METHANE RECOVERY PROJECT HOUBENSTEYN YSSELSTEYN, LIMBURG, THE NETHERLANDS

Document Prepared by GES Energie GmbH

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The Methane Recovery Project Houbensteyn was validated by TÜV Rheinland Group on August 25th, 2007 as domestic GHG offset project according to JI standards and has published an addendum on February 2009 to also fulfil VCS requirements. Technically, the project is an agricultural biogas plant that produces renewable energy (electricity and heat) from different organic input materials. The GHG emission reduction approaches were demonstrated in the PDD by the mitigation of uncontrolled methane emission out of manure and organic wastes as well as the generation of renewable thermal energy decentrally used to substitute fossil fuels. The project activity was put into operation in spring 2006. The Methane Recovery Project Houbensteyn has been verified for its first operation period from May 1st, 2006 to December 31st, 2007 in order to certify the correspondingly reduced GHG emissions by this project activity within this period.

The present Report monitors emission reductions that have occurred from the first monitoring period until the end of the project's crediting period (01/01/2008 - 30/04/2016), with a quantitative monitoring of emission reductions for only the last 6 years of the project's crediting period (01/05/2010 - 30/04/2016). The years between 01/01/2008 and 30/04/2010 are subject to a verification by the Verification Body concerning the evidence, that the project have reduced and not emitted GHG emissions in that period of time (see in Appendix E the "Request for exemption from quantitative monitoring for the crediting period from 01/01/2008 to 30/04/2010"). Consequently, no emission reductions are claimed in those years.

The current Monitoring Report refers to the monitoring concept of the PDD submitted in its version 04 by ARA Carbon Finance GmbH on July 2nd, 2007 to the TÜV Rheinland Group.

The project activity involves power generation using Combined Heat and Power engines (CHP) to produce electricity and heat: 4 CHPs with a total electric capacity of 1,38 MW has been put into operation till now. The project is under continuous operation since the commissioning of the first CHP in the year 2005.

The heat produced by the biogas plant is used for the own process of the biogas plant, but also substitutes fossil fuels for heating pig stalls and office building, for pre-heating of piglet food as well as for hygienization of digestate.

The total GHG emission reductions generated under the current monitoring period starting from 01/05/2010 to 30/04/2016 are 121.215 t CO_2e.

1.2 Sectoral Scope and Project Type

The VCS sectoral scopes applicable to the project activity are 1. “Energy (renewable/non-renewable)” and 13. (Waste handling and disposal). The project is not a debundled component of a larger project activity.

1.3 Project Proponent

Organization name	Houbensteyn Milieu BV
Contact person	Martin Houben
Title	Owner and Managing Director
Address	Ysselsteynseweg 69, 5813 BK, Ysselsteyn Limburg - The Netherlands
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1.4 Other Entities Involved in the Project

Organization name	GES Energie GmbH
Role in the Project	Carbon Consultant
Contact person	Pauline Kalathas
Title	Project Manager
Address	Domstrasse 11, 20095 Hamburg
Telephone	+49 (0)40 80 90 63 220
Email	p.kalathas@ges-energie.de

1.5 Project Start Date

The start of commissioning was the 01st of May 2006.

1.6 Project Crediting Period

The starting date of the crediting period and the first monitoring period is set to the 01st of May 2006. The project uses a fixed crediting period of 10 years which ends on 30th of April 2016.

1.7 Project Location

The project activity takes place on the estate of the project owner Houbensteyn Milieu BV in Ysselsteyn, Limburg, southeastern part of the Netherlands. The geographical coordinates are N51°29'36" E5°54'27".

1.8 Title and Reference of Methodology

Two small-scale methodologies according to the CDM standards of the UNFCCC are used in the project:

Type III, other project activities, AMS III.D, *"Methane recovery in agricultural and agro-industrial activities"* (Version 11), referring to the capture of methane gases from decomposing manure. The actual version is named *"Methane recovery in animal manure management systems"* (Version 21).

Type I, Renewable Energies, Category AMS I.C, *"Thermal energy for the user with or without electricity"* (Version 09), referring to the utilization of the waste heat to replace fossil energy. The actual version is named *"Thermal energy production with or without electricity"* (Version 21).

1.9 Participation under other GHG Programs

The project is not registered under any other GHG program.

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

1.10 Other Forms of Credit

The project has been planned for the generation of voluntary emission reductions (VER) in Ysselsteyn, Limburg, The Netherlands, based on the UNFCCC criteria for JI projects according to Article 6 of the Kyoto Protocol and subsequent decisions of the Joint Implementation Supervisory Committee with regard to JI modalities and procedures and the application of approved methodologies. Even if the project activity investigated being currently treated as a VER-project, approved CDM baseline methodologies as well as the *Tool for the demonstration and assessment of additionality* of the UNFCCC were applied in order to allow a conversion into a JI project at a later stage.

However, the project has never been converted into a JI project and hence, is not listed as a JI project on the UNFCCC website.

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.

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 will not be counted towards the greenhouse gas emission inventory of the Netherlands (see Appendix A, *Evidence for no double counting*).

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

The project contributes to achieve nationally defined sustainable development priorities, which are set out in the "Sustainable development goals: the situation for the Netherlands"[1].

The project activity contributes to generating electricity and heat from renewable sources, that helps in country energy security, reduces the GHG emissions and encourages clean, renewable and efficient technologies. Furthermore, the project activity contributes to enhancing local employment by providing direct and indirect employment generation during construction and operation phases. Other positive impacts of the project activity are the improved quality of digestated manure compared to manure and the reduction of odor emissions in the vicinity spreading the digestate.

2 SAFEGUARDS

2.1 No Net Harm

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

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

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

[1] See https://www.cbs.nl/en-gb/publication/2018/10/the-sdgs-the-situation-for-the-netherlands, p. 35/36 (Renewable energy) and p. 50 (Climate policy)

2.2 Local Stakeholder Consultation

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

Since the biogas installation impacted positively the region on an economical, environmental and a social level, the stakeholders still give till today positive feedback and consider the project as an example that can motivate other communities to generate renewable energies using the local manure and reducing this way the GHG emissions as well as odor. No complain or litigation has taken place during the entire crediting period of the project.

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 only positive.

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 already in operation when the crediting period started in spring 2006. The 1st CHP engine with 346 kW_{el} was commissioned in 2005, the 2nd and the 3rd engines where commissioned in December 2006. The 4th CHP engine has been installed in 2009 and correspond to the extension of the plant's capacity mentioned in the PDD on page 9. The biogas plant is still in operation.

CHP Units		Electric capacity installed	Thermal capacity installed	Electric efficiency [FT]	Start of operation date
		kWel	kWth	%	
WKK1	MAN LE 312	346	421	37,5	2005
WKK2	MAN LE 312	346	421	37,5	2006
WKK3	MAN LE 312	346	421	37,5	2006
WKK4	MAN LE 312	346	421	37,5	2009

Table 1: Data of installed CHP units from Houbensteyn Milieu BV (Sources: Meetprotocol elektriciteit en warmte - Houbensteyn Milieu, p. 4 and Data sheet MAN LE 312)

The biogas plant treats swine manure from the operator's own farm located in the near vicinity of the project site, with at least 50% of the total biomass fed. Co-ferments from agricultural and food industries are also delivered and fed to the biogas plant.

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

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

3.2 Deviations

3.2.1 Methodology Deviations

1. Biogas production

Deviant from the Methodology described in the PDD, the amount of biogas is not measured but calculated by the amount of electricity produced. Reason is that the flow meter installed to measure the biogas volume is not calibrated. The calculation of the biogas flow, based on a reference method described by the CCX Agricultural Methane Gas Project Guidelines, has already been assessed in the last monitoring period and estimated as a conservative way to calculate the amount of biogas produced (this approach has also already been proposed in the PDD, p.19). This calculation is also used in similar climate protection projects with biogas technology. The electricity measurement can be considered as very accurate because it is also the basis for the accounting with the utility. No negative influence on the amount of emission reductions can be expected as the calculated value is expected to be very close to the actual value.

This deviation has already been assessed and verified by the Verification Body TÜV Rheinland as well as by Verra under VCS for the last monitoring period in 2006/2007.

2. Conservativity factor

Another deviation from the methodology is the application of an overall deduction factor of 0,5 on the emission reductions due to methane recovery. This conservativity factor covers the uncertainties due to the fact, that the project owner has to deal with a lot of organic waste streams of different type and only default values are used instead of local values for waste specific parameter. Furthermore, the project was developed at a time when the methodological approaches and guidelines were not yet mature. Following the conservativeness principle prescribed by the VCS methodology as well as ISO 14064, the application of an additional security factor of 0.5 (conservativity factor) is appropriated to highly compensate the risk of an over-estimation of the emission reductions.

