heat meters:

WM	Heat type		Make, type	Measuring	Accuracy	Meet require-ments
1	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN100 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,07% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
2	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN150 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,22% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
3	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN100 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,11% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
4	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN125 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,0,04% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
5	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN125 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,18% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
6	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN125 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,06% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja

Serial number of WM2: 5341737

QA/QC procedures to be applied	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 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 "Electricity Measuring Code". Fudura Meetbedrijf B.V. has a certified data collection, validation and distribution system EDS. Fudura Meetbedrijf B.V. is certified in accordance with the ISO 9001-2008 standard. Concerning heat measurements, limited validation takes place on the basis of checking completeness. Correction takes place by using reference electricity measurements. If measurement data are incomplete after checking, they are recollected and validated. If the measurement fails, it is reported to the producer who must resolve the failure in consultation with his supplier.
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	$EG_{thermal,TE,y}$
Data unit	Gj

<table>
<tr><td>Description</td><td>Quantity of thermal energy consumption for the thermal evaporating process during the year y</td></tr>
<tr><td>Source of data</td><td>Heat meter (WM 6 Indamper)</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. The daily measurements are recorded and send by Fudura both monthly and annually to CertiQ 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>2017</td><td>0</td></tr>
<tr><td>2018</td><td>4,091</td></tr>
<tr><td>2019</td><td>40,350</td></tr>
<tr><td>2020</td><td>79,714</td></tr>
<tr><td>2021</td><td>119,472</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Technical specification of heat meters:
<table>
<tr><th>WM</th><th>Heat type</th><th></th><th>Make, type</th><th>Measuring</th><th>Accuracy</th><th>Meet require-ments</th></tr>
<tr><td>1</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN100 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,07%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>2</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN150 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,22%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>3</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN100 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,11%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>4</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN125 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,0,04%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>5</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN125 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,18%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
<tr><td>6</td><td>Warm water</td><td>GJ</td><td>Ista Calec ST
Sensus WS-Dynamic
DN125 PT500</td><td>Debiet retour,
Temperatuur heen,
Temperatuur retour</td><td>Rekendeel: 0,06%
Flow sensor Volgens PTB 22.16
Temperatuur sensor: Klasse A</td><td>Ja</td></tr>
</table>
Serial number of WM 6: 5675809</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 meter. The meters are operated, maintained and calibrated according to the manufacturer’s instructions. Heat measurements are carried out in accordance with the applicable</td></tr>
</table>

	rules described in the "Electricity Measuring Code". Fudura Meetbedrijf B.V. has a certified data collection, validation and distribution system EDS. Fudura Meetbedrijf B.V. is certified in accordance with the ISO 9001-2008 standard. Concerning heat measurements, limited validation takes place on the basis of checking completeness. Correction takes place by using reference electricity measurements. If measurement data are incomplete after checking, they are recollected and validated. If the measurement fails, it is reported to the producer who must resolve the failure in consultation with his supplier.
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	$EG_{thermal,WKK1,y}$
Data unit	Gj
Description	Quantity of thermal energy consumption for the digestate drying process during the year y
Source of data	Heat meter (WM 4)
Description of measurement methods and procedures to be applied	The heat use is measured by a heat meter and recorded digitally. The daily measurements are recorded and send by Fudura both monthly and annually to CertiQ for certification.
Frequency of monitoring/recording	Annually, based on monthly reports
Value applied	Year / Heat consumption [Gj/y]: 2017: 9,137 2018: 25,309 2019: 19,968 2020: 21,195 2021: 28,140
Monitoring equipment	Technical specification of heat meters:

Year	Heat consumption [Gj/y]
2017	9,137
2018	25,309
2019	19,968
2020	21,195
2021	28,140

WM	Heat type		Make, type	Measuring	Accuracy	Meet require-ments
1	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN100 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,07% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
2	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN150 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,22% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
3	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN100 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,11% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
4	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN125 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,0,04% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
5	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN125 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,18% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja
6	Warm water	GJ	Ista Calec ST Sensus WS-Dynamic DN125 PT500	Debiet retour, Temperatuur heen, Temperatuur retour	Rekendeel: 0,06% Flow sensor Volgens PTB 22.16 Temperatuur sensor: Klasse A	Ja

