[1]E X E C U T I V E   S U M M A R Y

GHG Mitigation Project
- Biogas Plant *Sandbeiendorf* -

- Validated GHG mitigation project following the JI and CDM mechanisms according to UNFCCC standards
- Significant reduction of uncontrolled methane emissions arising during storage of manure in the baseline scenario
- Decentral GHG mitigation approach

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[1] This executive summary is to be understood as an overview of the GHG mitigation project *Sandbeiendorf* containing among others selected informations of the PDD which has been submitted on Dec 12th 2003 to the validator TÜV SÜD, Germany.

KEY DATA

➢ Project Name	*Sandbeiendorf*
➢ Project Location	39517 Sandbeiendorf, Germany
➢ Project Operator	van Gennip Tierzuchtanlagen GmbH & Co. Handels KG
➢ VER Owner	ARA Carbon Finance GmbH
➢ Baseline (primary approach)	Uncontrolled methane emissions during storage of swine manure in lagoons
➢ Project Activity	Technical digestion of manure, additionally BGTE (biogas to energy)
➢ Project Type	Biogas Plant including CHP (Combined Heat and Power)
➢ GHG Reduction Approach	Primary: Mitigation of uncontrolled methane emissions through technical digestion; Secondary: Generation of renewable heat
➢ Crediting Life Time	Jan-01-2004 to Dec-12-2013 (10 years)
➢ Validation	Dec-19-2003
➢ Validator	TÜV-SÜD, Germany
➢ Estimated GHG Reduction	14.036 t CO_2e annually
➢ Verification:	Due to ERPA

C O N T E N T

1 Introduction

In Germany before farmland application cattle and swine manure are normally stored either in open tanks or in open lagoons. During this stage of storage significant amounts of methane arise through anaerobic mineralisation processes resulting in uncontrolled greenhouse gas (GHG) emissions into the atmosphere. Due to this mechanism at the piggery of *Sandbeiendorf* appopximately 670 tons of methane annually emit being equivalent to approximately 14.100 tons of carbon dioxide.

Within the project *Sandbeiendorf* swine manure is not stored in lagoons. Instead, it is fed into a biogas plant where being technically digested under controlled conditions. By means of this project the emission potential of the digested manure is reduced to less than 10 percent of the potential of the untreated manure.

Additionally the methane gas technically generated in the biogas plant is being converted into heat and electricity through a CHP unit attached to the plant. Thus, as a positive side effect, energy out of renewable sources are generated to spare fossil sources.

2 Baseline

The baseline is the reference scenario which would occur in the absence of the project. Referring to stock farming the uncontrolled emissions of methane out of manure during storage is the most essential aspect of these baseline.

2.1 The general baseline of stock farming

In the reference scenario (baseline) of a typical farm unit, mainly during storage (and secondary during field application) huge amounts of the GHG methane (CH_4) emit out of the manure in the atmosphere. Since related to carbon dioxide methane has to be considered with a GWP factor of 21, the methane emissions quantitatively contribute to the far highest ratio of GHG emissisons compared to the entire emissions generated through the baseline system (compare chapter 2.2 and chapter 4.2).

Apart from the methane approach, to maintain the operation and administration processes, farm enterprises are continuously in need for power and heat. Within the baseline scenario, these energy demands are assigned to suppliers using fossil sources.

Moreover at farming within the process of manure management, emissions of the GHG nitrous oxide (N_2O) could be identified.

The single baseline fluxes contributing to the total amount of GHG out of farm units are shown in Fig. 1.