This factor has already been assessed and verified by the Verification Body TÜV Rheinland as well as by Verra under VCS for the last monitoring period in 2006/2007. Furthermore, this deviation has also been evaluated during the last monitoring in 2012 of the Methane Recovery Project Princepeel Wilbertoord, that is the same project type and category as the present project (see in Appendix B the *Project Review Report* of Project Princepeel, pages 5-7). The factor 0.5 has been originally applied during the last monitoring on the total amount of emission reductions. However, since the emission reductions achieved through the replacement of fossil fuel for heating the livestock stall and for hygienization are based on available, accurate and conservative data, which is not affected by uncertainties, the conservativity factor 0.5 in the current monitoring have been applied only on the emission reductions from methane recovery in order to stay consistent with the purpose of application of this factor on the source of uncertainties.

Through the selection of conservative values for the biogas production of input substrates and the application of an overall deduction factor of 0,5, it is absolutely secured that, in general, no over-estimation of the emission reductions can occur.

3.2.2 Project Description Deviations

1. Increase of manure quantities

Deviation in the implementation of the project has been the increase in the manure quantities over the crediting period of the project. Higher amounts of manure generally and of manure with a dry matter content have been treated than initially planned. This development is attributed to the higher manure surpluses that the Netherlands have been experiencing in the last decade and that could not have been anticipated. To address these issues on a national level, dutch policies have been developed to reduce the amounts of manure surplus again. Hence, the biogas plants in the Netherlands had to adapt their plant concepts to the changed biomass market. For the project activity, this has resulted in an increase in emission reductions, even if the plant capacity has stayed the same as described in the initial project documentation.

This deviation has already been worked out, assessed and verified by the Verfication Body TÜV Rheinland as well as by Verra under VCS during the last monitoring for the Methane Recovery Project Princepeel Wilbertoord, that is the same project type and category as the present project (see in Appendix B the *Project Review Report* of Project Princepeel, page 7).

2. Amount of emission reductions

The amount of emission reductions is higher than the estimated amounts in the PDD. This is partly due to the larger amounts of manure that are processed in the biogas plant, as described above. But it is also due to the fact, that only the baseline methane emissions released from stored manure are calculated in the PDD and not the one from waste management. Hence, the yearly estimated methane emissions reductions written down in the PDD do not correspond to the entire methane emissions that are reduced through the project activity. Furthermore, the Global Warming Potential of CH_4 has been adapted from 21 to 25 according to the Fourth Assessment Report and VCS Requirements, which also leads to higher emission reductions.

3. Carbon Consultant

Deviant from the last Monitoring in 2006/2007, the company of the Carbon Manager has changed from ARA Carbon Finance GmbH to GES Energie GmbH, but this company and its employees belong to the same company group as the ARA Carbon Finance GmbH. This has no impact on the quality of the Monitoring Report and the resulting emission reductions, since the actual Carbon Consultant has been working in the carbon sector for almost 15 years.

4. Biogas flow meter

Deviant from the description in the PDD, no flow meter has been running during the present monitoring period. In the first years of operation of the biogas plant, a flow meter has been installed, as required in the monitoring plan in the PDD. Practice during this period has shown that the flow meter was unable to deliver reliable measurements, due to contaminations like moisture (condensation) or Sulfur (H_2S). Therefore, the measurements could not be used as accurate values for calculation the emission reductions.

Hence, the biogas flow has been calculated following a reference method described by the CCX Agricultural Methane Gas Project Guideline, based on the electric energy produced, the efficiency of the CHPs and the calorific value of biogas (please refer to section 5.1.1 of the present Monitoring Report). The calculation of the biogas amount bases on the electricity production measured by an electric meter with an accuracy <1%. Since the accuracy of the electric meter is highly precise and the method described by CCX is considered to be conservative, using the CCX method will have a conservative effect on the quantity of emission reductions.

5. Methane content

The methane content has been continuously measured, but the data has not been regularly recorded, deviant from the PDD requirements. Only an estimation of the average annual methane content is possible. Hence, the methane content has been calculated based on the literature values, as it has been done for the biogas production and methane content from non-waste co-ferments" (please refer to section 5.1.1. of this Monitoring Report). The calculated average value of methane content in the biogas over the monitored years is 58,96 % and correspond to the estimated average value for methane content of the biogas plant Houbensteyn of 59% (see Appendix D "20201028_VCS_Data Inquiry_Houbensteyn"). Since the biogas production is calculated based on the electricity production and the methane content in the biogas, the biogas production will decrease proportionally with a higher methane content. Hence, the level of methane content in the biogas has no direct impact on the amount of emission reductions.

6. Manure

The manure entering the biogas plant is exclusively coming from the project owner's farms. As in the last monitoring, the manure quantities are not measured but calculated as the difference between the digestate sold (which is measured and recorded) and the co-ferment inputs (also measured and recorded). This deviation from the PDD description is considered to be very conservative, as the weight lost due to dissolved biogas it not taken into account. Therefore, this method leads to fewer emission reductions.

7. Heat use

The fossil fuel replacement for space heating and pre-heating piglet food is calculated according to the PDD Section D.2., point 3 (PDD p. 23) and is based on the historical average amount of annual natural gas consumption of 37.000 Nm^3 (PDD p.30), instead of measured. The project proponent has decided to use this calculation method as proposed in the PDD instead of using the measured values of heat use, even if it leads to less emission reductions, because the work efforts to collect the necessary documents and evidence are economically not viable. As can be seen from the difference between the measured and calculated amounts of external heat consumption, the calculation of the amount of external heat use is far below the measured amounts (see Appendix C "Cross Check" under spreadsheet "ER Heat"). Hence, the chosen method leads to a very conservative amount of emission reductions.

In the PDD, the parameter ETPS represents the thermal energy produced for space heating since parameter ETFP represents the thermal energy produced for piglet food pre-heating. In the project, both parameters are measured with only one heat counter. This deviation has no influence on the amount of emission reductions since the calculation is based on the historical fuel consumption, as described above.

8. Emergency boiler

The emergency boiler has only been used in 2006 to heat the digester to launch the biogas process. After the successful warming up of the installation, the plant has used the own heat produced to keep the digesters warm. The boiler was disconnected after the launching phase of the project and, according to this, could not be used during the current monitoring period, deviant from the description in the PDD on page 19. Since the emergency boiler has been disconnected, no fuel use and consequently no project emission can occur during the current monitoring period.

3.3 Grouped Projects

Project activity is not a grouped project.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	D_{CH4}
Data unit	t CH_4/m^3
Description	Density of Methane
Source of data	UNFCCC
Value applied	0,0007168
Justification of choice of data or description of measurement methods and procedures applied	Density of methane at standard temperature and pressure. “Methane Recovery Project Houbensteyn”, PDD p. 22
Purpose of Data	Calculation of emissions from manure management systems and agricultural/ food wastes
Comments	None

Data / Parameter	GWP_{CH4}
Data unit	t CO_2e / t CH_4
Description	Global warming potential of methane
Source of data	UNFCCC
Value applied	25

Justification of choice of data or description of measurement methods and procedures applied	Global Warming Potential value for methane for the second commitment period is 25 t CO_2e/t CH_4
Purpose of Data	Calculation of emissions from manure management systems and agricultural/ food wastes
Comments	The GWP value set in the PDD has been adapted to the second commitment period with value from the fourth assessment report according to UNFCCC and VCS Requirements

Data / Parameter	CEF
Data unit	t C / TJ
Description	Carbon emission factor of natural gas
Source of data	“Methane Recovery Project Houbensteyn”, PDD p. 23
Value applied	15,3
Justification of choice of data or description of measurement methods and procedures applied	Parameter used in the equation of the methodology to calculate the emission reduction from using renewable heat
Purpose of Data	Calculation of annual emission from the theoretical combustion of natural gas in the hygienization system and annual emission reduction through renewable thermal energy displacing fossil energy
Comments	None

Data / Parameter	FCO
Data unit	t Co_x / t C
Description	Fraction of carbon oxidized
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2, Table 1.4
Value applied	1,000
Justification of choice of data or description of measurement methods and procedures applied	Parameter used in the equation of the methodology to calculate the emission reduction from using renewable heat
Purpose of Data	Calculation of annual emission from the theoretical combustion of natural gas in the hygienization system and annual emission

	reduction through renewable thermal energy displacing fossil energy
Comments	Emission factor value has been adapted to the actual value set in the IPCC

