# Climate protection by efficient manure management and biogas

Project Design Document

for the registration of a Joint Implementation project

27.01.2010

Biogáz Unió Zrt- Farkasréti u. 45, 2040 Budaörs

Greenstream Network GmbH-Großer Burstah 31, 20457 Hamburg

# Contents

# 1. General information

## 1.1 Subject of the project

Biogaz Unio Zrt. develops several agricultural biogas plants in Hungary that use animal manure from barns as a substrate. Methane produced during actual storage of the manure will be captured in the biogas plant and used for the production of renewable energy in a combined heat and power facility.

The project activity will replace the old manure management system with its deep open lagoons and avoid the methane ($CH_4$) emissions caused by them. Manure will instead be transported from the barns to the gastight digesters of the biogas plant, where the emitted methane is captured, stored and finally destroyed in the CHP. The heat produced from the CHP facilities will replace fossil fuels in the existing heating systems of the barns and thus reduce carbon dioxide ($CO_2$) emissions. The digestate (manure and other substrates after the biogas treatment) will be used as a fertilizer in a similar way manure is used today. But because of the added co-substrates nitrogen (and nutrient) content in the digestate will be higher than in the manure alone. So the use of digestate instead of manure will reduce the need for artificial fertilizer.

The project activities will face great economical risks and will not be realized without being registered as JI projects under the specifications of the Kyoto-protocol. A track 1 approach is chosen here. Required content for the project design document (PDD) is shown in Annex 3 of the government Decree 323/2007 (XII.11.).

To use synergy effects, reduce the efforts of registration as a climate protection project and because the projects have similar technical concepts, ten projects of the same kind will be bundled.

## 1.2 Bundleing

There is no definition for a project bundle under JI but CDM rules define a bundle as:

*“Bringing together of several small-scale CDM project activities, to form a single CDM project activity or portfolio without the loss of distinctive characteristics of each project activity (EB 21, Annex 21, paragraph 3).”*

This bundle has received the Letter of Endorsement (as of 27.10.2009, see Appendix II) as a bundle.

All projects fulfill the requirements of small scale projects (see point below).

## 1.3 Small-scale Projects

Paragraph 14 of decision 3/CMP.2, referring to paragraph 28 of decision 1/CMP.2, defines requirements for a small scale project activity.

A non-energy-efficiency project can have a maximum of 15 MW installed electric power or a claimed emission reduction of maximum 60.000 t $CO_2$e.

Furthermore it must be ensured, that the small scale projects are not debundled components of one big project.

The ten bundled plants have different locations and can therefore not be addressed as one project. There also is no other activity of the presented kind located at the below specified locations which the projects could be part of.

## 1.4 Places of implementation

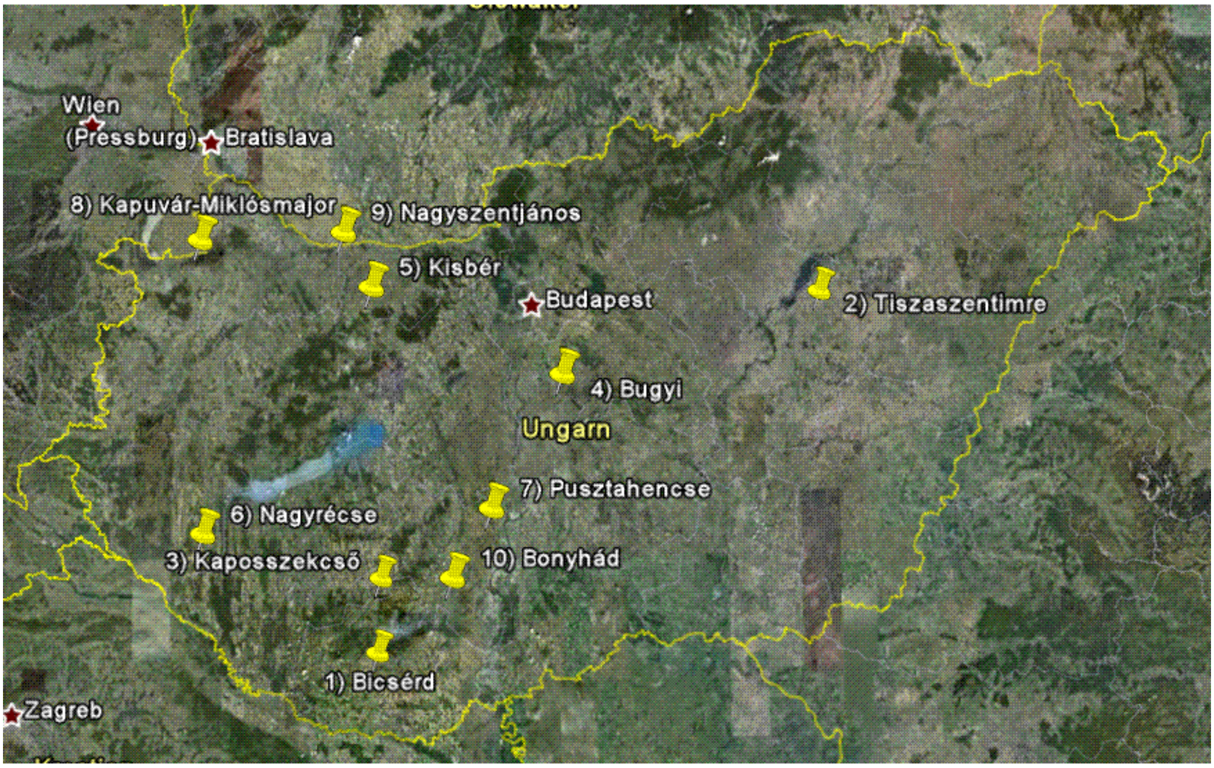


**Figure 1: places of implementation**

| project | address | langitude and altitude |
|---|---|---|
| 1) Bicsérdi Arany-Mező Zrt. Biogáz üzem | 7671 - Bicsérd, Alkotmány tér 1. | 46°01’41 North, 18°05’06 East |
| 2) Tiszaszentimre Mg.Zrt. | 5322 – Tiszaszentimre, Erzsébet major | 47°27’59.13 North, 20°42’30.45 East |
| 3) Kaposszekcsői Mezőgazdasági Zrt. | 7361 – Kaposszekcső, Ifjúság u. 8-10. | 46°20’51.07 North, 18°06’51.36 East |
| 4) Cosinus Gamma Kft Biogáz Kiserőmű | 2344 – Bugyi-Juhászföld | 47°8’15.17 North, 19°10’45.93 East |
| 5) Kisbéri Biogasanlage | 2870 - Kisbér, Ménes major | 47°29’15.89 North, 18°02’55.33 East |
| 6) Nagyrécsei Biogázüzem | 8756 – Nagyrécse Parcellaszám: 051/8 | 46°28’22 .55 North, 17°03’38.82 East |
| 7) Pusztahencsei Biogázüzem | Pusztahencse, Földespuszta Parzellenzahl.: 0120/36 | 46°36'06.17 North, 18°45'26.94 East |
| 8) Kapuvár-Miklósmajor | 9330 - Kapuvár-Miklósmajor | 47°40'14.41" North, 17°1'3.40" East |
| 9) Nagyszentjános Biogasanlage | 9072 - Nagyszentjános Fő út 1. | 47°42'22.63" North, 17°52'50.18" East |
| 10) Biogázüzem – Pannónia MG ZRt. | Teveli út, Bonyhád, Tolna megye, Dél-Dunántúli régió, Magyarország | 46°19'22.6 North, 18°31'38.1 East |