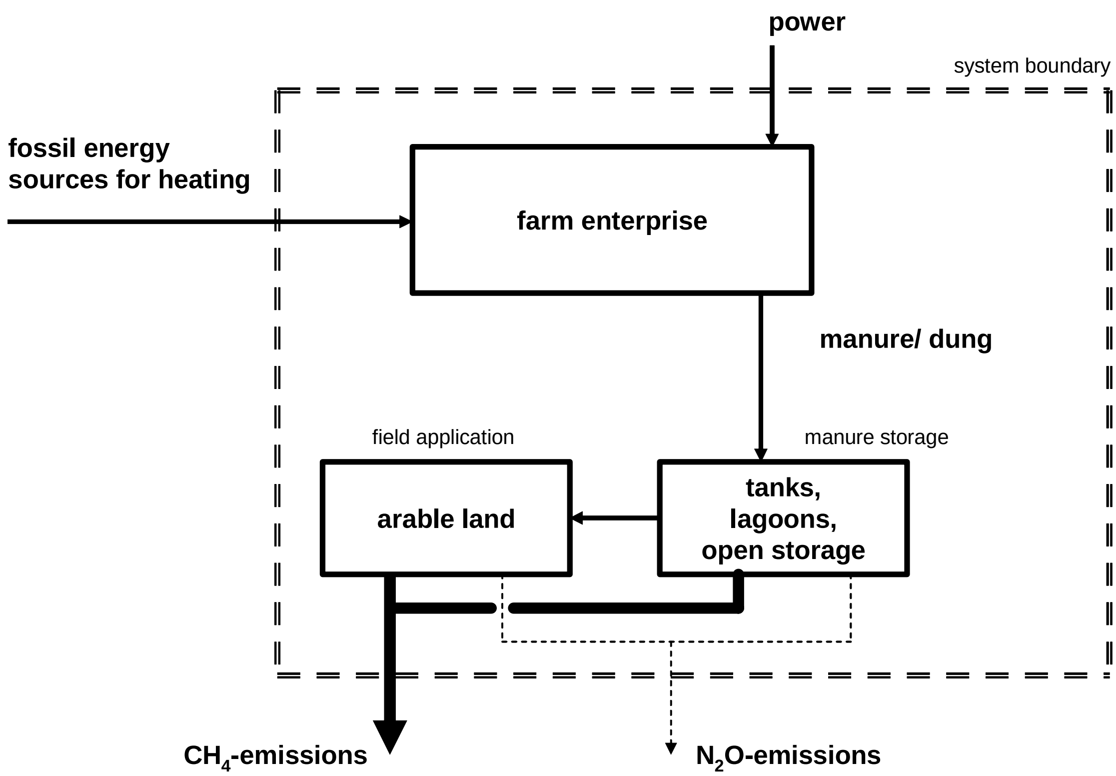

Fig. 1 Baseline system of a typical farm unit leading to GHG emissions

2.2 The specific baseline *Sandbeiendorf*

The stock farming *Sandbeiendorf* is a piggery consisting of units for raising and fattening. Approximately 60.000 animals are kept indoors in big groups receiving both natural and artificial light. The enterprise is legally licensed under the acts of both the "Bundesimmissionsschutzgesetz" (immission protection law) and the "Tierschutzgesetz" (animal protection law). The compliances with the legal conditions are proved continuously and thoroughly by the appropriate "Veterinäramt" (department of veterinary). A veterinarien is on-site 5 days a week. Additionaly, the piggery is holder of a "QS-Zertifikat" (Quality System Cerificate) being issued every two years by the "LKV-Landeskontrollverband" (state control organisation) after complying with the strict animal welfare obligations regularly to be proven. Among others the obligations refer to high standards of hygiene, food, veterinary supervision, livestock husbandry, and so on.

Within the operation of the piggery approximately 70.000 m³ of manure arise annualy to be stored in lagoons as shown in Fig. 2

Fig. 2 One of eight lagoons where pig manure is stored resulting in appr. 670 tons methane emissions anually (14.100 t CO_2e/a)

All single emission sources of the stock farming *Sandbeiendorf* are shown in Tab. 1.

Tab. 1 GHG emissions sources (baseline) of the stock farming *Sandbeiendorf*

Source	**Amount**	**Emission Factor**	**CO_2e**
Propane	372.013 l/ a	1,52 kg CO_2/ l	565,46 t/ a
Fuel	464.489 l/ a	2,68 kg CO_2/ l	1.255,55 t/ a
Lagoos (CH_4)	671.755 kg/ a	21,00 kg CO_2/ kg CH_4	14.106,86 t/ a
[1)]Shaft 1 (CH_4)	1.919 kg/ a	21,00 kg CO_2/ kg CH_4	40,31 t/ a
[1)]Shaft 2 (CH_4)	320 kg/ a	21,00 kg CO_2/ kg CH_4	6,72 t/ a
Power in	2.994.429 kWh/ a	0,49 kg CO_2/ kWh	1.467,27 t/a
Total (without subsources CH_4 / shaft 1 and 2)			**17.395,14 t/ a**

1) The emissiosn sources "pumping shaft 1" and "2" contribute below 1 % of the total emissions of baseline. According to international standards there is no need of further consideration within the following calculation of the entire GHG reductions.