CapHeat	Cap_{Heat}
Data unit	KJ / kg K
Description	Specific heat capacity of manure
Source of data	"Methane Recovery Project Houbensteyn" PDD, p. 23
Value applied	4,18
Justification of choice of data or description of measurement methods and procedures applied	Parameter used in the equation of the methodology to calculate the emission reduction from using renewable heat
Purpose of Data	Calculation of annual consumption of natural gas in the hygienization system
Comments	The heat capacity of the manure to be pre-heated is set to the capacity of water 4,18 kJ/kg K

CapHeat	T_{Hyg}
Data unit	°C
Description	Outlet temperature of digestate
Source of data	"Methane Recovery Project Houbensteyn", PDD p. 23
Value applied	71
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 set to 71°C
Purpose of Data	Calculation of annual consumption of natural gas in the hygienization system
Comments	None

CapHeat	T_{Inlet}
Data unit	°C
Description	Inlet temperature of manure to the hygienization system
Source of data	"Methane Recovery Project Houbensteyn", PDD p. 23

Value applied	10
Justification of choice of data or description of measurement methods and procedures applied	Value set to the average ambient temperature in the region
Purpose of Data	Calculation of annual consumption of natural gas in the hygienization system
Comments	None

CapHeat	Eff_{HEx}
Data unit	%
Description	Heat exchanger efficiency
Source of data	"Methane Recovery Project Houbensteyn", PDD p. 23
Value applied	88
Justification of choice of data or description of measurement methods and procedures applied	Parameter used in the equation of the methodology to calculate the emission reduction from using renewable heat
Purpose of Data	Calculation of annual consumption of natural gas in the hygienization system
Comments	None

4.2 Data and Parameters Monitored

This Monitoring Report comprises in total 6 years of monitored data. In order to keep the Monitoring Report clear, only the values for the year 2015 are given below for each parameter when displaying the values of all monitored years is not possible. The values of the other monitored years are stated in the annexed spreadsheet with the details of all the calculation steps for every year (see Appendix C).

Since the quantitative monitoring period of this Report includes the last 6 years of the crediting period of the project activity (01/05/2010 - 30/04/2016), the annual values monitored in 2010 and 2016 are converted into the monitoring periods of 8 months and 4 months, respectively.

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 electricity produced (EEP), the methane content of the biogas and the efficiency of the CHP engines.
Frequency of monitoring/recording	See parameter EEP
Value monitored	(see table below)
Monitoring equipment	N/A
QA/QC procedures to be applied	See Parameter EEP
Purpose of the data	Calculation of baseline emissions

Year	Biogas produced [m³]
2010	3.304.928
2011	5.040.816
2012	5.105.081
2013	4.941.820
2014	4.915.469
2015	5.153.667
2016	1.702.964

Calculation method	$$BGP = \frac{EEP}{(ETA_{CHP-el}) * HV_{Biogas}}$$ Where: BGP Biogas produced [m^3] EEP Electrical energy produced [MWh] ETA_{CHP-el} Electric efficiency of the CHP engines HV_{Biogas} Calorific value of biogas [kWh/m^3] With $$HV_{Biogas} = 0,01 \frac{MWh}{m^3} \cdot x_{CH4}$$ Where: 0,01 Stoichiometric combustion calculation of CH_4 [MWh/m^3]: 802,6 kJ/mol /0,02241 m^3/mol = 35.814,37 kJ/m^3 = 0,01 MWh/m^3 x_{CH4} CH_4 volume content of biogas flow [%]
Comments	None

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	The methane content is calculated based on literature values for all the substrate inputs (annually weighed average content).
Frequency of monitoring/recording	N/A
Value monitored	see table below

Year	Weighted average methane content [%]
2010	58,43
2011	58,50
2012	59,13

	2013 — 58,94 2014 — 58,92 2015 — 59,07 2016 — 59,70
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of the data	Calculation of baseline emissions
Calculation method	The weighted average methane content is calculated based on the amount and methane content of each substrate entering the biogas installation.
Comments	None

Data / Parameter	Fraction of time
Data unit	h
Description	Runtime of the CHP
Source of data	Runtime counter in CHP
Description of measurement methods and procedures to be applied	Runtime counters automatically record the number of hours that a CHP operates. The value increases continuously during lifetime. The operation hours are read back directly on the runtime counter and recorded quarterly in an excel file. The annual operation hours of the plant are calculated as difference between the runtime hours of the beginning and of the end of the year.
Frequency of monitoring/recording	Data logged quarterly
Value monitored	(see table below)
Monitoring equipment	Runtime meter

2015	**Hours of operation [FT]**
CHP Unit	**h**
WKK1	8.597
WKK2	8.691
WKK3	8.646
WKK4	8.681

QA/QC procedures to be applied	Runtime meters have an inaccuracy of < 1% (see Appendix D "Runtime counter - Accuracy - Jenbacher"). Calibration is not necessary
Purpose of the data	Calculation of baseline emissions
Calculation method	N/A
Comments	None

Data / Parameter	ETPS
Data unit	kWh
Description	Thermal energy production for space heating
Source of data	Heat counter
Description of measurement methods and procedures to be applied	The heat used externally is officially measured since mid-2012 with 3 heat meters to measure the external heat delivered from the CHPs: 1 heat meter for heating space and pre-heating piglet food as well as 2 heat meters for the hygienization unit.
Frequency of monitoring/recording	Continuously
Value monitored	**Year** / **Total external heat used [kWh]**: 2010 – Not measured officially; 2011 – Not measured officially; 2012 – 3.752.222 (Jun - Dec); 2013 – 7.497.222; 2014 – 7.632.500; 2015 – 7.510.000; 2016 – 2.832.500 (Jan - Apr)
Monitoring equipment	Technical specification of heat counter (please refer to Appendix D, "Meetprotocol electriciteit en warmte Houbensteyn Milieu B.V.", p. 10)
QA/QC procedures to be applied	Heat counters are a standard technique applied in private and industrial processes for long and are highly precise. Calibration is regularly done by a certified company.
Purpose of the data	To determine the displaced fossil fuels of the baseline scenario
Calculation method	The fossil fuel replacement for heating space is calculated according to the PDD Section D.2., point 3 (please refer to the

Value monitored:

Year	Total external heat used [kWh]
2010	Not measured officially
2011	Not measured officially
2012	3.752.222 (Jun - Dec)
2013	7.497.222
2014	7.632.500
2015	7.510.000
2016	2.832.500 (Jan - Apr)

	PDD p. 23) and is based on the historical amounts of natural gas consumption (PDD 30).
Comments	None

Data / Parameter	ETFP
Data unit	kWh
Description	Thermal energy production for pre-heating the piglet food
Source of data	Heat counter
Description of measurement methods and procedures to be applied	The heat used externally is officially measured since mid-2012 with 3 heat meters to measure the external heat delivered from the CHPs: 1 heat meter for heating space and pre-heating piglet food as well as 2 heat meters for the hygienization unit.
Frequency of monitoring/recording	Continuously
Value monitored	(see table below)
Monitoring equipment	Technical specification of heat counter (please refer to Appendix D, "Meetprotocol electriciteit en warmte Houbensteyn Milieu B.V.", p. 10)
QA/QC procedures to be applied	Heat counters are a standard technique applied in private and industrial processes for long and are highly precise. Calibration is regularly done by a certified company.
Purpose of the data	To determine the displaced fossil fuels of the baseline scenario
Calculation method	The fossil fuel replacement for pre-heating the piglet's food is calculated according to the PDD Section D.2., point 3 (please refer to the PDD p. 23) and is based on the historical amounts of natural gas consumption (PDD 30).
Comments	None

Value monitored:

Year	Total external heat used [kWh]
2010	Not measured officially
2011	Not measured officially
2012	3.752.222 (from Jun to Dez)
2013	7.497.222
2014	7.632.500
2015	7.513.056
2016	7.432.222

<table>
<tr><td>Data / Parameter</td><td>EEP</td></tr>
<tr><td>Data unit</td><td>kWh</td></tr>
<tr><td>Description</td><td>Electrical energy produced</td></tr>
<tr><td>Source of data</td><td>Power meter</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>Electric power meter at each CHP measures the produced electric energy.</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>Electricity produced [kWh]</th></tr>
<tr><td>2010</td><td>7.241.953</td></tr>
<tr><td>2011</td><td>11.059.074</td></tr>
<tr><td>2012</td><td>11.319.336</td></tr>
<tr><td>2013</td><td>10.922.467</td></tr>
<tr><td>2014</td><td>10.861.349</td></tr>
<tr><td>2015</td><td>11.416.939</td></tr>
<tr><td>2016</td><td>3.812.782</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Technical specifications of the power meter at CHP units (see Appendix D “Meetprotocol elektriciteit en warmte - Houbensteyn Milieu BV - 2012”, p. 7, 8 and “Photo - gross EP meter_WKK[no]_new”):
<table>
<tr><th>EAN Code</th><th>Serial nr</th><th>Brand</th><th>Type</th><th>Description</th><th>Unit</th><th>Accuracy class</th></tr>
<tr><td>EAN 33436</td><td>37 578 524</td><td>ZDM410.CT44.0457</td><td>kWh1</td><td>Gross production meter WKK1</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 23595</td><td>51 286 505</td><td>ZDM410.CT44.0457</td><td>kWh3</td><td>Gross production meter WKK2</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 23595</td><td>37 435 494</td><td>ZDM410.CT44.0457</td><td>kWh4</td><td>Gross production meter WKK3</td><td>kWh</td><td>Class 1</td></tr>
<tr><td>EAN 23595</td><td>95 215 481</td><td>ZDM410.CT44.0457</td><td>kWh5</td><td>Gross production meter WKK4</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 (inaccuracy < 1 %). The electric meters are sealed and maintained by the grid operator. Calibration is done by authorized service providers in compliance with the European CE-Directive (MIT = Measurement Instrument Directive).</td></tr>
</table>