Serial number of WM 4: 5601295

QA/QC procedures to be applied	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 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 "Electricity Measuring Code". Fudura Meetbedrijf B.V. has a certified data collection, validation and distribution system EDS. Fudura Meetbedrijf B.V. is certified in accordance with the ISO 9001-2008 standard. Concerning heat measurements, limited validation takes place on the basis of checking completeness. Correction takes place by using reference electricity measurements. If measurement data are incomplete after checking, they are recollected and validated. If the measurement fails, it is reported to the producer who must resolve the failure in consultation with his supplier.
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	$EG_{thermal,EG,y}$
Data unit	Gj

<table>
<tr><td>Description</td><td>Quantity of thermal energy consumption for the digestate drying process by exhaust heat during the year y</td></tr>
<tr><td>Source of data</td><td>Calculated by electricity and heat measuring company Fudura BV (correspond to WM 6 Rookgassen 2017-2019 and WM 7 2020-2021 in App B – 7 -)</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>The exhaust gas supply is registered per CHP by means of an open-close signal with an end contact. For each quarter of an hour, it is registered how many seconds the exhaust gas valve has been open. Each CHP has its own gross production meter that registers the electricity produced. The partial load is determined per 15 minutes per CHP. Together with the associated electrical and thermal efficiency, the amount of heat released when the exhaust gases are cooled back to 100 ºC is calculated. The method is a conservative method in which the actual heat production will be higher rather than lower due to reduced electrical efficiencies.</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>2017</td><td>20,207</td></tr>
<tr><td>2018</td><td>21,209</td></tr>
<tr><td>2019</td><td>21,874</td></tr>
<tr><td>2020</td><td>21,553</td></tr>
<tr><td>2021</td><td>27,956</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>EAN</th><th>Seriennr. Gross meter</th><th>Brand</th><th>Meter Type</th><th>Name</th><th>Unit</th><th>Accuracy class</th></tr>
<tr><td>EAN 915</td><td>88502998</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN1</td><td>Gross production WKK5</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>93968706</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN2</td><td>Gross production WKK2</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>94088664</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN3</td><td>Gross production WKK4</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>94088667</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN4</td><td>Gross production WKK3</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 440</td><td>94732952</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN5</td><td>Gross production WKK1</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>93968702</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN6a</td><td>Gross production WKK6</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>38402196</td><td>Landis+Gyr ZMD402CT44.0457</td><td>GEN6b</td><td>Gross production WKK6</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>38402193</td><td>Landis+Gyr ZMD402CT44.0457</td><td>GEN6c</td><td>Gross production WKK6</td><td>kWh</td><td>Class 1</td></tr>
</table>
</td></tr>
</table>

JB420	Rendement elektrisch	kWh-th per ^{o}C per kWh-el
100%	42,1%	0,001908
75%	40,9%	0,001678
50%	38,8%	0,001625
25%	33,5%	0,001599

JB320	Rendement elektrisch	kWh-th per ^{o}C per kWh-el
100%	40,8%	0,00188
75%	39,7%	0,00169
50%	37,8%	0,00163
25%	32,8%	0,00160

Waukesha 475	Rendement elektrisch	Rendement rookgassen
100%	35,2%	22,3%

Waukesha 550	Rendement elektrisch	Rendement rookgassen
100%	37,6%	22,3%

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. 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 meters.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	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.

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	An average distance from the Princepeel and external farms to the biogas plant has been calculated based on each farm's locations.
Frequency of monitoring/recording	Annually
Value applied	Average transport distance for manure from Princepeel farms: <table><tr><td>Year</td><td>Average distance [km/truck]</td></tr><tr><td>2017 - 2021</td><td>9.1</td></tr></table> Average transport distance for manure from external farms: <table><tr><td>Year</td><td>Average distance [km/truck]</td></tr><tr><td>2017</td><td>6.3</td></tr><tr><td>2018</td><td>6.3</td></tr><tr><td>2019</td><td>-</td></tr><tr><td>2020</td><td>-</td></tr><tr><td>2021</td><td>-</td></tr></table>
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	Based on the farm location, the weighted average transport distance from the Princepeel and external manure suppliers to the biogas plant is calculated.
Comments	-

Data / Parameter	EEP
Data unit	kWh
Description	Electrical energy produced
Source of data	Power meter
Description of measurement methods	Electric power meter at each CHP measures the produced electric energy.