Propane and fuel is used to heat the pens and the operating buildings. The appropriate emissions amout to appr. 1.800 t CO_2e. The most significant GHG source of the baseline are the manure lagoons contributing to annual methane emissions of appr. 14.100 t CO_2e. Two rather insignificant punping shafts contribute to marginal emissions below one percent of the total emissions. The electriciy demand (power in) according to the german energy mix (the GHG Protocol WBCSD and WRI, May 2003: Electricity all fuels, Germany 2000) amounts to 1.467 t CO_2e. Hence the total amount of GHG emissions due to baseline sources cumulates to 17.395 t CO_2e annually.

3 Project Activity

The project activity is characterized by reducing the uncontrolled methane emissions of the stored manure through technical digestion by a biogas plant.

3.1 Principles of a biogas process in the agricultural sector

With the biogas process one obtains so called biogas from organics. Organics in the agricultural sector primary means manure. Sometimes, coferments like energy crops, kitchen waste, fats, and so on, are added. Biogas is renewable energy.

The manure, and additionally, if applicable, the coferments are collected in a sump and semi-continuously fed in a digester where different kinds of microorganisms metabolize the organic material under anaerobic conditions.

The fermentation process in the digester leads to two products:

(gaseous) Biogas, consisting of about 60 % methane (CH_4) and 40 % carbon dioxide (CO_2), mainly to be converted into heat and power by an attached power unit (CHP/ combined heat and power);

(solid) Digested manure, to be stored and subsequently used as fertilizer of better quality than the raw material (neutral pH-value, no caustic action when applied to plants, easy availability of ammonia, less odour, and so on).

Fig. 3 shows the principles of the process.

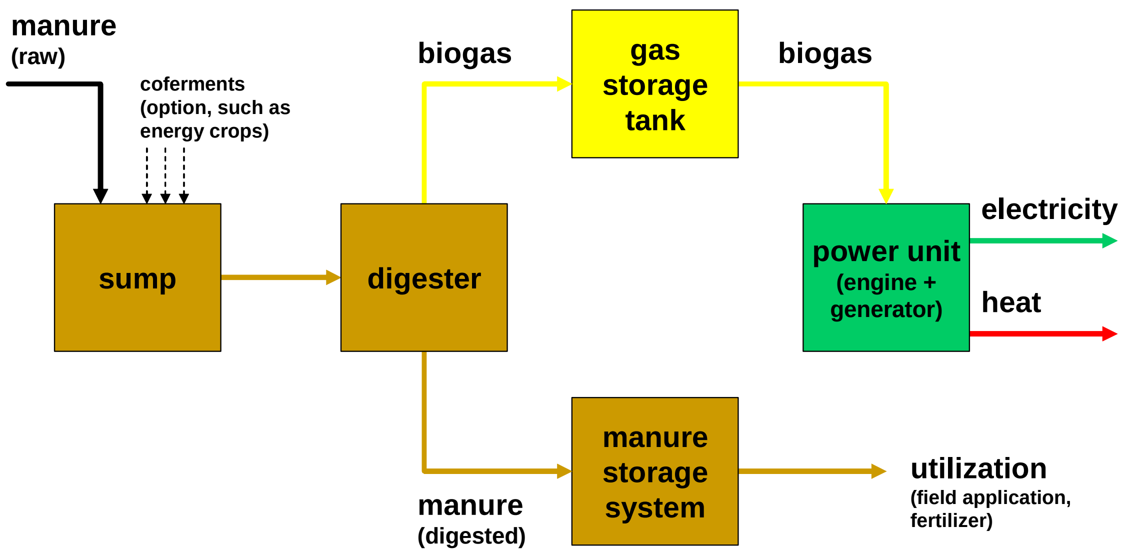

Fig. 3 Process principles of biogas production, agricultural sector, including CHP

3.2 General project activity (biogas plant)

In the typical project scenario, instead of storage, the raw manure aroused from the farm unit is pumped into a sump and from there semi-continuously fed in the digester. The biogas generated during the fermentation process is going to be converted to heat and power (compare chapter 3.1), whereas the digested manure is transferred in the storage system identical to the reference scenario (baseline), but with a significant reduced potential of methane emissions (> 10 %).