**Figure 2: BGP Bicserd**


**Figure 3: BGP Tiszaszentimre**


**Figure 4: BGP Kaposszekcső**


**Figure 5: BGP Bugyi**


**Figure 6: BGP Kisbér**

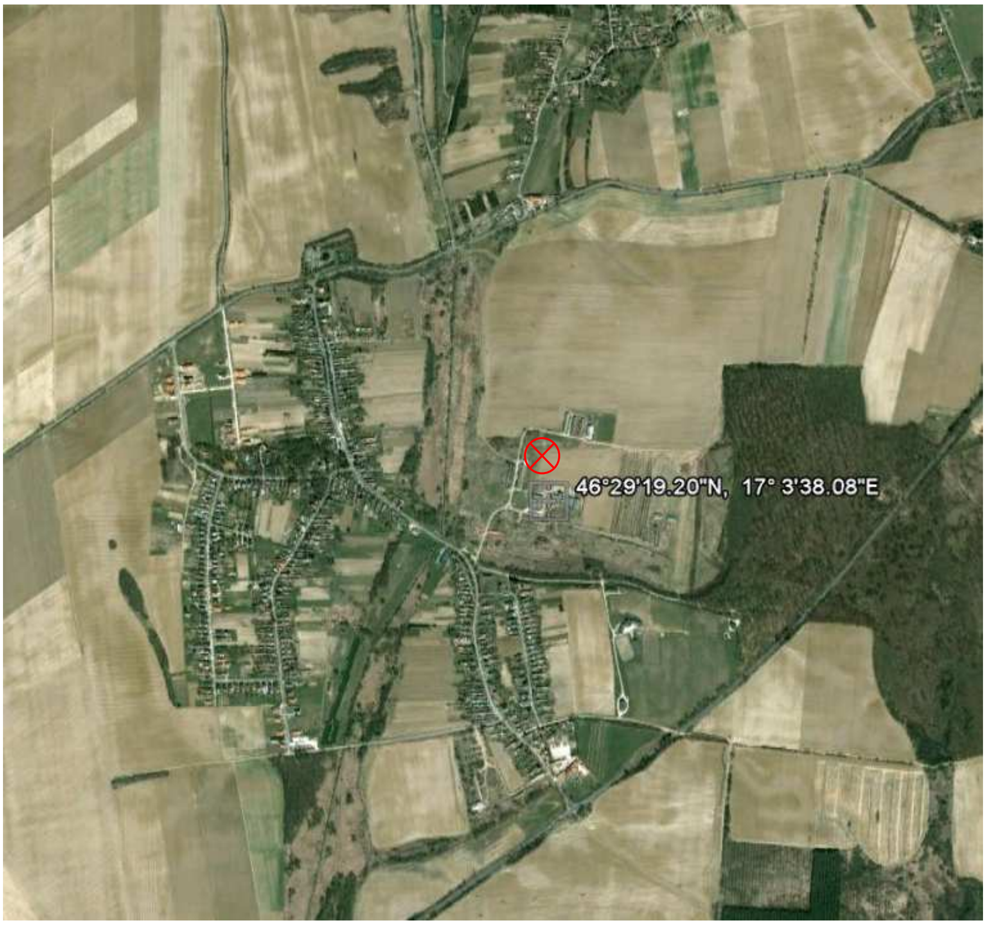


**Figure 7:BGP Nagyrécse**


**Figure 8 BGP Pusztahencse**


**Figure 9 BGP Kapuvár**


**Figure 10 Nagyszentjános**


**Figure 11 Bonyhád**

## 1.5 Information on the project developer

Biogaz Unio Zrt. is a developer and general contractor of agricultural biogas plants in Hungary. They also offer the climate protection legally aspects to their clients. For this purpose a cooperation agreement between project owners and Biogaz Unio Zrt. ist closed.

Name: Biogáz Unió Zrt

Address: 2040 Budaörs, Farkasréti u. 45.

Phone number: +36 23 444 020

Mobile: +36 30 200 54 66

E-mail: info@biogazunio.hu

Homepage: www.biogazunio.hu

## 1.6 Information on the contact person appointed by the project developer

Biogaz Unio Zrt. subcontracted Greenstream Network Biogas GmbH with the management of the carbon cycle, including the project documentation, coordination of verification and validation and the regularly monitoring report.

| Contact for | Name | Address | Phone | Electronic address |
|---|---|---|---|---|
| Carbon Management | Dr. Aric Gliesche | 20457 Hamburg, Grosser Burstah 31 | +49 40 80 90 63 119 | aric.gliesche@greenstream.net |
| Bicsérd projekt | Berki Gyula | 7671 Bicsérd, Alkotmány tér 1. | +36 630 3369 613 | baranykorona@freemail.hu |
| Tiszaszentimre projekt | Lukács Mihály | 5340 Kunhegyes, Szabadság tér 9-10. | +36 30 9500 342 | lukacs.mihaly@kozeptisza.hu |
| Kaposszekcső projekt | Gál József | 7361 Kaposszekcső, Ifjúság u. 8-10. | +36 30 645 3805 | kaposszekcsomgrt@aldocom.hu |
| Bugyi projekt | Csaplár János | 2344 Bugyi-Juhászföld | +36 30 9349325 | csaplarj@vnet.hu |
| Kisbér projekt | Varga Tibor | 2890 Tata, Zsigmond u. 5. | +36 30 5672509 | ponraczesfia@t-online.hu |
| Nagyrécse projekt | Ország László | 8756 Nagyrécse, Zrínyi u. 3. | +36 30 3374120 | orszagne@freemail.hu |
| Pusztahencse projekt | Hegedűs Viktor | 8000 Székesfehérvár, Prohászka Ottokár utca 23-25 ½ | +36 20 31 5078 | hegedusviktor@chello.hu |
| Kapuvár-Miklósmajor | Szajkó Lóránt | 9081 Győrújbarát, Petőfi út 107. | +36 20 953 4668 | szajko.lorant@kisalfoldi |

| | | | | |
|---|---|---|---|---|
| projekt | | | | .hu |
| Nagyszentjános projekt | Szajkó Lóránt | 9081 Győrújbarát, Petőfi út 107. | +36 20 953 4668 | szajko.lorant@kisalfoldi.hu |
| Pannónia projekt | Jakab Béla | 7150 Bonyhád, Zrinyi u.3. | +36 30 69 83 861 | b.jakab52@gmail.com |

**Table 2: contact persons of the projects**

## 1.7 Time schedule of the realization of the project

| | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse |
|---|---|---|---|---|---|---|
| ERU Estimation Assignment Carbon Manager | 2009/02 | 2009/02 | 2009/02 | 2009/02 | 2009/02 | 2009/02 |
| Investment implemented | 2010/04 | 2010/04 | 2009/08/21 | 2010/03/15 | 2010/03 | 2010/07 |
| Building permit | 2009/06/16 | 2010/03 | 2009/08/14 | 2010/01 | 2010/03 | 2010/05 |
| Begin of construction | 2010/04 | 2010/04 | 2009/08/25 | 2010/03/15 | 2010/03 | 2010/07 |
| Énd of construction | 2010/09 | 2010/09 | 2010/02 | 2010/11/15 | 2010/09 | 2010/12 |
| Begin of operation | 2010/09 | 2010/09 | 2010/03/01 | 2010/08 | 2010/09 | 2010/12 |

| | Pusztahencse | Kapuvár-Miklósmajor | Nagyszentjános | Bonyhád |
|---|---|---|---|---|
| ERU Estimation Assignment Carbon Manager | 02/2009 | 02/2009 | 02/2009 | 02/2009 |
| Investment implemented | 01/2010 | 06/10/2008 | 04/2010 | 28/11/2008 |
| Building permit | 08/2009 | 25/02/2008 | 26/09/2008 | 22/10/2009 |
| Begin of construction | 01/2010 | 06/10/2008 | 04/2010 | 15/09/2009 |
| Énd of construction | 08/2010 | 03/2010 | 09/2010 | 15/04/2010 |
| Begin of operation | 08/2010 | 03/2010 | 09/2010 | 31/05/2010 |

**Table 3: time schedule**

## 1.8 Crediting period

A seven year crediting period with an option to renew twice has been chosen which will start on:

**01/07/2010**

And will end on:

**30/06/2017**

This starting date takes place after registration of the projects as specified in the rules.

# 2. Technological and financial information

## 2.1 Description of the technology applied

The biogas production starts with collection of manure in the mixing tank. From there the digesters are continuously fed with manure and co-substrates. In the digesters methane bacteria metabolize the methane at a temperature of 40℃. The process is very complex and includes the sub steps hydrolysis, acidification, acetic acid generation, and methane generation. It is very vulnerable to temperature change and substrate composition. Result of this process is biogas with a methane content of ca. 60%.

The biogas will be collected under a double membrane top and directed from there to the CHP plant. The top can also serve as a gas storage. In the CHP the methane is combusted to produce electrical energy. The digestate will be moved to a post digester and finally to a digestate storage. Finally, it will be spread on the fields as fertilizer.

The technology of the projects is the same. The process schematic presented here (figure 5) is state of the art and already installed in hundreds of locations worldwide.

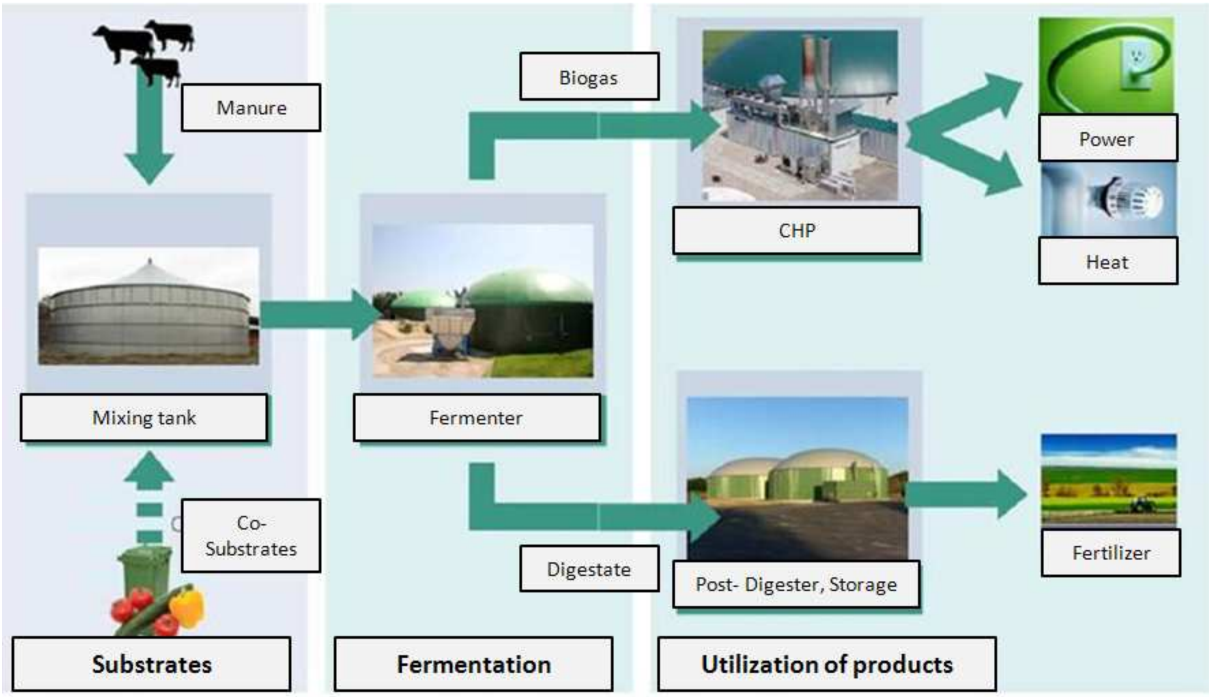


**Figure 12: Process of biogas production**

## 2.2 Financial plan of the project

Appendix I contains the detailed financial models for the installations. The currency is Forint.