Purpose of the data	Calculation of baseline emissions, of biogas produced by the plant and cross-checking the biogas produced and destroyed by the CHP engines
Calculation method	N/A
Comments	None

Data / Parameter	EEI
Data unit	kWh
Description	Electric energy imported
Source of data	Power meter
Description of measurement methods and procedures to be applied	The own electricity consumption for running the biogas plant is measured with a power meter. The gross and net electricity productions are directly measured, so that the own electricity consumption can be calculate as difference from gross and net electricity (see chapter 4.3).
Frequency of monitoring/recording	Continuously and at invoicing of the utility
Value monitored	(see table below)
Monitoring equipment	Technical specifications of the power meter at CHP units (see Appendix D "Meetprotocol elektriciteit en warmte - Houbensteyn Milieu BV - 2012", p. 7, 8 and Appendix D "Photos - gross and net EP meters_old"): (see table below)
QA/QC procedures to be applied	Precision is very high (inaccuracy < 1 %). The electric meters are sealed and maintained by the grid operator. Calibration is done by authorized service providers in compliance with the European CE-Directive (MIT = Measurement Instrument Directive).

Value monitored:

Year	Electricity consumed for own process [kWh]
2010	800.246
2011	1.147.201
2012	1.173.947
2013	1.151.806
2014	1.140.225
2015	1.211.940
2016	387.380

Monitoring equipment:

EAN Code	Serial nr	Brand	Type	Description	Unit	Accuracy class
EAN 33436	85 401 754	ZDM410.CT44.0257	kWh2	Main connection meter WKK1	kWh	Class 1
EAN 23595	85 227 803 85 227 804	ZDM410.CT44.0007	kWh6 kWh7	Main connection + control meter WKK2, WKK3, WKK4	kWh	Class 1

Purpose of the data	To demonstrate that the net impact of electricity production and consumption is positive.
Calculation method	The project's own electricity consumption can be calculated as gross electricity production minus net electricity production = own consumption.
Comments	None

Data / Parameter	MCOFi
Data unit	t
Description	Mass of each co-ferment i fed into the digester
Source of data	Scales recording
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 which is stored as hard copy in folder on the plant's site. The amounts of co-substrates are also electronically logged in the computer-based program Optimad from the Bright Company (see Appendix D "Screenshot Optimad"). The data is then exported and recorded in the system as PDF file (see Appendix D "[year] coproducten").
Frequency of monitoring/recording	At delivery
Value monitored	see table below
Monitoring equipment	Specification of the weighing scale on the installation (see Appendix D "Technical specifications weighing scale"):

Value monitored:

Substrates in 2015	**Amounts [t]**
Corn grain	159
Grain	1.812
Rice bran	550
Cocoa products	1.282
Coffee grounds	2.470
Food waste	5.448
Glycerine	598
Oil waste	220
Plant fat	3.292
Sugar water/ Fruit waste liquid	765
Vegetable waste	106
Total	**16.702**

<table>
<tr><td></td><td>KEURINGS / CONTROLE RAPPORT
Serienummer(s): 3550
Type: sca1c1
Fabrikaat BWT Klasse: III
Ordernummer 10910 Tnr. : T2992 cem-cy 01/0025-5.2
Max: 70000 kg min: 400 kg e= 20 kg d= 20 kg</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>Weighing scales are precise and belong to the accuracy class III. Calibration occurs when the devices need service or repair.</td></tr>
<tr><td>Purpose of the data</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Calculation method</td><td>N/A</td></tr>
<tr><td>Comments</td><td>None</td></tr>
</table>

<table>
<tr><td>Data / Parameter</td><td>MANURE</td></tr>
<tr><td>Data unit</td><td>t</td></tr>
<tr><td>Description</td><td>Volume of manure fed into digester</td></tr>
<tr><td>Source of data</td><td>Calculated</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>The manure quantities are calculated as the difference between the amount of digestate sold and the amount of co-ferment inputs. The amounts of digestate and co-ferment inputs are measured and recorded daily in operation manual and in electronic databases.</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>See parameter MCOFi</td></tr>
<tr><td>Value monitored</td><td><table><tr><th>Manure in 2015</th><th>Amount [t]</th></tr><tr><td>Liquid - pig</td><td>48.849</td></tr><tr><td>Total</td><td>48.849</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td>Specification of the weighing scale on the installation (see Appendix D “Technical specifications weighing scale”):
KEURINGS / CONTROLE RAPPORT
Serienummer(s): 3550
Type: sca1c1
Fabrikaat BWT Klasse: III
Ordernummer 10910 Tnr. : T2992 cem-cy 01/0025-5.2
Max: 70000 kg min: 400 kg e= 20 kg d= 20 kg</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>Weighing scales are precise and belong to the accuracy class III. Calibration occurs when the devices need service or repair.</td></tr>
<tr><td>Purpose of the data</td><td>Calculation of baseline emissions</td></tr>
</table>

Calculation method	Manure [t/y] = Digestate sold [t/y] - Co-ferment inputs [t/y]
Comments	None

Data / Parameter	OIL
Data unit	m^3
Description	Oil consumed in emergency boiler
Source of data	Volume scale and/or delivery receipt
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	At delivery
Value monitored	0
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of the data	Calculation of project emissions
Calculation method	N/A
Comments	Emergency boiler has only been used to launch the biogas process and was removed afterwards. Hence, no fuel could be used during the monitoring years 2010-2016

4.3 Monitoring Plan

The person responsible for collecting all data relevant for the monitoring of GHG emission reductions is Martin Houben, managing director of Houbensteyn Milieu BV. He has taken over the responsibility for monitoring and recording all data. The operation and maintenance of the biogas plant is being done by the operation personnel 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 substrate (recorded daily), the power and heat generation of the plant (recorded quarterly) as well as the runtime hours of the CHPs (recorded quarterly). These data are also logged electronically.

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 monthly records of the daily electricity gross production rates are provided by Fudura in excel files saved in folders (see Appendix D “Gross EP Fudura 2010-2011 - EAN [no]”) or can be found since 2012 in the obligatory measurement reports certified by the recognized measuring company Fudura B.V. (see Appendix D “Meetrapport [year] - Houbensteyn Milieu”). 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 (see E-Mail from a Fudura adviser in Appendix D “Fudura_Electric meters”). 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 (see Appendix B “Project Review Report” of the Methane Recovery Project Princepeel Wilbertoord from VCS, Finding 1, p. 3).

The accuracy class of the CHPs’ power meters is given in a report named “Meetprotocol electriciteit en warmte Houbensteyn Milie B.V.”, p. 8 (see Appendix D). 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.