<table>
<tr><td>and procedures to be applied</td><td></td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Continuously</td></tr>
<tr><td>Value monitored</td><td>
<table>
<tr><th>Year</th><th>Electrical energy produced [kWh/y]</th></tr>
<tr><td>2017</td><td>35,078,778</td></tr>
<tr><td>2018</td><td>33,295,450</td></tr>
<tr><td>2019</td><td>36,212,197</td></tr>
<tr><td>2020</td><td>34,667,028</td></tr>
<tr><td>2021</td><td>39,474,117</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Specifications of the power meters at the different CHP units:
<table>
<tr><th>EAN</th><th>Seriennr. Gross meter</th><th>Brand</th><th>Meter Type</th><th>Name</th><th>Unit</th><th>Accuracy class</th></tr>
<tr><td>EAN 915</td><td>88502998</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN1</td><td>Gross production WKK5</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>93968706</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN2</td><td>Gross production WKK2</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>94088664</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN3</td><td>Gross production WKK4</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>94088667</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN4</td><td>Gross production WKK3</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 440</td><td>94732952</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN5</td><td>Gross production WKK1</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>93968702</td><td>Landis+Gyr ZMD410CT44.0457</td><td>GEN6a</td><td>Gross production WKK6</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>38402196</td><td>Landis+Gyr ZMD402CT44.0457</td><td>GEN6b</td><td>Gross production WKK6</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 915</td><td>38402193</td><td>Landis+Gyr ZMD402CT44.0457</td><td>GEN6c</td><td>Gross production WKK6</td><td>kWh</td><td>Class 1</td></tr>
</table>
</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>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.

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 meters.</td></tr>
<tr><td>Purpose of the data</td><td>To cross-check the biogas produced and destroyed by the CHP engines</td></tr>
<tr><td>Calculation method</td><td>Please refer to App B – “Technical description of heat application from exhaust gases” on page 88 of the PD version 04 Methane Recovery Project Princepeel Wilbertoord from March, 3rd 2022.</td></tr>
<tr><td>Comments</td><td>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</td></tr>
</table>

	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.

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 "[year] Assurance Rapport - Princepeel)
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	$\sum$ (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]
2017	14,846,800
2018	14,933,933
2019	18,687,519
2020	17,077,096
2021	16,680,156

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	<table><tr><th>Year</th><th>Methane content [%]</th></tr><tr><td>2017</td><td>59.5</td></tr><tr><td>2018</td><td>56.1</td></tr><tr><td>2019</td><td>48.8</td></tr><tr><td>2020</td><td>51.1</td></tr><tr><td>2021</td><td>59.6</td></tr></table>
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	-

	$B_{Biomass,y}$
Data unit	t
Description	Net quantity of co-ferments i fed into the digester
Source of data	Scale recordings
Description of measurement methods and procedures to be applied	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 database. The records are also logged in the RVO system.
Frequency of monitoring/recording	At delivery
Value monitored	(see table below)

Year	Co-substrate input [t/y]
2017	50,709
2018	49,232
2019	54,928
2020	45,901
2021	47,708

Monitoring equipment	Specifications of the weighing scale on the installation:

Type/Model, *Type/Model:*	VS125 18x3m
Fabrikant, *Manufacturer:*	PRECIA MOLEN
Serienummer, *Serial number:*	VS125 18x3m
Weegvermogen, *Weighing capacity:*	60.000 kg
Indeling, *Division:*	20 kg
Nauwkeurigheidsklasse, *Accuracy class:*	III
Toelatingsnummer, *No of type approval certificate:*	T2177
Bouwjaar, *Year of construction:*	2008