**Investment costs and financing**

Investment costs can be divided into investments for infrastructure (mostly manure management) and the biogas plant itself. As the manual of Hungarian ministry for environment and water requires the calculation of the IRR with 100 % equity this also has been assumed in the financial model. The real structure of used capital is shown in the table below. This is a conservative approach because the actual costs of financing of the real projects are not included.

| | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse |
|---|---|---|---|---|---|---|
| Equity | 5% | 5% | 15% | 25% | 5% | 15% |
| Debt capital | 50% | 33,8% | 30% | 25% | 40% | 62% |
| Aid | 45% | 61,2% | 55% | 50% | 55% | 23% |

| | Pusztahencse | Kapuvár-Miklósmajor | Nagyszentjános | Bonyhád |
|---|---|---|---|---|
| Equity | 8% | 22% | 19% | 29% |
| Debt capital | 45% | 28% | 29% | 31% |
| Aid | 47% | 50% | 52% | 40% |

**Table 4: capital structure of investments**

The investment costs in terms of Forint per kWh of installed electric capacity vary strongly between the projects. This is due to different investment needs for modernization and construction of infrastructure.

Financing of the projects will be done by private equity, debt capital and incentives from EU program. It is planned to use loans of 40-55% of the investment sum. The incentives from the “new program for rural development in Hungary“ are supposed to help building up numerous additional capacities. The program focuses on the treatment of manure and capacities between 250 kW – 3 MW. EU incentives are non back payable grants from the EMVA program. They depend on the number of Livestock units (LU).

### Revenues

The only source of annual revenues is the feed-in tariff for the produced electricity. Full load operating hours are expected to be 7.000 only. A biogas plant of the planned type may have a mean value of full load operating hours of 7.500 h in Germany. But in Hungary one has to take into account that the feed-in tariff varies during the day. The project operator will try to avoid to feed-in electricity during times of low tariff which is not covering costs. Therefore a better statistics of full load operation hours could be the one from Switzerland, where time-dependent feed-in tariffs have been paid until 2009. There the mean value of full load operation hours was 6.200 h (see statistics for 2008 on www.naturemade.ch).

| Daytime | Begin-End of Tariff | Hours/day [h] | Tariff [Forint/kWh] | Average [Forint/kWh] |
|---|---|---|---|---|
| Peak | *06:00 – 22:00* | 16 | **30,00** | **26,62** |
| Valley | *22:00 – 01:30 and*<br>*05:00 – 06:00* | 4,5 | **27,60** | |
| Deep valley | *01:30 – 05:00* | 3,5 | **9,90** | |

**Table 5: structure of feed-in tariff in Hungary**

**Expenses**

Annual expenses contain costs for employees (administration and operation), maintenance (divided in maintenance for CHP and the rest of the plant), substrate costs, analysis and insurance. Every facility needs two qualified employees working in shifts to ensure daily feeding and maintenance of the plants. There is an increased need of personnel considered during the time of harvest.

**Taxes**

Taxes are calculated with 25% of the estimated annual net operating results.

# 3. Baseline Study

The baseline represents the most plausible scenario in absence of the project activity and is the base to calculate the emissions that are expected in this scenario. To determine the baseline, a project specific approach is chosen.

The „Guidance on criteria for baseline setting„ allows for this approach the usage of a CDM Methodology or the creation of an own baseline in accordance with the requirements of Appendix B of the JI Guidelines. If the choice is to create an own baseline the complete or partially usage of approved CDM Methodologies that are in compliance with the project activity is allowed. It is also allowed to use the simplified small scale methodologies if they apply, which is the case here. The project activity is segmented in three parts as shown in the table below:

| Project activity | | Baseline scenario | Baseline source |
|---|---|---|---|
| A) | Methane reduction from manure management | Lagoon for storage of manure | own |
| B) | Carbon dioxode Reduction from replacement of fossil fuel heating systems | Natural gas heating | AMS-I.C |
| C) | Reduction of Carbon Dioxode and Nitrogen from substitution of artificial fertilizer | Production of artificial fertilizer | own |

**Table 6: Baseline scenario**

For project activity part A) an own adapted methodology based on AMS-III.D was used.This has already been practiced and accepted in European countries like Switzerland and France. This own methodology is appropriate to specific European circumstances.

For project activity part B) this document follows the approved CDM Methodology: AMS-I.C. Thermal energy production with or without electricity.

For project activity part C) there is no approved methodology yet. Thus a new approach was developed. The main three ingredients of fertilizers are nitrogen, phosphor and potash. Because of possible assignment problems with the mining of phosphor and potash the new approach will cover the substitution of nitrogen only.

### Identification of the baseline

To identify the baseline alternatives are developed for every project part A,B and C and checked for plausibility. Not only the isolated alternatives but also possible combinations of them are considered. The aim is to show which baseline represents the most plausible scenario.

### Manure Management

A lagoon is considered as the baseline activity (no cross, table 3). As an alternative the usage of earth basins would appear, because their usage is much cheaper. But due to legal reasons[1] earth basins are not allowed anymore in Hungary. Combinations 1-3 in Table 7 can therefore be excluded from further considerations.

### Production of renewable thermal energy

Besides the utilization of heat from CHP, as in the case of the project activity, the heat can also be generated from other renewable sources like a wood oven. Usage of a system with fossil fuels (new or old installation) is the minimum activity (no cross). Investment costs for wood heating systems are higher than for a conventional. Because installation of a new (renewable) heating system is not obligatory by legal reasons and also not necessary from a technical point of view (expected rest lifetime is at least 15 years) the investment is very unlikely.

### Natural fertilizer

Status quo is the usage of manure for fertilizing and the additional purchase of artificial fertilizer. The digestate reduces the demand for artificial fertilizer. The possibilities for reducing the demand without project activity are very limited. It would be possible to buy manure from other farms, which is rarely possible due to a lack of choice. It would also cause leakage effects because the other farms would eventually have an increased demand for artificial fertilizer. The reduced usage of fertilizer is not plausible because for the same productivity of the farms, at least the same amount of fertilizer is needed. Therefore combinations 5+6 can be excluded. Combination 3 is excluded due to legal reasons as mentioned above.

The following table shows the possible combinations of activities. In brackets are the alternative activities.

[1] 59/2008. (IV. 29.) FVM rendelet (vizek mezőgazdasági eredetű nitrátszennyezéssel szembeni védelméhez szükséges cselekvési program részletes szabályairól)

| Scenario | A) **Other Manure Management System (earth basins)** | B) **Production of renewable energy (example: wood heating system)** | C) **Natural Fertilizer (example: Buy from other farms)** |
|---|---|---|---|
| **No activity** | | | |
| **1** | X | | |
| **2** | X | X | |
| **3** | X | | X |
| **4** | | X | |
| **5** | | X | X |
| **6** | | | X |
| **Project activity** | X | X | X |

**Table 7: Alternative scenarios**

It is shown, that the most plausible scenario is no activity at all (apart from the legally required lagoons). The identified baseline scenario does equal the determined.

The baseline scenario is legally valid (legal additionality), the environmental and financial additionality is covered below.

## Project Boundary

The project boundary has to include all significant anthropogenic sources of greenhouse gases that are influenced by the project activity.

The criterion for significance is a share of at least 1% of the baseline emissions or an amount of 2.000 t $CO_2$e depending on which value is lower.

Project boundary of project activity part A) is the site of the livestock and manure generation and management, including the facilities which capture and use the methane.

Project boundary project activity part B) is defined in AMS-I.C as

*„The physical, geographical site of the project equipment producing the renewable energy delineates the project boundary. The boundary also extends to the industrial, commercial or residential facility, or facilities, consuming energy generated by the system and the processes or equipment that is affected by the project activity."*

The project boundary of project activity part C) is defined as follows: because the substitution of natural fertilizer is taken into account, the production site is within the project boundary. It must be located in Hungary though. Emission reductions from part C) of projects, where this is not the case, are not considered in the emission reduction calculations.