The relevant fluxes of the project system contributing to GHG emissions or GHG sinks, respectively are shown in Fig. 4. The project activity, measured in total GHG emissions, is much smaller compared to the baseline and thus effectively enables emission reduction credits to be generated. Particularly the significant reduction of methane emissions out of manure during storage and field application contribute to this effect. Furthermore, the utilization of heat and power from renewable energy sources could be taken into account.

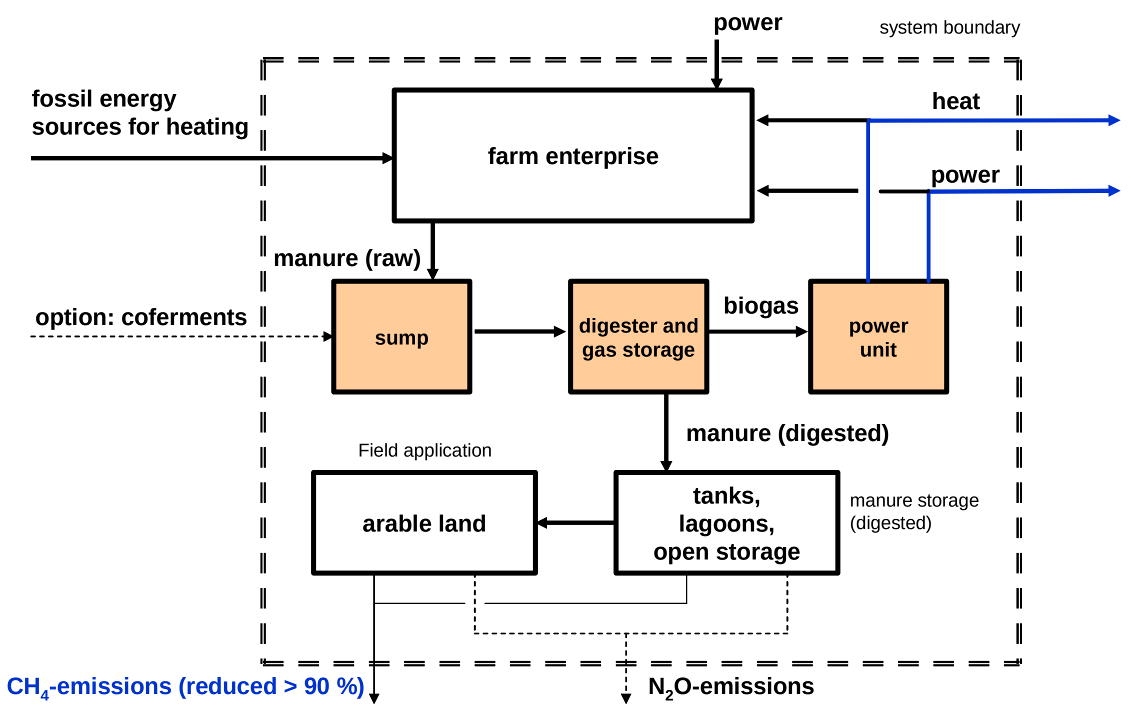

Fig. 4 Project system of a farm unit linked with a biogas process

3.3 Project system *Sandbeiendorf*

The biogas plant *Sandbeiendorf* consists of the main process units sump, digester, gas storage tank and CHP. Within the CHP a gas engine and a generator converts the biogas produced in the digester into thermal and electrical energy. The thermal energy is extracted by heat exchangers from the cooling water of the engine and then pumped to the buildings for heating purposes. The electrical power produced in the generator is fed into the public grid.

Instead of pumping into the lagoons (baseline) the entire manure of the piggery (appr. 70.000 tons annually) is directly fed into the sump and then into the digester of the biogas plant. Only after the metabolization process the then digested manure is fed into the lagoons remaining a residual methane emission potential of less then 10 % compared to the raw manure. After storage the digested manure is applied as fertilizer on local farmland.

Fig. 5 illustrates parts of the biogas plant *Sandbeiendorf*.

Fig. 5 Digester (background center) and gas storage tank (left) of the biogas plant *Sandbeiendorf*

All single emission sources of the project activity *Sandbeiendorf* are shown in Tab. 2.