QA/QC procedures to be applied	Weighing scales are precise and belong to the accuracy class III. Calibration occurs when the devices need service or repair. 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 the data	To cross check the biogas produced and destroyed by the engines
Calculation method	N/A
Comments	-

4.3 Monitoring Plan

The person responsible for collecting all data relevant for the monitoring of GHG emission reductions is Pieter Smits, managing director of B.V. Landgoed Princepeel, supported by Gert-jan Kuijpers who takes care of administration and registration. 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

Manure delivered by external farms and co-ferments are 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"). The delivery notes of weighed manure and co-ferments are stored in folders on the plant's site. The amounts of manure and co-substrates are logged electronically in the computer-based process visualization system from Siemens named Wincc (Windows Control Center). The data is saved for 1 month in Wincc and then exported to files named "Overzicht productleveringen [year] Princepeel BV" (see Appendix B).

Each substrate delivery is also logged digitally 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. This data can be exported as excel file. This file also contains the digestate quantities which, like manure and co-ferments, are weighed before leaving the biogas plant. Furthermore, the total amount of manure, co-ferments and digestate are disclosed in the mandatory annual electricity and heat measurement reports of the company (see Appendix B "[year] Assurance rapport – Princepeel"). These reports also gather data regarding heat and electricity production as well as digestate and are compiled and checked by Ekwadraat, 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".

Manure delivered by the Princepeel farms is calculated as the difference between the total amount of manure delivered minus the amount of manure delivered by external farms for the years 2017 and 2018 (see the calculation steps in Appendix A under "BE Manure – AMS-III D"). As of 2019, manure from external farms was no longer treated. Therefore, the manure amounts are directly reported from the measurement reports (see Appendix B "[year] Assurance rapport – Princepeel").

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

Pig manure samples from Princepeel farms, Aben farms (VCS Project ID 335) and Houbensteyn farms (VCS Project ID 336) 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 Princepeel 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 Princepeel farms to the biogas plant as well as from external farms to the biogas plant (in 2017/2018). 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 "D Tec specification – Tank trailer".

For manure transported from the Princepeel farms to the biogas plant, the distance from the furthest farm location to the biogas plant (9.1 km) has been taken as transport distance for the monitoring years 2017-2021 (see Appendix A under "PE – Transport"), as the quantity of

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

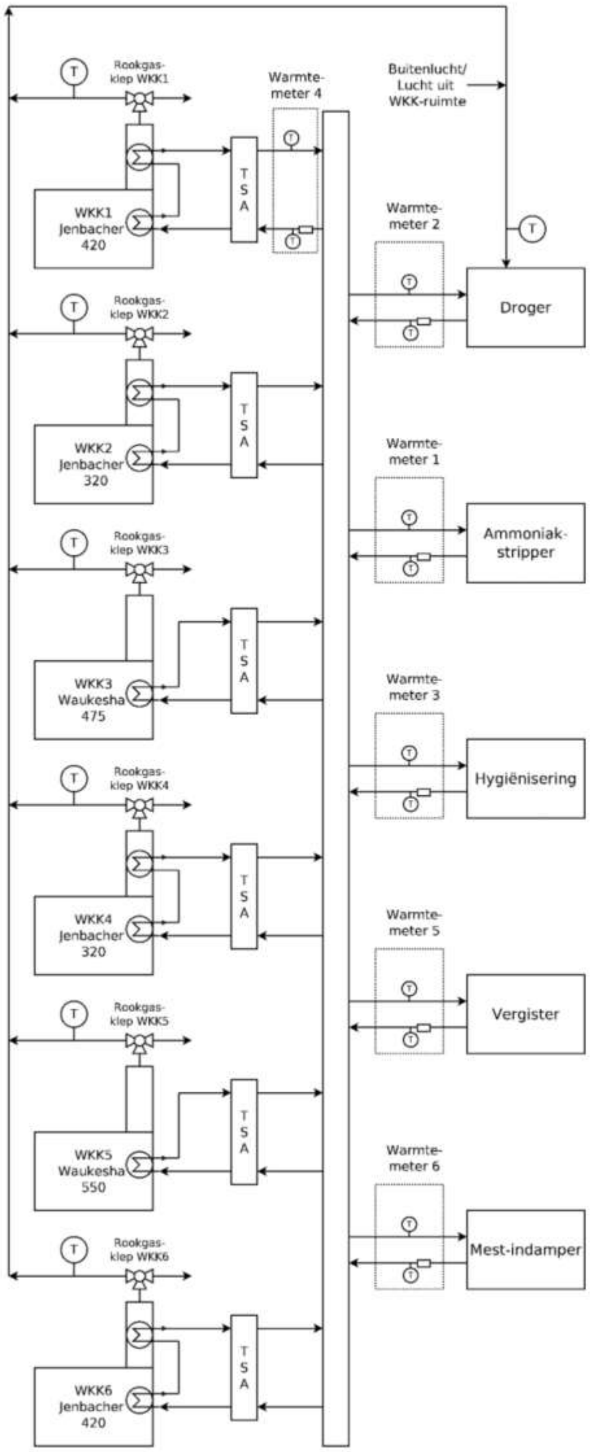
[8] https://www.eurofinsfoodtesting.com/accreditations-certifications