The project boundary therefore covers the geographic, physical location of the livestock and the manure management as well as the biogas plant and the production site of artificial fertilizer.

| Sources of greenhousegas emissions | Emissions without project activity | Project emissions |
|---|---|---|
| Manure management | CH4 emissions from manure storage | CH4 emissions from handling and combustion of biogas CO2 Emissions from consumption of electric energy |
| Heating system with fossil fuels | CO2 emissions from combustion of fossil fuels | CO2 Emissions from transport of biomass |
| Production of Nitrogen for artificial fertilizer | CO2 und N emissions from production of artificial fertilizer | none |

**Table 8 Project boundary**

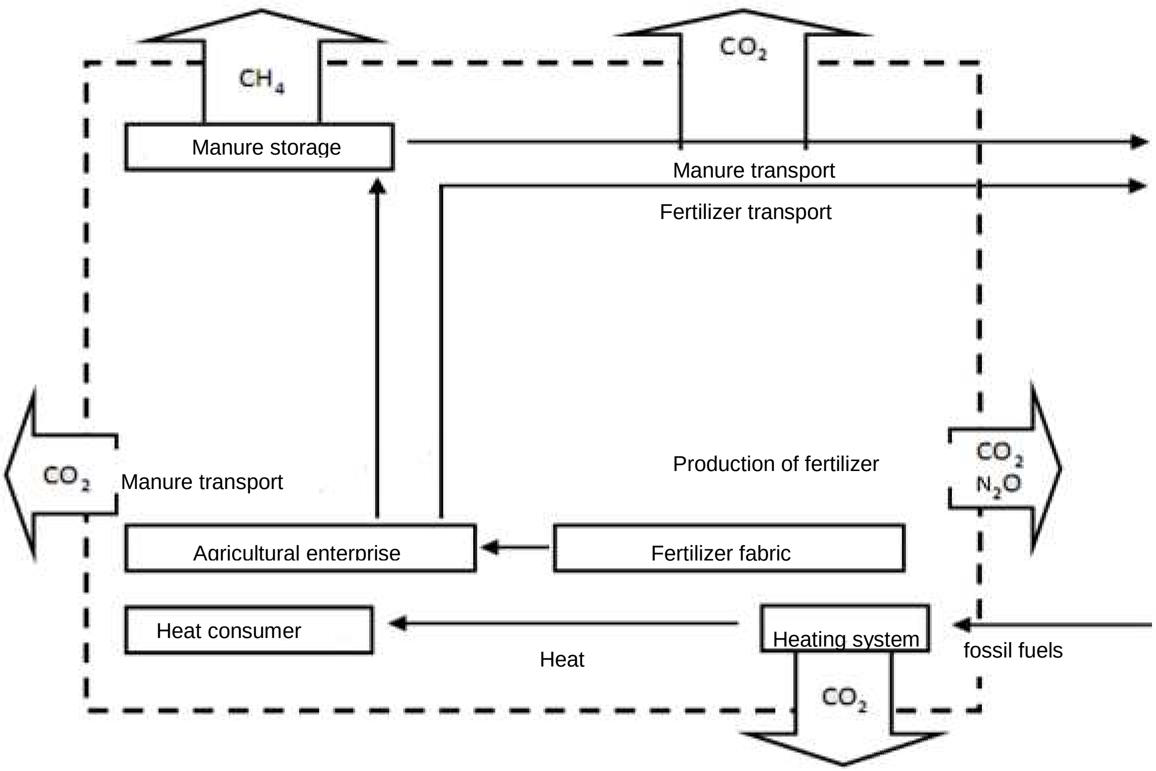

**Figure 13: project boundary of baseline scenario**

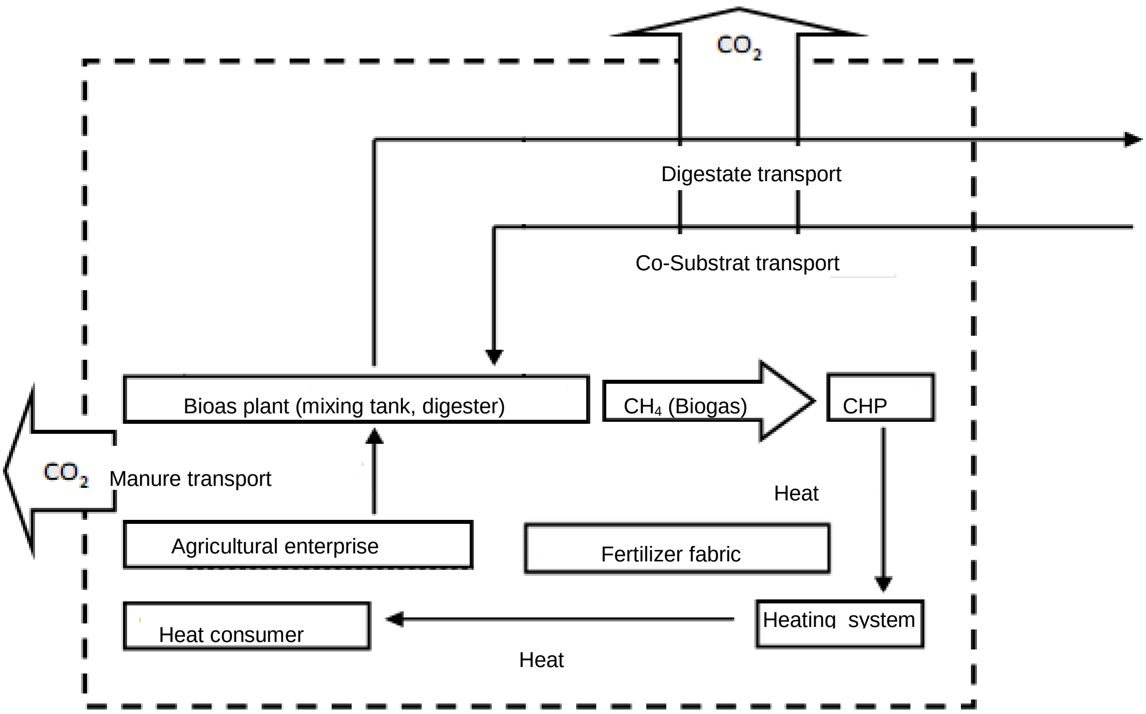


**Figure 14: project boundary of project scenario**

## 3.1 Additionality

### 3.1.1 Analysis of Reference

To prove the additionality the manual of the Hungarian ministry for environment and water was used[2]. It recommends the calculation of the internal rate of return (IRR) as a benchmark for the financial additionality. An IRR below 8% means the *mild criterion* of additionality is fulfilled an IRR under 0% fulfills the *sharp criterion*. The calculation shall be performed with 100% equity assumed and without depreciations and inflation. The following formula is given from the manual:

$$\sum_{\boldsymbol{i=0}}^{\boldsymbol{n}} \frac{(-\boldsymbol{Bi} + \text{Á}\boldsymbol{i} - \boldsymbol{Ki} + \boldsymbol{Mi})}{(\mathbf{1} + \boldsymbol{IRR})^{\boldsymbol{i}}}$$

[2] ÚTMUTATÓ AZ EGYÜTTES VÉGREHAJTÁSI PROJEKTEK ADDICIONALITÁSÁNAK ELLEN-ŐRZÉSÉHEZ ÉS AZ ENERGETIKAI PROJEKTEK ALAPVONAL KIBOCSÁTÁSAINAK MEGHATÁROZÁSÁHOZ (see Appendix V)

| | |
|---|---|
| n = m + z | m is the time of project implementation, z the total lifetime |
| $B_i$ | investment costs in the year i |
| $Á_i$ | revenues in year i |
| $K_i$ | total operation and maintenance costs |
| $M_i$ | remaining value of the equipment in year i. Remaining value shall reflect market value. $M_i$=0 except in the last year |
| IRR | internal rate of return |

A total lifetime of 20 years was expected. The loss of value and the remaining value at the end of the lifetime was calculated by using a linear depreciation rate of 5% which is between the rates obligatory in Hungary for depreciation of buildings (2%) and machinery (14,5%)[3].

This calculation is a conservative approach because costs of financing have increased caused by the financial crisis. In the time the projects were looking for financing the interest of bank loans were above 10%. The calculations with the specifications of the manual lead to the IRRs shown in Table 8.

| | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | Pusztahencse | Kapuvár-Miklósmajor | Nagyszentjános | Bonyhád |
|---|---|---|---|---|---|---|---|---|---|---|
| IRR normally | 7,34 | -3,92 | 3,22 | -0,60 | 0,48 | 5,88 | 6,23 | 7,49 | 7,56 | 5,55 |
| IRR as JI project | 14,7 | 3,63 | 7,73 | 2,11 | 7,57 | 11,04 | 9,45 | 14,49 | 15,5 | 14,92 |

**Table 9: IRR of the projects**

The figures in the table show that all projects have an IRR below 8% und therefore fulfill the mild criterion of additionality. It also shows that the approval as a JI project and the transfer of ERUs is suitable to make the projects more economical feasible.

### 3.1.2 Common practice

In Hungary biogas technology is funded by feed-in tariffs and a mandatory purchase of the energy by the electric companies. But the tariffs are too small to encourage farmers to invest in Biogas plants. The expected revenue is too small compared to the high risks and investment costs. A presentation of MT-Biogas which is added as Appendix IV, shows the point of view of a company with reputation and experience in the young Hungarian biogas sector. The project developers indicate that in Hungary the difference between the costs of energy production and the revenues from selling the energy is very small. The tariff also depends on the daytime, making it necessary to feed in electricity during certain times. This results in the need for bigger gas storages as usual.