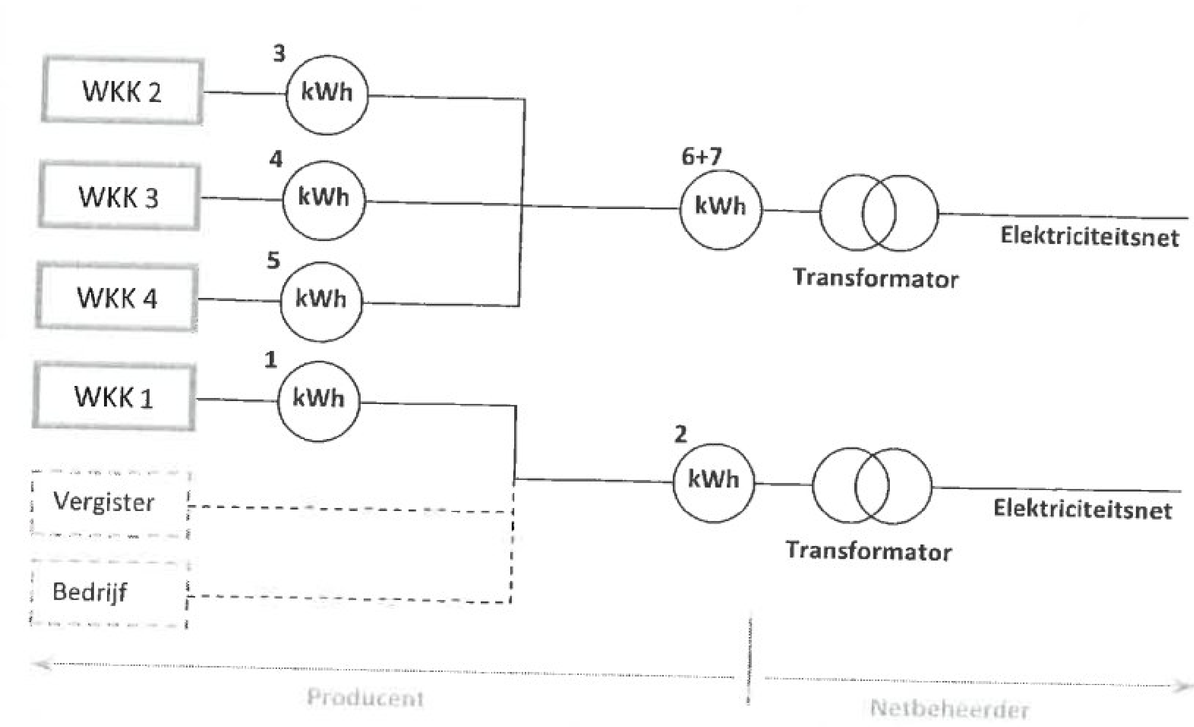

Figure 1: Schematic representations of electricity flow, including system boundary and meters [2]

As can be seen from the schema above, all CHP installations are equipped with their own gross production counter (kWh 3, kWh 4, kWh 5 and kWh 1). The own electricity consumption (for digesters, self-consumption of the CHPs and external heat consumers) is directly taken from the electricity produced by the biogas plant. Since the net production is also measured with electricity meters (kWh 6+7 and kWh 2), the project's own electricity consumption can be calculated (gross production - net production = own production). In an excel file, the monthly records of gross and net electricity production as well as the calculated own electricity consumption were put into an excel file to have an overview of the power generation and consumption (see Appendix D "Electricity production and consumption _2010 2016").

The runtime counters automatically record the number of hours that a CHP operates (see Appendix C in the calculation spreadsheet under "CHP"). The runtime hours can be read directly on the CHP engine. The runtime hours are recorded quarterly from the operation staff the operation manual as well as in an excel file (see Appendix D "Overview runtime hours_2010-2016").

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 chapter 3.2.2., the methane content has been calculated based on the literature

[2] Appendix D - "Meetprotocol electriciteit en warmte Houbensteyn Milieu B.V.", p. 5.

values, as it has been done for the biogas production and methane content from non-waste co-ferments (please refer to section 5.1.1. of this Monitoring Report). The calculated average value of methane content in the biogas over the monitored years is 58,96 % and correspond exactly to the estimated average value for methane content of the biogas plant Houbensteyn of 59% (see Appendix D "20201028_VCS_Data Inquiry_Houbensteyn"). Since the biogas production is calculated based on the electricity production and the methane content in the biogas, the biogas production will decrease proportionally with a higher methane content. Hence, the level of methane content in the biogas has no direct impact on the amount of emission reductions.

The heat produced by the biogas plant is used for the own process as well as for heating the pig stalls, the office buildings, pre-heating the food of piglets and for hygienization of digestate since 2007. The thermal energy used externally is officially measured by means of heat counters since June 2012 and electronically recorded under the files named "Meetrapport [year] - Houbensteyn Milieu" (see Appendix D). The calibration is done regularly by authorized service providers named Kamstrup. According to the PDD on page 19, no direct measurement of the heat displaced for hygienization has to be done because the hygienization conditions of the fermenter output (37°C) do not correspond to the baseline conditions (19°C). Instead, theoretical values are used based on the actual amount of manure used in the biogas plant to calculate the amount of emission reductions by displacing fossil fuels (please refer to section 5.1.3). Concerning the fossil fuel replacement for space heating and pre-heating piglet food, it is calculated according to the PDD Section D.2., point 3 (PDD p. 23) and is based on the historical average amount of annual natural gas consumption of 37.000 Nm^3 (PDD p.30), as explained under section 3.2.2 of the current monitoring report. Since June 2012, the heat used externally is officially measured by heat counters by Fudura and recorded in the annual measurement reports (see Appendix D "Meetrapport [year] - Houbensteyn Milieu"). The official measurements are used to cross check and prove that the calculated amounts of external heat consumption are plausible and conservative.

The co-ferment substrates entering the biogas plant are weighed at delivery by a weighing scale. The delivery notes of each substrate delivered are stored as hard copies in folders on the plant's site. The amounts of co-substrates are electronically logged in the computer-based program Optimad from the Bright Company (see Appendix D "Screenshot Optimad"). The data is then exported and recorded in the system as PDF file (see Appendix D "[year] coproducten").

As in the last monitoring period, the amount of manure coming from the project owner's farm is determined through a calculative method, with help of the digestate sold that is measured and recorded for the monitoring years 2010-2016 (see Appendix D "[year] mestafvoer HYS") as well as co-ferments inputs. The amount of co-ferment inputs is subtracted from the amount of digestate sold. This method is considered to be very conservative, as it does not take into account the weight loss due to dissolved biogas. The digestate leaving the biogas plant is weighed and the weighed amounts are logged in the official software of the government Dutch National

Service for Enterprise (Rijksdienst voor Ondernement RVO), that records all the nutrients shifts and flows between farms under minj.rvo.nl.

The emergency boiler has only been used in 2006 to heat the digester to launch the biogas process. After the successful warming up of the installation, the plant has used the own heat produced to keep the digesters warm. The boiler was disconnected after the launching phase of the project. Hence, the emergency boiler has not been used during the current monitoring period.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

5.1.1 Manure management systems and agricultural/ food wastes

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

$$GHG_{red,\ IIID} = AF \bullet (BGP \bullet MC - \Sigma\ BGCO_i \bullet MCCO_i) \bullet D \bullet GWP_{CH4}$$

With:

$$AF = 1 - dm_{nw,\ i} \ / \ (dm_{manure} + \Sigma\ dm_{nw,\ I} + \Sigma\ dm_{w,\ j}) \bullet 0{,}1$$

Where:

$GHG_{red,IIID}$	is the annual emission reduction through methane recovery, in t CO_{2e}
BGP	is the total annual biogas produced by the project activity BGP, in Nm^3
AF	is an adjustment factor, which ensures a conservative estimation of the realized emission
$dm_{nw,I}$	is the dry matter of the proceeded quantity of non-waste co-ferment i
dm_{manure}	is the dry matter of the proceeded quantity of manure
$dm_{w,j}$	is the dry matter of the proceeded quantity of waste co-ferment j
$BGCO_i$	is the annual biogas portion of the total biogas amount produced, caused by a digested non-waste co-ferment i if applied, to be determined by the appropriate

input amount (MCOFi) and the specific gas productivity of the non-waste co-ferment i, in m^3

MC	is the average annual methane content in the biogas, in Nm^3 methane / Nm^3 biogas
$MCCO_i$	is the average methane content arising in the biogas through digesting a non-waste co-ferment i, in Nm^3 methane / Nm^3 biogas
D	is the density of methane, set to 0,7168 kg CH_4 / Nm^3 CH_4 according to ACM0001
GWP_{CH4}	is the Global Warming Potential of methane, set to 25 t CO_{2e} / t CH_4 according to UNFCCC

The calculation of the methane emission reductions bases on the total amount of methane produced in the biogas plant, from which the amount of methane produced out of non-waste is deducted, because only the emission reductions caused by manure and waste, that would have otherwise been left to decay, are taken into account.

The co-ferments intended to be fed into the biogas installation are separated into waste and non-waste co-ferments:

- the waste co-ferments have been left to decay on landfills in the baseline scenario
- the non-waste co-ferments are substrates that would not have been landfilled in the baseline scenario since these substrates could be used as animal feed.