Tab. 2 GHG emissions sources of the project activity *Sandbeiendorf*

Source	**Amount**	**Emission Factor**	**CO_2e**
Propane	372.013 l/ a	1,52 kg CO_2/ l	565,46 t/ a
Fuel	2.151.481,62 kWh/ a	0,266 kg CO_2/ kWh	573,18 t/ a
Lagoons (CH_4)	34,56 t/ a	21,00 kg CO_2/ kg CH_4	725,69 t/ a
Power in	3.218.247 kWh/ a	0,49 kg CO_2/ kWh	1.576,94 t/a
Power out	4.476.360 kWh/ a	- 0,49 kg CO_2/ kWh	- 2.193,42 t/ a
Total			**1.247,85 t/ a**

Like in the baseline scenario propane is used to heat the pens of the young pigs and hence is not substituted. Fuel is partially substituted by thermal energy of the CHP to heat the buildings.

The remaining emissions of the digested manure stored in the lagoons amount to 726 tons CO_2e (baseline emissions: 14.107 t CO_2e, compare table 1). The electricity demand (power in) is slightly increased due to the operation equipment (pumps, agitators, and so on). The electricity production from the CHP (power out) amounts to 2.190 t CO_2e.

4 GHG Reductions

The GHG reductions of an offset project are determined by subtracting the baseline emissiosn from the emissions of the project activity. Within the biogas plant *Sandbeiendorf* several approaches could be taken into consideration. The total amount of reduction generated is derived by superimposing the single approaches.

4.1 General GHG Reduction Approaches of Biogas Projects

Table 3 shows the single GHG reduction approaches generally applied for biogas projects in the agricultural sector.

Table 3 General methodical approaches to detremine GHG reductions by a biogas project

Approach	Baseline	Project	Credit
Reduction of uncontrolled CH_4 emissions	Emissions out of untreated manure during storage and application	Emissions out of digested manure, **less than 10% comp. to baseline**	Delta, conversion to CO_2-e by GWP 21 **60 – 100% of total**
Generation of heat out of renewable energy sources	Demand on fossil energy sources for heating purposes	Utilization of heat, substitute fossil for renewables	To be calculated specifically **0 – 20 % of total**
Generation of power out of renewable energy sources	Demand on power generated by fossil energy sources	Utilization of power, substitute fossil for renewables	To be calculated specifically **0 – 20 % of total**
Reduction of uncontrolled N_2O emissions	Emissions out of untreated manure during storage and application	Emissions out of digested manure, less compared to baseline	Delta, conversion to CO_2-e by GWP 310; qualitatively at present

The reduction of uncontrolled methane emissions out of manure could be amounted to 60 % - 100 % of the total reduction, and thus quantitatively clearly dominates the secondary approaches listed (production of heat and power as well as the reduction of N_2O emission).

If linking effects to other climate systems are likely to occur (i.e. feeding generated power in the main grid), the production of power and/ or heat out of renewable energy sources is quantitatively neutralized when calculating the total amount of GHG reductions for certification.

4.2 GHG Reduction Amount for Certification of *Sandbeiendorf*

The annual GHG reductions calculated for certification superimposed by the different methodical approaches are listed in table 4.

Tab. 4 GHG reductions achieved by the biogas project Sandbeieindorf, all values as annual tons of CO_2e

Source	Baseline	Project Activity	Leakage	GHG Reductions
Propane	565,46	565,46	0,00	0,00
Fuel	1.255,55	573,18	0,00	682,37
Coferments	0,00	0,00	0,00	0,00
Lagoons (CH_4)	14.106,86	725,69	0,00	13.381,17
Power in	1.467,27	1.576,94	0,00	-109,67
Power out	0,00	-2.193,42	0,00	2.193,42
Subtotal	17.395,14	1.247,85	0,00	16.147,29
deducting Power	1.467,27	-616,48	0,00	2.083,75
Total	**15.927,87**	**1.864,33**	**0,00**	**14.063,54**