The number of running biogas plants in Hungary proves this point. In the end of 2008 only half a dozen Biogas plants existed. Most of them are neither technical nor economical

[3] German industry and commercial chamber:http://www.ulm.ihk24.de/produktmarken/international/Kompetenzzentrum/Laenderinformationen/Ungarn/Zoll,_Wirtschaftsrecht,_Steuern/Ungarn_senkt_weiter_die_Steuer.jsp

comparable to the ones in the project activity.[4] Until now (end of 2009) only a few model plants exist which produce a notable amount of biogas. For example the biogas plant in Palhalma that was implemented as a JI project.

The plants in this bundle have a much lower electric capacity (500 – 800 kW) and use manure (which has little solid mass). Those agricultural plants are not comparable to industrial biogas plants aiming for maximum energy production rather than for emission reduction. They also do not have the financial background of big energy companies or even the state of Hungary, like Palhalma, which is run by a state owned company. For common agricultural enterprises such an investment bears big financial risks as described above. The structure of the feed-In tariff favors big scale plants because of the missing size staggering.

Actually some projects that have a comparable size and technology and were not implemented as JI projects already got in financial troubles, like the biogas plant in Klárafalva. Those examples show the economical risks that biogas plants in Hungary, and especially small ones, face in practice.

Finally the common practice of farmers is to keep the actual situation unchanged. Without the additional financial incentive of emission reductions, farmers will not change the manure storage in the lagoons and continue not caring about the corresponding methane emissions.

[4] Article in „Germany Trade and Invest“ (german) : http://www.gtai.de/ext/Einzelsicht-Druck/DE/Content/__SharedDocs/Links-Einzeldokumente-Datenbanken/fachdokument,templateId=renderPrint/MKT200908138002.html

# 4 Emission reduction

For each of the three parts of the project (A, B and C) the baseline emission, project emission and emission reductions are calculated. The used formula and the calculated results are shown in this document while detailed calculations and sources and reference of values can be found in Appendix III.

## 4.1 Reduction of methane emissions from manure management

### 4.1.1 Baseline emissions

The baseline scenario is the aerobically rotting of animal manure and the leakage of methane into the atmosphere. The emissions from the baseline scenario are calculated by the following formula:

$$BE_{A,y} = GWP_{CH4} * D_{CH4} * UF_b * \sum_{j,LT} MCFj * B_{0,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{Bl,j}$$

| | |
|---|---|
| $BE_y$ | Baseline Emissions of part A in the year y (t $CO_2e$) |
| $GWP_{CH4}$ | Global Warming Potential of CH4 (21) |
| $D_{CH4}$ | Density of CH4 (0,00067 t/m³ at room temperature (20 °C) and 1 atm pressure) |
| $UF_b$ | Correction factor to equal model uncertainties (0,94) |
| $j$ | manure management system |
| $MCF_j$ | annual methane conversion factor (MCF) for manure management system j |
| $LT$ | Livestock (cattle, swine, breeding pig, poultry) |
| $B_{0,LT}$ | Maximum Methane production potential of organic solids for livestock „LT“ (m³ $CH_4$/kg dm) |
| $N_{LT,y}$ | Annual average number of animals of livestock „LT“ in the year y |
| $VS_{LT,y}$ | Organic volatile solids of livestock "LT" that is brought in the manure management system in the year y (dry matter, kg dm/head/year) |
| $MS\%_{Bl,j}$ | Fraction of manure in the manure management system j |

For calves the values of cattle are multiplied with a factor of 0,4 which equals the relation of Livestock units of cattle:calve 1:0,4. Emissions from manure treatment in the baseline scenario are shown in table 9:

| $BE_{A,y}$ [$tCO_{2e}$] | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| 2010 | 4.357 | 4.337 | 8.930 | 3.058 | 3.763 | 1.937 | 26.382 |
| 2011 onwards | 17.427 | 17.348 | 11.907 | 9.175 | 15.050 | 23.242 | **94.149** |
| $BE_{A,y}$ [$tCO_{2e}$] | **Pusztahencse** | **Kapuvár-Miklósmajor** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| 2010 | 1.935 | 3.370 | 2.138 | 9.726 | | | **17.170** |
| 2011 onwards | 5.806 | 4.494 | 8.552 | 19.452 | | | **38.304** |

**Table 10: Baseline emissions manure management**

### 4.1.2 Project emissions

Project emissions are given by:

- The Methane leakage from the manure management system during production, collection and transport until the point of utilization
- Emissions from combustion or flaring
- Emissions from utilization of fossil fuels or the electric energy from the operation of the plant

$$PE_{A,y} = PE_{PL,y} + PE_{flare,y} + PE_{power,y}$$

| | |
|---|---|
| $PE_y$ | project emissions from project part A in the year y (t $CO_2$e) |
| $PE_{PL,y}$ | Emissions from physical leakage of methane in the year y (t $CO_2$e) |
| $PE_{flare,y}$ | Emissions from combustion or flaring of biogas y (t $CO_2$e) |
| $PE_{power,y}$ | CO2 Emissions from utilization of fossil fuels or the electric energy from the operation of the plant (t $CO_2$e) |

**Physical leakage**

Project emissions from physical leakage during production, collection and transport of biogas to the point of flaring/combustion can be calculated using the following formula:

$$PE_{PL,y} = GWP_{CH4} * D_{CH4} * PLF_y * \sum_{j,LT} B_{0,LT} * N_{LT,y} * VS_{LT,y} * MS\%_{Bl,j}$$

| | |
|---|---|
| $PLF_y$ | physical leakage factor in the year y [%] |
| $MS\%_{i,y}$ | Fraction of manure used in manure management system i in the year y. |

For the ex-ante calculation a value for PLF of 3% is estimated. We propose a restrictive monitoring plan to prove the supposed project leakage factor, by measuring this value by an independent external service during project operation.

| PEpl [$tCO_{2e}$] | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| 2010 | 168 | 188 | 342 | 141 | 155 | 73 | **1.068** |
| 2011 onwards | 674 | 752 | 457 | 424 | 619 | 877 | **3.801** |
| PEpl [$tCO_{2e}$] | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | |
| 2010 | 75 | 144 | 87 | 359 | | | **664** |
| 2011 onwards | 224 | 192 | 349 | 717 | | | **1.482** |

**Table 11: project emissions from physical leakage**

**Emissions from flaring + incomplete methane combustion**

To calculate emissions from the combustion of biogas in the flare the „Tool to determine project emissions from flaring gases containing methane“ is used. It contains the following formula for project emissions from flaring:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} * (1 - \boldsymbol{\eta}_{flare,h}) * GWP_{CH4} /1000$$

| | |
|---|---|
| $PE_{flare,y}$ | Emissions from flaring of biogas in the year y (t $CO_2e$) |
| $TM_{RG,h}$ | Mass flow of methane in the rest gas in hour h ($m^3/h$) |
| $\eta_{flare,h}$ | Efficiency of the flare in hour h (%) |
| $GWP_{CH4}$ | Global Warming Potential of methane valid for the crediting period. (t CO2e/t CH4) |

As a conservative assumption, mass flow in the time of flare operation is estimated the same as in time of CHP operation. This means the calculation was done as if the gas used in the flare is not residual gas but biogas.

In the calculation, 7.500 hours of operation are assumed, deviant from the 7.000 hours in the financial model. This is because the non-operating hours are thought to save gas during the hours of low feed-in tariffs. The 1.260 hours here is the estimated time when biogas cannot be combusted in the CHP nor saved in the storage.

Project Emissions from flaring account for less than 1% of total emission reduction and must not be considered:

| $PE_{flare}$ [$tCO_{2e}$] | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| 2010 | 8 | 10 | 37 | 11 | 7 | 5 | **78** |
| 2011-től | 33 | 42 | 49 | 32 | 29 | 62 | **247** |
| percent of emission reduction [%] | 0,19 | 0,25 | 0,38 | 0.36 | 0.18 | 0.24 | |
| $PE_{flare}$ [$tCO_{2e}$] | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| 2010 | 12 | 13 | 6 | 24 | | | **54** |
| 2011-től | 37 | 17 | 22 | 47 | | | **124** |
| percent of emission reduction [%] | 0,7 | 0,26 | 0,27 | 0,23 | | | |

**Table 12:project emissions from flaring**

## <u>Emissions from the utilization of electric energy from the grid or fossil fuels</u>

Hungarian authorities will not grant certificates from the generation of electric energy from renewable sources [5].

It is estimated that the project activity will have a demand of electricity that counts about 10% of the electric energy produced and fed into the grid. Therefore showing the electricity production shows a significant positive balance. The amount of energy produced will be monitored though to prove this statement during project operation.

A subtraction of an emission, calculated by electricity consumption of the plant would not represent the real project activity, as there are no additional emissions caused by this consumption.