<u>Biogas flow (BGP) and Methane content (MC)</u>

Since the biogas flow BGP could not be directly recorded, BGP is calculated following a reference method described by the CCX Agricultural Methane Gas Project Guidelines and used in different similar climate protection projects. The produced electricity and methane content of the biogas are used to calculate the biogas flow as follows:

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

with:

- BGP: Biogas produced [m^3]

- EEP: Electricity energy produced [MWh]
- ETACHP-el Electric efficiency of the CHP engines [%] (Ref.: engine data sheet)
- HVBiogas Caloric value biogas [kWh/m³]:

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

with:
x_{CH4}: = CH_4 volume content of biogas flow [%]

Methane is the component that determines the calorific value of biogas. The net calorific value of methane has been derived from common stoichiometric combustion calculation of methane under normal conditions: 802,6 kJ/mol / 0.02241 m^3/mol = 50,01 MJ/kg = 0,01 MWh/m^3 [3]. Hence, the calorific value of biogas is given by the multiplication with 0,01. As described under *4.3. Monitoring Plan* of this Report, the methane content has been calculated based on literature values. However, since the biogas production is calculated based on the electricity production and the methane content in the biogas, the biogas production will decrease proportionally with a higher methane content. Hence, the level of methane content in the biogas has no direct impact on the amount of emission reductions.

To calculate the biogas production, the electricity production and the electric efficiency of the CHP is needed. The electricity production of the biogas is measured by an electric power meter at the CHP. The electric meters are sealed and maintained by an independent and qualified company, Fudura B.V. As the measurements for the amounts of electricity produced are the base for the feed-in tariff, the value measured can be stated as very accurate.

The efficiency of the CHP engines is taken from the data sheet of the CHPs (see Appendix D "Data sheet MAN LE 312"). The efficiency value of a CHP in the technical data sheet of the CHP manufacturers is the highest the CHP engine will have in practice. Consequently, this value has a conservative impact on the emission reductions because a higher efficiency value leads to less emission reductions.

Using the formula above, the biogas flow in the monitoring years 2010-2016 is represented in the following table and detailed below for the year 2015:

BGP = 11.416.939 kWh / (0,375 * 5,91 kWh/m^2)

= 5.153.667 m^3

[3] Source: HAHNE: Technische Thermodynamik, (ISBN 348659231-9), page 406

Year	Electricity produced [kWh]	Weighted average Methane content [%]	Calorific value [kWh/m³]	Efficiency	Biogas Flow [m³]
	EEP	x_{CH4}	HV_{Biogas}	$ETA_{CHP\text{-}el}$	BGP
2010	7.241.953	58,43	5,84	0,375	3.304.928
2011	11.059.074	58,50	5,85	0,375	5.040.816
2012	11.319.336	59,13	5,91	0,375	5.105.081
2013	10.922.467	58,94	5,89	0,375	4.941.820
2014	10.861.349	58,92	5,89	0,375	4.915.469
2015	11.416.939	59,07	5,91	0,375	5.153.667
2016	3.812.782	59,70	5,97	0,375	1.702.964

Table 2: Calculated biogas flow (BGP) from electricity production per year

Biogas flow (BGCO) and Methane content (MCCO) from non-waste substrates

The biogas flow and methane content from non-waste substrates are calculated based on the data provided by literature mainly from the “Bayerische Landesanstalt für Landwirtschaft (Lfl)”[4]. Lfl data and calculation methods are recognized and commonly used as reference values in practice in the biogas field. Two other sources have been used, where the biogas production or methane content of specific substrates could not be found in the Lfl: “Gaserträge und Nährstoffgehalte - Abfall (Archea)”[5] and “Ökostrom Schweiz”. Both references base also on officially recognized sources and are also used for GHG emission reduction projects on both the voluntary and the mandatory markets.

To calculate the biogas potential and methane content of the biogas, the values for dry matter, organic matter, biogas production from dry matter and methane content from the non-waste co-ferments (as well as from waste and manure for cross-check reasons) are needed and taken from the described sources above. Where no precise data for specific substrates were available, the co-ferment has been analyzed and the highest values from a substrate with similar specifications has been taken to calculate the biogas potential and the methane content of the biogas, in order to maintain the principle of conservativeness.

The values for BGCO and MCCO from non-waste co-ferments of the year 2015 are presented in the table below (the values for the remaining years of the present Monitoring are presented under Appendix C in the attached calculation spreadsheet):

[4] https://www.lfl.bayern.de/iba/energie/049711/

[5] https://www.archea-biogas.de/_mediafiles/9-substrate.pdf

	Substrate	Amount	Dry matter (dm)	Organic dm (odm)	Total dry matter	Biogas production from odm	Biogas production from fresh mass	Methane content	Biogas potential from substrate "i"	Methane potential from substrate [x]
		[t]	[%]	[%]	[t]	[m³/ t odm]	[m³/ t fresh mass]	[%]	[m³]	[m³]
NON-WAS	Corn grain	159	87,00	98,30	138,33	690,20	590,27	52,80	93.852	49.554
	Grain	1.812	40,00	93,90	724,80	518,70	194,82	52,30	353.021	184.630
	Rice bran	550	89,20	91,20	490,60	705,80	574,17	56,40	315.794	178.108
WASTE	Cocoa products	1.282	90,40	92,00	1.158,93	412,90	343,40	55,30	440.240	243.453
	Coffee grounds	2.470	36,50	81,00	901,55	550,00	162,61	54,00	401.641	216.886
	Food waste	5.448	14,40	81,50	784,51	642,60	75,42	59,80	410.864	245.697
	Glycerine	598	100,00	99,50	598,00	850,00	845,75	50,00	505.759	252.879
	Oil waste	220	99,90	99,90	219,78	1.150,00	1.147,70	68,00	252.494	171.696
	Plant fat	3.292	95,00	92,00	3.127,40	500,00	437,00	56,00	1.438.604	805.618
	Sugar water/ Fruit waste liquid	765	4,30	72,50	32,90	500,00	15,59	55,00	11.924	6.558
	Vegetable waste	106	15,00	76,00	15,90	500,00	57,00	56,00	6.042	3.384
M	Liquid - pig	48.849	6,00	85,00	2.930,94	400,00	20,40	60,00	996.520	597.912
	Total	**65.551**			**11.124**			**59,07**	**5.226.754**	**2.956.374**

Table 3: Input substrates and their biogas and methane potential in 2015

As described under *3.1.1. Methodology deviation* of this Report, the conservativity factor of 0.5 has been applied on the calculated emission reductions to compensate the risk for an over-estimation of the emission reductions.

The application of the formula above and of the factor of conservativity results in emission reductions due to the project activity *Methane Recovery Project Houbensteyn Ysselsteyn* in the Monitoring year 2015 of:

$GHG_{red,\ IIID}$ = 0,9878 * (5.153.667 m³ * 59,07 % - 762.667 m³ * 53,23 %) * 0,0007168 t CH_4/m³ * 25 * 0,5

= 23.354 t CO_2e

2015			
Parameter ID	**Value**	**Unit**	**Description**
AF	0,9878	#	Adjustment factor
$dm_{nw,\ I}$	1.353,73	t	Dry matter of the proceeded quantity of non-waste co-ferment i
$dm_{w,\ j}$	6.838,97	t	Dry matter of the proceeded quantity of waste co-ferment j
dm_{manure}	2.930,94	t	Dry matter of the proceeded quantity of manure
BGP	5.153.667	m³	total annual biogas produced by the project activity
MC	59,07	%	average annual methane content in the biogas
$BGCO_i$	762.667	m³	Portion of biogas from co-ferments
$MCCO_i$	53,23	%	Methane content of co-ferments (weighted average)
D_{CH4}	0,0007168	t CH_4/m³	Density of methane
GWP_{CH4}	25	#	Global Warming Potential of methane
KF	0,5	#	Factor of conservativity
$GHG_{red,\ IIID}$	**23.354**	**t CO_2e**	Annual emission reduction through methane recovery

Table 4: Emission reductions through methane recovery in 2015

The emission reductions through methane recovery for the remaining years of the Monitoring are presented under Appendix C in the attached calculation spreadsheet ("ER *Year*").

5.1.2 Replacement of fossil fuel for heating space and pre-heating piglet food

The amount of waste heat produced by the biogas plant and used externally for space heating, for piglet food pre-heating and for hygienization were officially measured since June 2012, but not from the beginning of the current monitoring period. Therefore, and as explained in previous chapters, the formula described in the PDD in Section D.2. (page 23) as well as in the last Monitoring Report (page 17) is used to calculate the fossil fuel displaced by the waste heat for heating space and pre-heating piglet food.

The GHG emission reduction through the project activity with thermal energy produced and delivered to the stall building and for food pre-heating, where fossil sources have been displaced, is calculated according to the small-scale Methodology AMS I C, as per the registered PDD Section D with the following equation:

GHG_{red, IC_Heat} = Gas_{hist_Heat} • 0,0036 TJ/MWh • CEF • FCO • 44/12 t CO_2 / t C_{ox}

Where:

GHG_{red,IC_Heat} is the annual emission reduction through thermal energy displacing fossil energy, in t CO_2 = t CO_2e

Gas_{hist_Heat} is the average annual thermal energy previously needed to heat the stalls building and fuel the food pre-heating unit, in MWh

CEF is the carbon emission factor for natural gas, set to 15,3 t C / TJ according to IPCC

FCO is the fraction of carbon oxidised, set to 1 t COx / t C according to IPCC

The amount of heat substituted (natural gas) for heating space and pre-heating the food is calculated based on the historic fuel use of 37.000 m^3/a, according to the PDD p. 30. The conversion in megawatt hour needed for application of the formula above is as follows: 37.000 Nm^3/year • 8,816 kWh/Nm^3[6] = 326,16 MWh/year.