manure delivered by each farm of the Princepeel company is not directly measured and in order to be conservative.

Regarding manure transported from external farms to the biogas plant in 2017 and 2018, only 1 company (HO Bontrup B.V.), located 6.3 km away delivered manure to the biogas plant.

Heat production

The heat produced by the biogas plant has been used since 2006 for the company's own process as well as for ammonia stripping, thermal evaporation and drying digestate:



Figuur 3. Schematische weergave warmtebenutting

Figure 3: Schematic representation of heat flow, including heat meters and users (Source: Appendix B "Meetprotocol Landgoed de Princepeel BV", p. 8)

The thermal energy used externally has been officially measured by Fudura since October 2014 by means of heat meters and is recorded electronically in files named “[year] Assurance rapport - Princepeel” (see Appendix B). Calibration is regularly performed by an authorized service provider called AquaMetro. The official measurements are used to calculate heat consumption from ammonia stripping, drying digestate and thermal evaporation, (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 Kroes (see Appendix B “[year] – Assurance rapport - Princepeel”). These reports are compiled and checked by Kroes, 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 Landgoes de Princepeel B.V.”, p. 10 (“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.

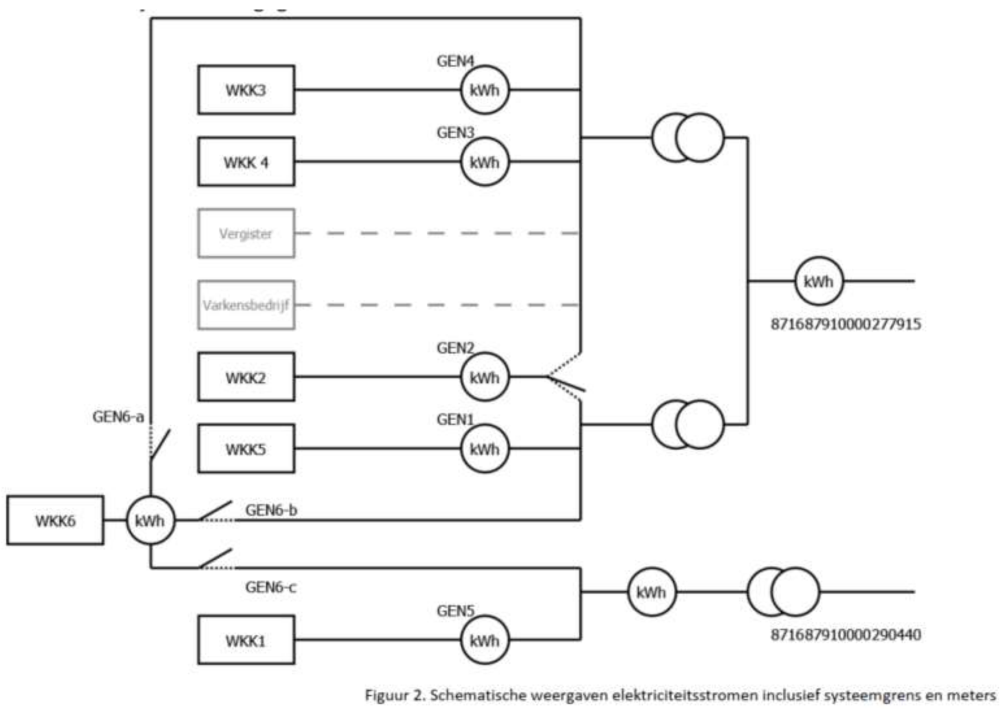


Figure 4: Schematic representations of electricity flow, including system boundary and meters (Source: Appendix B - "Meetprotocol Landgoed de Princepeel BV", p. 5.)

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 Kroes and recorded in the measurement reports (see Appendix B "[year] Assurance rapport – Princepeel"). 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 - JMS [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 (m^3 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 Landgoed de Princepeel 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 Houhensteyn farms, VCS Project ID 336), 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 Princepeel farms, as well as on Aben und Houbensteyn 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 2017-2021 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 49,998 t/y x 0.117 dm/fm x 0.773 svs/dm

= 8,859 t CO_2e/a

$BE_{pig,ext,2021}$ = 0

$BE_{ex\ post,2021}$ = 8,859 + 0

= 8,859 t CO_2e/a