### 4.1.3 Leakage

[5] E-Mail Correspondence 03.03.2009 (see Appendix VI)

No Leakage effects are expected

### Emission reduction from manure treatment

If baseline emissions, project emissions and leakage are known, the following formula can be used to calculate emission reductions from part A of the project activity.

$$ER_{A,y} = BE_{A,y} - PE_{A,y} - LE_{A,y}$$

| | |
|---|---|
| $ER_{A,y}$ | Emission reduction of part A in the year y ($tCO_2e$) |
| $BE_{A,y}$ | Baseline emissions of part A in the year y ($tCO_2e$) |
| $PE_{A,y}$ | Project emissions of part A in the year y ($tCO_2e$) |
| $LE_{A,y}$ | Leakage emissions of part A in the year y (here 0 $tCO_2e$) |

| $ER_{fA,y}$ 2010 | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| **Baseline [tCO2e]** | | | | | | | |
| Manure Management | 4.357 | 4.337 | 8.930 | 3.058 | 3.763 | 1.937 | **26.382** |
| **Project emission [tCO2e]** | | | | | | | |
| physical leakage | 168 | 188 | 342 | 141 | 155 | 73 | **1.068** |
| **Emission reduction [tCO2e]** | 4.188 | 4.149 | 8.588 | 2.917 | 3.608 | 1.864 | **25.314** |
| $ER_{fA,y}$ 2010 | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | |
| **Baseline [tCO2e]** | | | | | | | |
| Manure Management | 1.935 | 3.370 | 2.138 | 9.726 | | | **17.170** |
| **Project emission [tCO2e]** | | | | | | | |
| physical leakage | 84 | 144 | 87 | 359 | | | **1.511** |
| **Emission reduction [tCO2e]** | 1.851 | 3.227 | 2.051 | 9.368 | | | **15.659** |

**Table 13 emission reduction from manure management in 2010**

| $ER_{A,y}$ 2011 onwards | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | total |
|---|---|---|---|---|---|---|---|
| **Baseline [tCO2e]** | | | | | | | |
| Manure Management | 17.427 | 17.348 | 11.907 | 9.175 | 15.050 | 23.242 | **94.149** |
| **Proejct emissions [tCO2e]** | | | | | | | |
| physical leakage | 674 | 752 | 457 | 424 | 619 | 877 | **3.801** |
| **Emission reduction [tCO2e]** | 16.753 | 16.597 | 11.450 | 5.319 | 14.432 | 22.365 | **90.348** |
| $ER_{A,y}$ 2011 onwards | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | |
| **Baseline [tCO2e]** | | | | | | | |
| Manure Management | 5.806 | 4.494 | 8.552 | 19.452 | | | **38.304** |
| **Proejct emissions [tCO2e]** | | | | | | | |
| physical leakage | 253 | 192 | 349 | 717 | | | **1.511** |
| **Emission reduction [tCO2e]** | 5.552 | 4.302 | 8.203 | 18.735 | | | **36.793** |

**Table 14: emission reduction from manure management 2011 onwards**

## 4.2 Production of thermal energy

The methodology "AMS I.C. Thermal energy production with or without electricity" in the version 15 of 17. July 2009 will be used. The corresponding scenario for baseline emissions is found under paragraph 12 (a) „electricity is imported from the grid and thermal energy (steam/heat) is produced using fossil fuels"

### 4.2.1 Baseline emissions

The formula to calculate baseline emissions of the production of thermal energy by using fossil fuels is:

$$BE_{B,y} = \frac{EG_{thermal,y}}{\eta_{BL,thermal}} * EF_{FF,CO2}$$

| | |
|---|---|
| $BE_{B,y}$ | Baseline Emissions of fossil heat replaced by project acitvity in the year y[t $CO_2$e] |
| $EG_{thermal,y}$ | Net heat supplied by project activity in year y. [TJ] |
| $\eta_{BL,thermal}$ | Efficiency of fossil fuel based system in absence of project activity in year y [%] |
| $EF_{FF,CO2}$ | $CO_2$ Emission factor of fossil fuel in the baseline scenario [t $CO_2$ / TJ] |

The nearby farms of most projects had natural gas heating systems to produce heat, some used propane-butane gas. Using the above formula the baseline emissions are shown in table 13:

| $BE_{B,y}$ [$tCO_{2e}$] | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | total |
|---|---|---|---|---|---|---|---|
| 2010 | 19 | 970 | 524 | 20 | 15 | 299 | **975** |
| 2011 onwards | 76 | 389 | 698 | 61 | 61 | 1.197 | **2.482** |
| $BE_{B,y}$ [$tCO_{2e}$] | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | |
| 2010 | 20 | 30 | - | 22 | | | **89** |
| 2011 onwards | 59 | 40 | - | 45 | | | **244** |

**Table 15: Baseline emissions from heating with fossil fuels**

### 4.2.2 Project emissions

Project emissions according to the methodology cover:

- $CO_2$ emissions from collection, processing and transport of biomass to the location of the project activity
- $CO_2$ emissions from the consumption of electricity from the grid

**Transport emissions**

The main part of the substrates is manure which is led directly from the barns to the facilities. CO2 Emissions from transport of Co-Substrates account for less than 1% of emission reductions and are therefore not considered.

| PEtr [$tCO_{2e}$] | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **Összesen** |
|---|---|---|---|---|---|---|---|
| 2010 | 4 | 12 | 40 | 18 | 38 | 14 | **125** |
| percent of total ER | 0,10 | 0,28 | 0,41 | 0,93 | 0,96 | 0,63 | |
| 2011 onwards | 17 | 47 | 53 | 53 | 151 | 168 | **489** |
| percent of total ER | 0,10 | 0,28 | 0,41 | 0,93 | 0,96 | 0,63 | |
| PEtr [$tCO_{2e}$] | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | Összesen |
| 2010 | 3 | 6 | 17 | 87 | | | **114** |
| percent of total ER | 0,15 | 0,16 | 0,85 | 0,89 | | | |
| 2011-től | 10 | 8 | 69 | 175 | | | **262** |
| percent of total ER | 0,15 | 0,16 | 0,85 | 0,89 | | | |

**Table 16: project emissions of transport**

**Emissions from the consumption of electricity from the grid**

See chapter 4.1.2 of project emissions from manure treatment above.

### 4.2.3 Leakage

Leakage has to be considered if the equipment is taken from another activity or if the collection, processing and transport of biomass is outside project boundaries. Both is not the case here, the equipment is new and project boundaries contain collection, processing and transport of biomass.

### 4.2.4 Emission reduction from production of thermal energy

If Baseline Emissions, Project Emissions und Leakage are known, the total emission reduction can be calculated:

$$\boldsymbol{ER_{B,y} = BE_{B,y} - PE_{B,y} - LE_{B,y}}$$

| | |
|---|---|
| $ER_{B,y}$ | Emission reduction of activity B in the year y ($tCO_2e$) |
| $BE_{B,y}$ | Baseline emissions of activity B in the year y ($tCO_2e$) |
| $PE_{B,y}$ | Project emissions of activity B in the year y ($tCO_2e$) |
| $LE_{B,y}$ | Leakage emissions of activity B in the year y (here 0 |

| | |
|---|---|
| | $tCO_2e$) |

| $ER_{B,y}$ 2010 | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | total |
|---|---|---|---|---|---|---|---|
| **Baseline [tCO2e]** | | | | | | | |
| Substitution of fossil fuels | 19 | 97 | 524 | 20 | 15 | 299 | **975** |
| **Project emissions [tCO2e]** | | | | | | | |
| none | - | - | - | - | - | - | |
| **Emission reduction [tCO2e]** | 19 | 97 | 524 | 20 | 15 | 299 | **975** |
| $ER_{B,y}$ 2010 | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| **Baseline [tCO2e]** | | | | | | | |
| Substitution of fossil fuels | 20 | 30 | - | 22 | | | **72** |
| **Project emissions [tCO2e]** | | | | | | | |
| none | - | - | - | - | - | - | **-** |
| **Emission reduction [tCO2e]** | | | | | | | **72** |

**Table 17 emission reduction from substitution of fossil fuels 2010**

| $ER_{B,y}$ 2011 onwards | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | total |
|---|---|---|---|---|---|---|---|
| **Baseline [tCO2e]** | | | | | | | |
| Substitution fossil fuels | 76 | 389 | 698 | 61 | 61 | 1.197 | **2.482** |
| **Project emission [tCO2e]** | | | | | | | |
| none | - | - | - | - | - | - | |
| **Emission reduction [tCO2e]** | 76 | 389 | 698 | 61 | 61 | 1.197 | **2.482** |
| $ER_{B,y}$ 2011 onwards | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | |
| **Baseline [tCO2e]** | | | | | | | |
| Substitution fossil fuels | 59 | 40 | - | 45 | | | |
| **Project emission [tCO2e]** | | | | | | | |
| none | | | | | | | |
| **Emission reduction [tCO2e]** | 59 | 40 | - | 45 | | | |