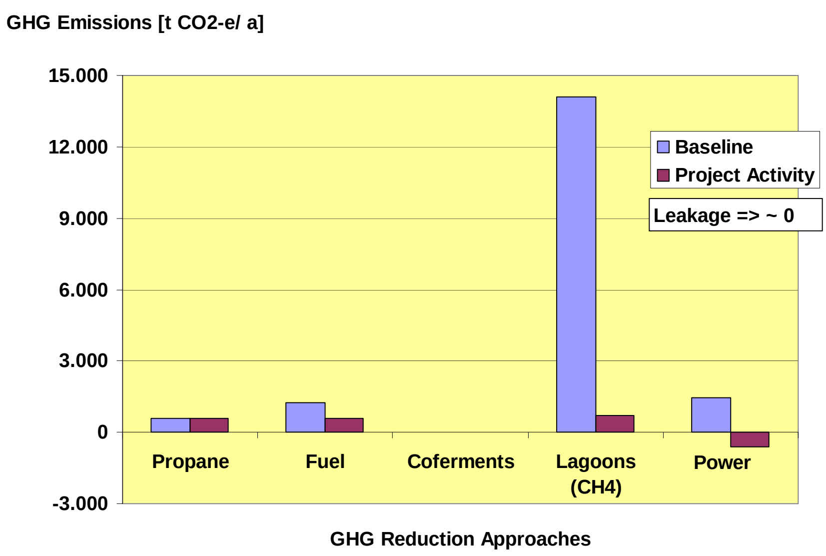

Fig. 6 Comparison of GHG emissions by sources: baseline vs. Project activity (ref. Tab. 4)

Fig. 6 clearly illustrates the dominant effect of methane reduction through the mitigation project *Sandbeiendorf* as part of the entire reduction approaches. The total GHG reduction achieved from the project *Sandbeiendorf* for certification amounts to **14.064 tons of CO_2e** annualy.

To avoid any conflicts of double counting with both the EU Emission Trading System and the German feed-in law (EEG), all GHG reductions achieved through the production of renewable power were quantitatively neutralized. Like *Sandbeiendorf* biogas projects in the agricultural sector are characterized as GHG mitigation projects both decentrally located and decentrally characterized in effect of GHG fluxes.

5 Monitoring

The GHG reductions to be verified and then certified are going to be achived by evaluating parameters according to the validated monitoring concept as listed in table 5. The monitoring is continuously performad by the operator of the biogas plant.

Tab. 5 Monitoring parameters to be continuously screened during plant operation

Pos.	Sign	Parameter	Unit	Device/ Location	Min. screeneing
1)	Z_{Strom}-ein	Power in	kWh	Electric Meter	Monthly
2)	Z_{Strom}-aus	Power out	kWh	Electric Meter	Monthly
3)	Z_{Propan}	Propane consumption	l	Fuel meter	Weekly
4)	$Z_{Heizöl}$	Fuel Consumption	l	Fuel meter	Weekly
5)	Z_V-$_{MB}$	Input flow sump	m³	Neck of sump	continuously
6)	Z_V-ein	Input flow digester	m³	Neck of digester	continuously
7)	$Z_{m,i+1}$	Amounts of coferments	kg	Balance	Balance protocol when occuring
8)	Z_{BG}	Amount of biogas out of gas storage	m³	Input gas line CHP	continuously
9)	$Z_{x\text{-}CH4}$	Methane content in biogas	m³ / m³	Outlet gas storage tank	monthly
10)	Z_e	Heat production	kWh	Distribution system	continuously
11)	$Z_{BHKW\text{-}1/2}$	Working hours CHP	h	Hour Meter CHP	monthly

6 Sustainability and socio-economic Aspects

Biogas plants in the agricultural sector are characterized by an ecoloigical sustainability on different levels.

First the digestion of manure within a closed and controlled technical system results in a significan reduction of uncontrolled methane emissions. Furthermore unpleasant odours of raw manure when applying on farmland are reduced.

Digested manure contains ammonium nitrogen instantly available for plants. For this reason in the farming sector digested manure is often used as substitute of industrial produced fertilizer based on ammonium nitrogen. Assuming a less production of such industrial fertilizer by the Haber-Bosch process, a sustainible energy saving can be taken into account.

Additionally; in contradiction to raw manure, digested manure contains rather no nitrate which results in a sustainable protection of ground water.

Biogas projects generate thermal and electrical energy out of renewable sources and thus contribute to a sustainable saving of fossil sources.

The farming sector often is characterized by lacking in economic infrastructure. Since the technical plant operation requires skilled manpower biogas plants contribute to the preservation and the creation of jobs.

Biogas plants ensure farmers the extension of their traditional service range from agricultur and stock farming to energy production. Hence sustainable new economic opportunities are created within the farming areas.