BASELINE EMISSIONS	CH_4 emission from manure management
Unit	t CO_2e
2017	4,936
2018	8,780
2019	10,640
2020	8,835
2021	8,859

Table 4 : Calculation of ex-post baseline emissions from manure management (2017-2021)

2. Baseline Emissions from external heat use

In the project activity, heat is used to produce fertilizers in the form of pellets and ammonium sulphate, and for the hygienization process of digestate. The waste thermal energy going to the 4 external heat consumers (ammonia stripper, digestate dryer, thermal evaporating and hygienization unit) is measured for each heat consumer with at least 1 heat meter (the drying process has 2 heat meters (WM 2 and WM 4), since the new CHP (WKK 1) has his own heat production measurements). Furthermore, the digestate is also dried by the thermal energy use out of the exhaust heat of the CHPs.

According to the section 4.1 of the PDD, baseline emissions from external heat use are calculated as follow:

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

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

a) Heat use for fertilizer production ($BE_{thermal,FP,y}$)

As described in section 4.1 of the PDD, the baseline emissions from thermal energy use for fertilizer production include baseline emissions from ammonia stripping, from digestate drying and from thermal evaporation, and are calculated ex-post based on the thermal energy use measurements:

$$BE_{thermal,FP,y} = BE_{thermal,AS,y} + BE_{thermal,DD,y} + BE_{thermal,TE,y}$$

Where

$BE_{thermal,AS,y}$	baseline emissions from ammonia stripping during the year y (Tj)
$BE_{thermal,DD,y}$	baseline emissions from digestate drying during the year y (Tj)
$BE_{thermal,TE,y}$	baseline emissions from thermal evaporation during the year y (Tj)

With

$$BE_{thermal,DD,y} = BE_{thermal,WM2,y} + BE_{thermal,WKK1,y} + BE_{thermal,EG,y}$$

Where

$BE_{thermal,WM2,y}$	baseline emissions from digestate drying during the year y (Tj), measured by heat meter WM2
$BE_{thermal,WKK1,y}$	baseline emissions from digestate drying during the year y (Tj), measured by heat meter WM4 from CHP WKK1
$BE_{thermal,EG,y}$	baseline emissions from digestate drying during the year y (Tj), calculated with the heat use from exhaust gases

As a result, the ex-post baseline emissions from heat use for fertilizer production in the monitoring years 2017-2021 are represented in the following tables and the emission calculation is detailed below for the year 2021:

$BE_{thermal,AS,y}$ = (1 Tj / 100%) x 56.40 t CO_2/Tj

= 64 t CO_2

$BE_{thermal,TE,y}$ = (119 Tj / 100%) x 56.40 t CO_2/Tj

= 6,738 t CO_2

$BE_{thermal,DD,y}$ = 2,600 + 1,587 + 1,577

= 10,925 t CO_2

With

$BE_{thermal,WM2,y}$ = (46 Tj / 100%) x 56.40 t CO_2/Tj

= 2,600 t CO_2

$BE_{thermal,WKK1,y}$ = (28 Tj / 100%) x 56.40 t CO_2/Tj

= 1,587 t CO_2

$BE_{thermal,EG,y}$ = (28 Tj / 100%) x 56.40 t CO_2/Tj

= 1,577 t CO_2

Herewith, total baseline emissions for fertilizer production are:

$BE_{thermal,FP,2021}$ = 64 + 10,925 + 6,738

= 17,727 t CO_2e

The different steps to calculate the ex-post baseline emissions from fertilizer production 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 2017-2021 are presented in the following table and the emission calculation is detailed below for the year 2021:

$EG_{thermal,CO2,HYG,2021}$ = 49,998,000 kg * 4.18 KJ/kg K * (70°C – 10.8°C) * 1 /100%

= 12 TJ

$BE_{thermal,CO2,HYG,2021}$ = (12 TJ / 100%) * 56.40 t CO_2/TJ

= 698 t CO_2

Therefore, emission reductions from fossil fuel displacement due to the project Methane Recovery Project Princepeel Wilbertord during the monitoring period 2017-2021 are, with example below for the monitoring year 2021:

$BE_{thermal,CO2,tot,2021}$ = 17,727 t CO_2 + 698 t CO_2

= 18,425 t CO_2

BASELINE EMISSIONS	**CO_2 emission from thermal energy production**
Unit	t CO_2
2017	2,297
2018	5,909
2019	9,960
2020	15,037
2021	18,425
Total emissions	**51,629**

Table 5: Total ex-post baseline emissions from thermal energy consumption (2017-2021)

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 Princepeel Wilbertoord during the monitoring years 2017 to 2021, with a calculation example below for the monitoring year 2021, of:

PE_{PL2021} = 0.10 x 8,859 t CO_2e

= 886 t CO_2e

BASELINE EMISSIONS	**Project emissions - Physical leakage**
Unit	t CO_2e
2017	494
2018	878
2019	1,064
2020	883
2021	886
Total emissions	**4,205**

Table 6: Project emissions from physical leakage (2017-2021)

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 Princepeel 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:

$PE_{transp,2021}$ = (49,998 t / 36 t/truck) x 9.1 km/truck x 1,028 g CO_2/km +

(0 t / 36 t/truck) x 0 km/truck x 1,028 g CO_2/km

= 13 t CO_2 + 0 t CO_2

= 13 t CO_2

BASELINE EMISSIONS	**Project emissions - Manure tranportation**
Unit	t CO_2e
2017	4
2018	13
2019	16
2020	13
2021	13
Total emissions	**59**

Table 7: Project emissions from incremental transportation of manure (2017-2021)

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)
01.0~~1~~6.2017 - 31.12.2017	7,234	498	0	6,736
01.01.2018 - 31.12.2018	14,689	891	0	13,798
01.01.2019 - 31.12.2019	20,600	1,080	0	19,521
01.01.2020 - 31.12.2020	23,872	896	0	22,975
01.01.2021 - 31.12.2021	27,284	899	0	26,385
Total	93,679	4,264	0	89,415

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 2017 till 2021 certified by Fudura BV named "[year] Assurance Rapport – Princepeel"
2. Electric efficiency of the CHPs under "Data sheet JMS [no]"
3. Technical specifications of the weighing scale named "Technical specifications weighing scale"
4. Annual quantities of manure delivered by external farms and co-substrates treated in the biogas plant recorded under "Overzicht productleveringen [year] Princepeel BV"
5. Analyse of manure measurements' results for dry matter and organic dry matter content recorded under "Measurements_dm-odm"
6. "Technical specifications of the tanks transporting manure to the biogas plant named "D Tec specifications – Tank trailer"
7. Reports containing information about electricity (and heat) production, their technical description, the monitoring methods as well as calibration reports named "Meetprotocol Landgoed de Princepeel B.V."