**Table 18 emission reduction from substitution of fossil fuels 2011 onwards**

## 4.3 Substitution of fertilizer

### 4.3.1 Baseline emissions

Baseline emissions are determined by the amount of fertilizer that can be substituted and by the emission factor for the production. Only nitrogen fertilizer is considered. Difference between nitrogen in the untreated manure (baseline scenario) and nitrogen in the digestate of the project activity is the additional amount of nitrogen that can replace artificial fertilizer. The result of multiplying this amount with an emission factor for production of nitrogen fertilizer represents the avoided GHG emissions. The upper limit for the claimed substitution is the consumption of nitrogen fertilizer in the baseline scenario, as it is not possible to substitute more fertilizer than there was actually used. Consumption in the baseline is estimated to be as high as in the year before the project activity. The amount of artificial nitrogen is calculated by the amount of the certain products multiplied with their nitrogen content. The following formula has been elaborated to calculate the baseline emissions with the above considerations:

$$\boldsymbol{BE_{C,y} = min\left[\left(G_y * GN_y - MB_{manure,y} * MSN_y\right), \left(F_{i,y} * FSN_{i,y}\right)\right] * NFEF_y}$$

| | |
|---|---|
| $G_y$ | Amount of digestate in year y (t) |
| $GN_y$ | Fraction of nitrogen in digestate in year y (%) |
| $MB_{manure\ y}$ | Amount of manure in the baseline scenario in year y (t) |
| $MSN_y$ | Fraction of nitrogen in the manure in year y (%) |
| $NFEF_y$ | Emission factor of production of nitrogen for fertilizer (t CO2e / t N) |
| $NF_y$ | Amount of nitrogen in artificial fertilizer (t) |
| $F_{i,y}$ | Amount of fertilizer of type i in the year y (t) |
| $FSN_{i,y}$ | Fraction of nitrogen in fertilizer i in year y (%) |

The calculation results in a Baseline emission of:

| $BE_{C,y}$ [$tCO_{2e}$] | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | sum |
|---|---|---|---|---|---|---|---|
| 2010 | 40 | - | 557 | 122 | 371 | 180 | **1.270** |
| 2011 onwards | 160 | - | 743 | 365 | 1.485 | 2.156 | **4.909** |

| $BE_{C,y}$ [$tCO_{2e}$] | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| 2010 | 40 | - | 557 | 122 | 290 | 58 | **1.067** |
| 2011 onwards | 160 | - | 743 | 365 | 1.162 | 696 | **3.125** |
| $BE_{C,y}$ [$tCO_{2e}$] | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | |
| 2010 | 184 | 676 | - | 393 | | | **1.253** |
| 2011 onwards | 551 | 902 | - | 785 | | | **2.238** |

**Table 19: baseline emissions of fertilizer substitution**

### 4.3.2 Project emissions

Project emissions are those emissions that can be counted towards the production of the digestate. Those emissions are already covered in the parts A and B of the project activities above. The digestate needs no additional treatment that would cause emissions. It is supposed that the transport of digestate to spread it on the fields equals the transport of the manure and the artificial fertilizer in the baseline scenario. As the result $PE_{C,y} = 0$.

### 4.3.3 Leakage

Leakage must not be considered. The manure has been used as fertilizer before and thus no other emission reduction is avoided by the usage of the digestate.

### 4.3.4 Emission reduction from substitution of fertilizer

$$ER_{C,y} = BE_{C,y} - PE_{C,y} - LE_{C,y}$$

| | |
|---|---|
| $ER_{C,y}$ | Emission reduction of part C in the year y ($tCO_2e$) |
| $BE_{C,y}$ | Baseline emissions of part C in the year y ($tCO_2e$) |
| $PE_{C,y}$ | Project emissions of part C in the year y ($tCO_2e$) |
| $LE_{C,y}$ | Leakage emissions of part C in the year y (here 0 $tCO_2e$) |

| $ER_{C,y}$ 2010 | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| **Baseline [tCO2e]** | | | | | | | |
| Substitution Nitrogen fertilizer | 40 | - | 557 | 122 | 290 | 58 | **1.067** |
| **Project emission [tCO2e]** | | | | | | | |
| none | - | - | - | - | - | - | |
| **Emission reduction [tCO2e]** | 40 | - | 557 | 122 | 290 | 58 | **1.067** |
| $ER_{C,y}$ 2010 | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| **Alapvonal [tCO2e]** | | | | | | | |
| Substitution Nitrogen fertilizer | 184 | 676 | - | 393 | | | **1.253** |
| **Project emission [tCO2e]** | | | | | | | |
| none | - | - | - | - | | | |
| **Emission reduction [tCO2e]** | 184 | 676 | - | 393 | | | **1.253** |

**Table 20: emission reduction from fertilizer substitution 2010**

| $ER_{C,y}$ 2011-től | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | total |
|---|---|---|---|---|---|---|---|
| **Baseline [tCO2e]** | | | | | | | |
| Substitution Nitrogen fertilizer | 160 | - | 743 | **365** | **1.162** | **696** | **3.125** |
| **Project emission [tCO2e]** | | | | | | | |
| none | - | - | - | **-** | **-** | **-** | **-** |
| **Emission reduction [tCO2e]** | 160 | - | 743 | **365** | **1.162** | **696** | **3.125** |
| $ER_{C,y}$ 2011-től | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| **Baseline [tCO2e]** | | | | | | | |
| Substitution Nitrogen fertilizer | 551 | 902 | - | 785 | | | **2.238** |
| **Project emission [tCO2e]** | - | - | - | **-** | | | |
| none | | | | | | | |
| **Emission reduction [tCO2e]** | 551 | 902 | - | 785 | | | **2.238** |

**Table 21: emission reduction from fertilizer substitution 2011 onwards**

## 4.4 Total emissions reductions

Total emissions reductions equal the sum of emission reductions from the three project activity parts A,B and C.

$$ER_{tot,y} = ER_{A,y} + ER_{B,y} + ER_{C,y}$$

| **2010** | **Bicsérd** | **Tiszaszentimre** | **Kaposszekcső** | **Bugyi** | **Kisbér** | **Nagyrécse** | **total** |
|---|---|---|---|---|---|---|---|
| $ER_{A,y}$ | 4.188 | 4.149 | 8.588 | 2.917 | 3.608 | 1.864 | **25.314** |
| $ER_{B,y}$ | 19 | 97 | 524 | 20 | 15 | 299 | **975** |
| $ER_{C,y}$ | 40 | - | 557 | 122 | 371 | 180 | **1.270** |
| | 4.247 | 4.246 | 9.668 | 3.059 | 3.994 | 2.143 | **27.365** |
| | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| $ER_{A,y}$ | 1.851 | 3.227 | 2.051 | 9.368 | | | **16.496** |
| $ER_{B,y}$ | 20 | 30 | - | 22 | | | **72** |
| $ER_{C,y}$ | 184 | 676 | - | 393 | | | **1.253** |
| | 2.054 | 3.933 | 2.051 | 9.782 | | | **17.821** |

**Table 22:Total emission reduction 2010**

| 2011 onwards | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse | total |
|---|---|---|---|---|---|---|---|
| $ER_{A,y}$ | 16.753 | 16.597 | 11.450 | 8.752 | 14.432 | 22.365 | **90.348** |
| $ER_{B,y}$ | 76 | 389 | 698 | 61 | 61 | 1.197 | **2.482** |
| $ER_{C,y}$ | 160 | - | 743 | 365 | 1.162 | 696 | **3.125** |
| | 16,989 | 16.986 | 12.891 | 9.178 | 15.654 | 24.257 | **95.955** |
| | **Pusztahencse** | **Kapuvár** | **Nagyszentjános** | **Bonyhád** | | | **total** |
| $ER_{A,y}$ | 5.552 | 4.302 | 8.203 | 18.735 | | | **36.793** |
| $ER_{B,y}$ | 59 | 40 | - | 45 | | | **144** |
| $ER_{C,y}$ | 551 | 902 | - | 785 | | | **2.238** |
| | 6.163 | 5.244 | 8.203 | 19.565 | | | **39.175** |

**Table 23 Total emission reduction 2011 onwards**

| | **2010** (starting 01 July) | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** (ending 30 june) | **total** |
|---|---|---|---|---|---|---|---|---|---|
| **Bicsérd** | 4.247 | 16.989 | 16.989 | 16.989 | 16.989 | 16.989 | 16.989 | 12.742 | 118.925 |
| **Tiszaszentimre** | 4.246 | 16.986 | 16.986 | 16.986 | 16.986 | 16.986 | 16.986 | 12.739 | 118.900 |
| **Kaposszekcső** | 9.668 | 12.891 | 12.891 | 12.891 | 12.891 | 12.891 | 12.891 | 3.223 | 90.238 |
| **Bugyi** | 3.059 | 9.178 | 9.178 | 9.178 | 9.178 | 9.178 | 9.178 | 6.118 | 64.243 |
| **Kisbér** | 3.914 | 15.654 | 15.654 | 15.654 | 15.654 | 15.654 | 15.654 | 11.741 | 109.580 |
| **Nagyrécse** | 2.221 | 24.257 | 24.257 | 24.257 | 24.257 | 24.257 | 24.257 | 24.257 | 169.802 |
| **Pusztahencse** | 2.054 | 6.163 | 6.163 | 6.163 | 6.163 | 6.163 | 6.163 | 4.122 | 43.140 |
| **Kapuvár** | 3.933 | 5.244 | 5.244 | 5.244 | 5.244 | 5.244 | 5.244 | 1.311 | 36.711 |
| **Nagyszentjános** | 2.051 | 8.203 | 8.203 | 8.203 | 8.203 | 8.203 | 8.203 | 6.152 | 57.422 |
| **Bonyhád** | 9.782 | 19.565 | 19.565 | 19.565 | 19.565 | 19.565 | 19.565 | 9.782 | 136.953 |
| | **45.176** | **135.130** | **135.130** | **135.130** | **135.130** | **135.130** | **135.130** | **89.954** | **945.912** |