If energy crops are applied as substrates or coferments for biogas plants the appropriate cultivation of farmland is required creating additional economic potential in the local region of such projects.

7 Additionality and Barrier Analysis

Biogas plants in the farming sector are normally characterized by both technical and economical barriers. The technical barriers are inherent to the process itself whereas economical barriers must be evaluated taking the architecure of the project system into account. Recently in Germany it could be shown that the feed-in tariff guaranteed by the feed-in law (EEG) is not sufficient to compensate this barriers.

7.1 Barrier 1: Digestion Process

The anaerobic digestion is a high complex mineralisation process at which different types of microorganisms decompose the substrate (i.e. manure) in different steps (hydolysis, acidification, acetic acid generation, methane generation) both simultaneously and at order. The entire process is highly sensitive towards both variation in temparature and variation in the concentration of the input material. During practical operation these variations occur inherently due to seasonal cycles and due to biological inconsistency of the input substrate. Additionally if cosubstrates are applied the variation effects do amplify. Inconsistency of input material and temperatures could result in a complete turn sour of the biological activity, an effect which in practice occurs rarely but regularly.

All defects and breakdowns of the biological activity in a digester directly causes a decrease of gas production and thus, within the follow-up process chain, a decrease of power production and revenues. In many projects this process barrier causes a significant lack of profitability often to be compensated by the connected farming enterprise.

7.2 Barrier 2: CHP Unit

Mostly after the digestion process CHP units are attached to the process system in order to produce electrical and thermal energy. The engines of these CHP are normally gas engines adjusted for biogas of a high and consistent quality. Especially the methane content of the biogas has to be consistent. In practice the methane content varies permanently resulting in a decreased power production and an increased attrition of the engine. Moreover trace elements existing in the biogas do cause additional attrition of the engines and causes volatile production rates and sometimes standstills and breakdown of the engines.

7.3 Conclusion

The realisation of biogas projects witin the farming sector requires investors being ambitious to capitalize such projects. Taking the described barriers into account investments in biogas projects have to be classified as risk investments if argueing in general terms. Hence an economical as well as an ecological sustainability could not be guaranteed without the implementation of further revenue streams such as the sale of emission credits.

A biogas project is additional if the project faces barriers leading to a high risk of economical failure. This risk profile could be identified strongly positively for biogas projects. Moreover to proof the additionality on a case-by-case basis a financial modelling of such project is going to be drawn in order to evaluate if the investment is not profitable taking benchmark alternatives into account.

8 Summary

Referring to biogas projects attached to farm units, the following statements can be shown:

- ⇨ Following the flexible JI and CDM mechanisms of the Kyoto protocol, biogas projects could be validated as GHG emission reduction projects;
- ⇨ The following approaches of GHG emission reduction through a biogas plant could be taken into account:
  - o Reduction of uncontrolled CH_4 emissions
    (60 - 100 % of total, if manure is the feed);
  - o Production of heat out of renewable energy sources, substitution of fossils
    (0 - 20 % of total);
  - o Production of power out of renewable energy sources, substitution of fossils
    (0 - 20 % of total);
  - o Reduction of uncontrolled N_2O-emissions
    (qualitatively at present, if manure is the feed);
- ⇨ Due to GWP 21, methane reductions are very effective in GHG emissions reduction;
- ⇨ Biogas investments lead to increased values both environmentally and economically;

- ⇨ Biogas projects in the argricultural sector are almost always units that are located decentrally;
- ⇨ The Biogas project *Sandbeiendorf* is validated as national GHG offset project by TÜV SÜD as independent third party assessment of the project design, the project baseline and the Monitoring and Verification Protocol (MVP) according to:
    - o the guidelines for the implementation of Article 6 of the KP as presented in the Marrakesh Accords under the decision 16/CP.7 and its annex ("JI Rules");
    - o other relevant rules, including the host country legislation and CDM criteria and project framework.
- ⇨ "Double Counting" is taken into account by omitting (neutralising) the emission credits (e.g. generated power to be fed into the main grid is subsidised by feed-in tariffs).
- ⇨ Biogas plants in the farming sector are characterizes by a high degree of ecological and socio-economical sustainability.
- ⇨ Biogas plants face both technical and economical barriers which often leads to investments of high risk profiles.