The application of the formula above results in emission reductions due to the project activity *Methane Recovery Project Houbensteyn* for the Monitoring year 2015 of:

GHG_{red, IC_heat} = 326,19 MWh * 0,0036 TJ/MWh * 15,30 t C/TJ * 1 t C_{ox}/t C * 44/12

= 65 t CO_2

Description	Parameter	2010	2011	2012	2013	2014	2015	2016	Unit
Average historical fuel consumption for heati	Gas_{hist_Heat}	217,46	326,19	326,19	326,19	326,19	326,19	108,73	MWh
Conversion from MWh in TJ	0,0036	0,0036	0,0036	0,0036	0,0036	0,0036	0,0036	0,0036	TJ/MWh
Carbon emission factor of natural gas	CEF	15,30	15,30	15,30	15,30	15,30	15,30	15,30	t C/TJ
Fraction of carbon oxidised	FCO	1,000	1,000	1,000	1,000	1,000	1,000	1,000	t CO_x/t C
Conversion factor C in CO_2	44/12	3,667	3,667	3,667	3,667	3,667	3,667	3,667	t CO_2/t CO_x
Emission reduction for fuel replacement from	**GHG_{red,IC_Heat}**	**43**	**65**	**65**	**65**	**65**	**65**	**21**	**t CO_2**

Table 5: Emission reduction through the displacement of natural gas for heating stall and pre-heating piglet food over the Monitoring period 2010 to 2016

The heat consumption in the year 2010 and 2016 has been adjusted to the shorter monitoring period during these years.

5.1.3 Replacement of fossil fuel for hygienization

The GHG emission reduction through the project activity with thermal energy produced and delivered to the hygienization system of the biogas plant, where fossil sources are displaced, is

[6] https://www.volker-quaschning.de/datserv/faktoren/index_e.php

calculated according to the small-scale Methodology AMS I C, as per the registered PDD Section D with the following equation:

$GHG_{red,\ IC\_Hyg}$ = $Fuel_{Hyg} \bullet Hu_{NGas} \bullet D_{NGas} \bullet CEF \bullet FCO \bullet 44/12\ t\ CO_2\ /\ t\ C_{ox}$

Where

GHG_{red,IC_Hyg} is the annual emission from the theoretical combustion of natural gas in the hygienization system, in t CO_2 = t CO_2e

$Fuel_{Hyg}$ is the theoretical average annual consumption of natural gas in the hygienization system, in t

Hu_{NGas} is the lower heating value of natural gas set to 33.490 kJ/Nm³

D_{NGas} is the density of natural gas, set to 0,7 kg/Nm³

CEF is the carbon emission factor for natural gas, set to 15,3 t C / TJ

FCO is the fraction of carbon oxidised, set to 1 t CO_x / t C according to IPCC

With

$Fuel_{Hyg}$ = $Manure \bullet Cap_{Heat} \bullet (T_{Hyg} - T_{Inlet}) \bullet 1\ /\ Eff_{Hex}$

Where:

$Fuel_{Hyg}$ is the average annual consumption of natural gas in the hygienization system, in Nm³

Manure is the annual manure excreted from the animals in kg

T_{Hyg} is the needed hygienization temperature, set to 71 °C

Cap_{Heat} is the heat capacity of the manure to be pre-heated, set to the capacity of water 4,18 kJ/kg K

T_{Inlet} is the manure inlet temperature to the hygienization system, set to the average ambient temperature 10 °C

Eff_{HEx} is the heat exchanger efficiency, set to 88 %

Even if the amount of heat supplied to the hygienization units would be directly measured by heat counters, these measurements would not correspond to the baseline properties of manure: while the baseline scenario does require only the manure to be heated up from storage (10°C =

ambient temperature) to 71 °C, the actual installed apparatus does heat up the complete digestate, but from fermenter exit temperature of about 36°C.

Thus, the amount of heat supplied to the hygienization units is calculated based on the amount of manure that have been fed into the digester according to the above formula for $Fuel_{Hyg}$, with example below for the Monitoring year 2015, of:

$Fuel_{Hyg}$ = 48.849.000 kg * 4,18 KJ/kg K * (71°C - 10°C) * 1 /88%

= 14,15 TJ

Description	Parameter	2010	2011	2012	2013	2014	2015	2016	Unit
Amount of manure	MANURE	31.921.807	40.507.000	67.859.000	47.663.000	47.183.000	48.849.000	62.088.000	kg
Specific heat capacity of manure	Cap_{Heat}	4,18	4,18	4,18	4,18	4,18	4,18	4,18	KJ/kg K
Inlet temperature of manure	T_{Inlet}	10	10	10	10	10	10	10	°C
Outlet temperature of digestate	T_{Hyg}	71	71	71	71	71	71	71	°C
Heat required for hygienization	#	8,14	10,33	17,30	12,15	12,03	12,46	15,83	TJ
Efficiency heat exchanger	Eff_{HEx}	88	88	88	88	88	88	88	%
Consumption of gas in hygienization systems	**$Fuel_{Hyg}$**	**9,25**	**11,74**	**19,66**	**13,81**	**13,67**	**14,15**	**17,99**	**TJ**

Table 6: Thermal energy needed for hygienization during the Monitoring years 2010 to 2016

As the unit for the quantity of thermal energy used for the hygienization of manure ($Fuel_{Hyg}$) is already in TJ, the parameter Hu_{NGas} and D_{NGas} are not necessary to calculate the final emission reductions. The heat consumption has to be multiplied with the carbon emission factor of natural gas and the fraction of carbon oxidized and the result has then to be converted in t CO_2e.

The application of the first formula above results in emission reductions due to the project activity Methane Recovery Project Houbensteyn Ysselsteyn during the monitoring years 2010 to 2016, with example below for the Monitoring year 2015, of:

GHG_{red, IC_Hyg} = 14,15 TJ * 15,3 t C/TJ * 1,000 t C_{ox}/t C * 44/12 t CO_2/t C_{ox}

= 794 t CO_2

Description	Parameter	2010	2011	2012	2013	2014	2015	2016	Unit
Consumption of gas in hygienization systems	$Fuel_{Hyg}$	9,25	11,74	19,66	13,81	13,67	14,15	17,99	TJ
Lower heating value of natural gas	*Hu_{NGas}*	*33.490*	*33.490*	*33.490*	*33.490*	*33.490*	*33.490*	*33.490*	*kJ/Nm³*
Density of natural gas	*D_{NGas}*	*0,70*	*0,70*	*0,70*	*0,70*	*0,70*	*0,70*	*0,70*	*kg/Nm³*
Carbon emission factor of natural gas	CEF	15,30	15,30	15,30	15,30	15,30	15,30	15,30	t C/TJ
Fraction of carbon oxidised	FCO	1,000	1,000	1,000	1,000	1,000	1,000	1,000	t CO_x/t C
Conversion factor C in CO_2	44/12	3,667	3,667	3,667	3,667	3,667	3,667	3,667	t CO_2/t CO_x
Emission reduction for hygienization	**GHG_{red,IC_Hyg}**	**518**	**658**	**1.103**	**774**	**766**	**794**	**1.009**	**t CO_2**

Table 7: Emission reductions through waste heat use for hygienization during the monitoring years 2010 to 2016

5.2 Project Emissions

The oil-fired emergency boiler was not installed in the biogas site during the actual monitored period. Hence, no emission by this source of the project activity occurred.

The manure treated in the biogas plant comes exclusively from the farm of the project owner. Therefore, no project emissions from transport of biomass due to the combustion of fossil fuels can be considered.

CH_4 emissions from physical leakage of biogas in the manure management systems, which includes production, collection and transport of biogas to the point of combustion or gainful use of the anaerobic digester, have to be considered. Those project emissions have not been considered during the last monitoring period. This is due to the fact, that the Carbon Consultant in charge of the Monitoring at that time was not aware of the existence of physical leakage from biogas plant. He has correctly followed the Monitoring Plan defined in the PDD. The current Monitoring Report has been established by a different Carbon Consultant, who has worked for years in the field of biogas as project developer as well as Carbon Manager for similar emission reductions projects from methane recovery. The biogas practice as well as corresponding methodologies regarding methane emissions from manure management systems have been considerably developed over the last 15 years. The practice has shown that few emissions from physical leakage of biogas on the plant can potentially occur. The CDM Methodology AMS III.AO *"Methane recovery through controlled anaerobic digestion",* Version 01[7], suggests estimating these project emissions using a default factor of 0,05 m^3 biogas leaked/m^3 biogas produced. Considering experience from practice, this value can be addressed as too high. The system of the biogas plant starting at the input of manure is gastight. The operator has an interest to keep the system gastight for security reasons, but also because biogas is the fuel that runs the engine and creates the income. Severe discrepancies between the biogas potential of the substrates and the produced electric energy would become apparent to the operator. Nevertheless, since no measurements of leaked methane on the plant are available, the proposed calculation for Project Emissions from physical leakage of biogas has been taken over, so that the principle of conservativity can be kept.

The calculation of the Project Emissions from physical leakage for the project Houbensteyn is shown in the table below with following equation (with the year 2015 as example):

$PE_{phy\ leakage,2015}$= 5.153.667 m^3 * 0,05 * 59,07% * 0,0007168 t CH_4/m^3 * 25 = 2.728 t CO_2e

[7] https://cdm.unfccc.int/filestorage/C/D/M/CDM_AMSU745LJQM81SDJJOJ2S4G7ID9EIKFGD/EB58_repan16_AMS-III.AO.pdf?t=aWx8cWF6bDdlfDC8bL3Q3JMGdSFxjetuSlEX, Page 6

Year	Biogas Flow [m³]	Default factor [m³ biogas leaked/m³ biogas produced]	Biogas leaked [m³]	Methane content of biogas [%]	Density of methane [t CH4/m³]	Global Warming potential of CH_4	Project emissions [t CO_2e]
2010	3.304.928	0,05	165.246	58,43	0,0007168	25	1.730
2011	5.040.816	0,05	252.041	58,50	0,0007168	25	2.642
2012	5.105.081	0,05	255.254	59,13	0,0007168	25	2.705
2013	4.941.820	0,05	247.091	58,94	0,0007168	25	2.610
2014	4.915.469	0,05	245.773	58,92	0,0007168	25	2.595
2015	5.153.667	0,05	257.683	59,07	0,0007168	25	2.728
2016	1.702.964	0,05	85.148	59,70	0,0007168	25	911

Table 8: Project Emissions from physical leakage during the monitoring period 2010 - 2016

5.3 Leakage

According to the PDD section E.2., no leakage has to be considered.

5.4 Net GHG Emission Reductions and Removals

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)
Year 2008	0	0	0	0
Year 2009	0	0	0	0
Year 2010	10.344	1.730	0	8.614
Year 2011	22.506	2.642	0	19.864
Year 2012	25.395	2.705	0	22.690
Year 2013	24.399	2.610	0	21.789
Year 2014	23.863	2.595	0	21.268
Year 2015	24.212	2.728	0	21.484
Year 2016	6.417	911	0	5.506
Total	137.136	15.921	0	121.215

APPENDIX A: DOUBLE COUNTING

Verified Carbon Standard

Supporting Documentation:

The following email evidence was provided to Verra by the project proponent to demonstrate that emissions reductions associated with methane emissions from manure digesters are not included within the national inventory.

The original email record is provided at the end of this document.

Email of Nov 21, 2017, from Jos Cozijnsen, on behalf of John Horrevorts in the framework of the Dutch Green Deal to establish a domestic CO2 market [not official translation]:	
Original (Dutch):	Translated (English):
Hallo Peter, "In vervolg op onze eerdere gesprekken wil ik je namens John Horrevorts, die aangesloten is bij onze green deal en met mestvergistingsprojecten bezig is in Brabant vragen om een mededeling dat bevestigt dat de methaanreducties van mestvergisting totnogtoe niet zijn meegenomen in de NIR. Dat kan wellicht via email, of over brief, met verwijzing naar de plek in de NIR. Graag horen we of je daar nog informatie voor nodig hebt of dat je dat zo kunt sturen."	"Hello Peter As a follow-up to our earlier discussions, I would like to ask you on behalf of John Horrevorts, who is involved in our green deal and with manure fermentation projects in Brabant, to submit a statement confirming that the methane reductions of manure digesters have not yet been included in the NIR. This may be possible via email, or letter, with reference to the place in the NIR. We would like to hear if you need information or that you can send it that way."
Email of Nov 27, 2017, from Peter , Dutch official, responsible for drafting the National Inventory Report:	
Original (Dutch):	Translated (English):
"Beste Jos en John Door middel van deze mail bevestig ik dat er in Nederland nog geen sprake van het meerekenen van emissiereducties als gevolg van mestvergisting. Hierbij verwijs ik naar de NIR2017 (http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/nld-2017-nir-14apr17.zip) waar in paragraaf 5.3.6 de volgende tekst staat vermeld: *A technical measure to prevent methane emissions caused by manure management is manure treatment in an anaerobic digester. In 2014, 2% of the total amount of manure in animal housing was treated in an anaerobic digester. The Netherlands is examining future needs and possibilities in this area to include anaerobic treatment in the methodology and to extend calculations. Results of initial research (Hoeksma et al., 2012) make it clear that further investigation is needed.* Op dit moment is het RIVM samen met de WUR een methode te ontwikkelen, waarmee de effecten van mestvergisting kunnen worden verrekend in de emissies. Het blijkt een complex onderwerp (met plussen en minnen), dat waarschijnlijk in de NIR 2019 zal worden doorgevoerd."	"Dear Jos and John, By means of this e-mail I confirm that there is no inclusion in the Netherlands of the emission reductions as a result of manure digesters. I refer to the NIR2017 (http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/nld-2017-nir-14apr17.zip where the following text is mentioned in section 5.3.6: A technical measure to prevent methane emissions caused by manure management is manure treatment in an anaerobic digester. In 2014, 2% of the total amount of manure in animal housing was treated in an anaerobic digester. The Netherlands is examining future needs and possibilities in this area to include anaerobic treatment in the methodology and to extend calculations. Results of initial research (Hoeksma et al., 2012) make it clear that further investigation is needed. At the moment, the RIVM, together with the WUR, is developing a method with which the effects of manure fermentation can be calculated in the emissions. It turns out to be a complex topic (with pluses and minuses) that will probably be implemented in the NIR 2019."

APPENDIX B: PROJECT REVIEW REPORT

For further information about the increase of manure amounts during the project activity, please refer to the Project Princepeel in the "Project Review Report of the Methane Recovery Project Princepeel Wilbertoord" under Finding 3, page 7.

For further information about the electricity meters and their accuracy, please refer to the Project Princepeel in the "Project Review Report of the Methane Recovery Project Princepeel Wilbertoord" under Finding 1, page 3.

APPENDIX C: SPREADSHEET WITH CALCULATION OF EMISSION REDUCTIONS

APPENDIX D: MONITORING PLAN - DOCUMENTATION

1. Filled questionnaire with project data, i.e. average methane content “20201028_VCS_Data Inquiry_Houbensteyn”
2. Inaccuracy of CHP runtime counters under “Runtime counter - Accuracy - Jenbacher”
3. Reports containing information about electricity (and heat) production, their technical description, the monitoring methods as well as calibration reports named “Meetprotocol elektriciteit en warmte Houbensteyn Milieu B.V.”
4. Technical specification of gross and net power meters named “Photo - gross EP meter - WKK[no]_new” and “Photos - gross and net EP meters_old”.
5. Computer based program to register the co-products entering the biogas plant named Optimad “Screenshot Optimad”.
6. Annual co-ferment inputs in the biogas plant named “[year] coproducten”
7. Technical specifications of the weighing scale named “Technical specifications the weighing scale”
8. Folders of monthly records from Fudura of the daily electricity gross production rates for the year 2010 -2016 named “Gross EP Fudura 2010-2016 - EAN [no]”
9. Records of the monthly production rates for the year 2012 till 2016 certified by Fudura BV named “Meetrapport [year] Houbensteyn Milieu”
10. Email information about operation, maintenance and calibration of electric meters complying with MID according to Fudura adviser named “Fudura_Electric meters”
11. Monthly records of gross and net electricity production and calculated own electricity consumption as overview in excel file “Electricity production and consumption _2010 2016”
12. Overview of the operation hours of each CHP during the monitoring period 2010-2016 named “Overview runtime hours_2010-2016”
13. Calculated amounts of manure in excel files named “[year] mestafvoer HYS”
14. Electric efficiency of the CHPs under “Data sheet MAN LE 312”

APPENDIX E: REQUEST FOR EXEMPTION FROM QUANTITATIVE MONITORING FOR THE CREDITING PERIOD FROM 01/01/2008 TO 30/04/2010