**Table 24: emission reduction over the first crediting period**

| ***source of emission*** | ***greenhouse gases*** | ***calculated/relevant*** | ***comment*** |
|---|---|---|---|
| Manure management | $CH_4$ | yes/yes | Main source of greenhouse gas emissions and focus of project activity. |
| Consumption of electric energy that was produced from | $CO_2$ | no/no | Avoidance of double aiding, climate protection effect is already promoted by feed-in tariff. |

| | | | |
|---|---|---|---|
| fossil fuels. | | | |
| Consumption of heat that was produced from fossil fuels. | $CO_2$ | yes/yes | The usage of heat from the CHP increases energy efficiency and climate protection effect. |
| Production of artificial fertilizer | $CO_2$, $N_2O$ | yes/yes | the demand for fertilizer is decreased by the amount of additional Nitrogen in the fertilizer. |

| ***source of emission*** | ***greenhouse gases*** | ***calculated/relevant*** | ***comment*** |
|---|---|---|---|
| physical leakage | $CH_4$ | yes/yes | Avoidane of methane leakage is a matter of ecological as well as economical operation. Will be monitored. |
| Combustion of Methane in the flare | $CH_4$ | yes/no | Runtime of flare is expected to be very low. High burning efficiency of the flare. |
| Transport of co-substrates and manure. | $CO_2$ | yes/no | Less than 1% of total emission reduction. |
| Consumption of electric energy produced from fossil fuels. (for own demand) | $CO_2$ | no/no | Energy balance of the plant is positive. Because the production is not considered the far lower consumption also is not considered. |

## 4.5 cost effectiveness of emissions reduction

To determine cost-effectiveness of emission reductions the investment costs were annualized using the capital recovery factor.

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

| | |
|---|---|
| i | opportunity costs |
| n | lifetime of the project |

The annualized investment costs plus the annual expenses were divided through the expected annual emission reductions. Result is the cost of reduction of one ton of $CO_2$

equivalent. Detailed calculations and assumptions can be seen in the appended spreadsheet III. As they allow inferences about confidential financial data only the results are shown in this document.

| | Bicsérd | Tiszaszentimre | Kaposszekcső | Bugyi | Kisbér | Nagyrécse |
|---|---|---|---|---|---|---|
| Reduction cost for 1 t CO2e [forint] | 8.293 | 10.886 | 16.347 | 13.479 | 10.871 | 10.922 |
| | Pusztahencse | Kapuvár | Nagyszentjános | Bonyhád | | |
| Reduction cost for 1 t CO2e [forint] | 37.196 | 18.073 | 13.886 | 13.346 | | |

**Table 25: costs of emission reduction**

Costs of emission reductions are rather low showing that the investment will efficiently reduce the emissions of GHG. It should also be considered that the project activity will not only reduce GHG emissions but also result in a variety of other benefits of different kinds (see chapter 7: impact assessment).

# 5 Determination Report

The determination report will be attached after the determination in appendix IX of this document.

# 6 Monitoring plan

The monitoring plan shows which parameters are necessary to calculate the actual annual emission reductions, based on measurements. The monitoring plan also shows how the measurements are performed and how the emissions reductions are calculated with the measurements.

**Monitoring part A (Methane recovery from manure management)**

The emission reduction is calculated with measurement of actual captured and combusted/flared biogas. Devices measuring this value have a very high accuracy in European biogas plants. Results will be cross checked with the amount of energy produced under consideration of the efficiency of the CHP. Because biogas plants in Europe receive their income from the compensation by feed in tariffs, these values are also of great importance for economics of the facility, so their exact measurement is state of the art.

$$ER_{A\,y,ex-post} = \left(MD_y - PE_{power,y,ex-post}\right)$$

| | |
|---|---|
| $ER_{A,y,ex\ Post}$ | Emission reduction from part A calculated ex-post ( t $CO_2$e) |
| $MD_y$ | Captured and combusted/flared methane from project activity in the year y ( t $CO_2$e) |
| $PE_{power,y,ex\ post}$ | Emissions from utilization of fossil fuels or electricity for the operation of the plant based on measured values, see table 26 (t$CO_2$e) |

Methane used in the project activity is calculated by:

$$MD_y = \left( BGP_y * MC_y - \sum_n BGCO_{n,y} * MCCO_{n,y} \right) * \ GWP_{CH4} * D_{CH4}$$

| | |
|---|---|
| $MD_y$ | Captured and converted methane from project activity in the year y ( t $CO_2$e) |
| $BGP_y$ | Amount of biogas that is flared or gainfully used in the year y (m³) |
| $MC_y$ | Average fraction of Methane in the biogas in year y (%) |
| $BGCO_{n,y}$ | Biogas production of Co-Substrates n in year y (m³) |
| $MCCO_{n,y}$ | Average fraction of Methane of Biogas from Co-Substrate n in year y (%) |

The measurement of physical leakage is necessary to determine physical leakage factor PLF. It is the relation between measured leaked CH4 (in t $CO_2$e) and the biogas at the CHP. The measurement will take place on one day, periodically and the measured leakage is estimated to be present during the whole time between the measurement, the last measurement and the monitoring report.

$$BGCO_{n,y} = MCOF_{n,y} * FCO_{n,y}$$

| | |
|---|---|
| $MCOF_{n,y}$ | Amount of Co-Substrates n in year y (t) |
| $FCO_{n,y}$ | Biogas production from Co-Substrate n in year y (m³/t FM) |

Measurement of physical leakage is necessary to determine physical leakage factor PLF.
It's the relation between measured leaked CH4 (in t $CO_2$e) and the Biogas at the CHP.

$$PLF_y = \frac{PL_y}{BGP_y * 0{,}01}$$

| | |
|---|---|
| $PLF_y$ | physical leakage factor in the year y [%] |
| $PL_y$ | physical leakage measured in the year y [t$CO_2$e] |

The cross check of emission reductions will be perfomed by the following equation:

$$ER_{A\ y,ex-post} = \ GWP_{CH4} * \frac{\frac{EG_{elec}}{\eta_{CHP}}}{10\ kWh/m^3} * 0{,}00067\ t/m^3$$

| | |
|---|---|
| $EG_{elec,y}$ | Net supplied electricity by project activity in year y |
| $\eta_{CHP}$ | Electric efficiency of the CHP (manufacturer specification) |

### Monitoring part B (Thermal energy production)

For Monitoring the $CO_2$ neutral substitution of fossil fuels for the generation of thermal energy a possible change of the heating system must be considered. If the heating consumer would change to a system with renewable fuels, the claimable emission reductions would equal zero. This is not expected for the next 15-20 years of rest lifetime though.

$$ER_{B\,y,ex-post} = \sum_{m} TEP_{m,y} * EF_{CO2-m}$$

| | |
|---|---|
| $TEP_{m,y}$ | Thermal energy used by heat consumer to substitute fossil fuel m in the year y (TJ) |
| $EF_{CO2-m}$ | Emissions factor of fossil fuel m (t $CO_2$e /TJ) |

### Monitoring part C (Artificial Fertilizer Substitution)

The substitution potential of the digestate is the difference between the amount of nitrogen in the manure and in the digestate. It is limited by the use of fertilizer before project activity, because not more Fertilizer can be substituted than was actually used.

Emission reductions ex-post are then calculated as following :

$$ER_{C\,y,ex-post} = min\left[\left(G_y * GN_y - MB_{manure,y} * MSN_y\right), \left(F_{i,y} * FSN_{i,y}\right)\right] * NFEF_y$$

| | |
|---|---|
| $G_y$ | Amount of digestate in year y (t) |
| $GN_y$ | Nitrogen amount of digestate in the year y (%) - measured |
| $M_{manure\ y}$ | Amount of manure in the year y(t) |
| $MSN_y$ | Nitrogen fraction in manure (%) - measured |
| $NFEF_y$ | Emission factor of Nitrogen production (t CO2e / t N) |
| $F_{i,y}$ | Amount of fertilizer i in the year y (t) |
| $FSN_{i,y}$ | Fraction of Nitrogen (%) |

## 6.1 Measured data

| Parameter | Unit | Description | Instrument of measurement | Recording | Measuring process | maintainance / calibration | Precision | Intervall | Comment |
|---|---|---|---|---|---|---|---|---|---|
| $M_{manure,y}$ | t | Amount of manure in the digester | weighing plattform / flow meter | Digital or analog weighing plattform | Trucks drive on the plattform empty and loaded. Difference is weight of the manure. Internal manure will be measured with a flow meter | Weighing systems in this scale are very robust. Annual Check | >99% | at delivery | |
| $M_{co\text{-}ferment,i,y}$ | t | Amount of co-substrates of type i in the digester | weighing plattform | Digital or analog weighing plattform | Trucks drive on the plattform empty and loaded. Difference is weight of the Co-Substrate. | Weighing systems in this scale are very robust. Annual Check | >99% | at delivery | |
| $PL_y$ | tCO2e | Methane leakage of the plant | external measurement service | external measurement service | external measurement service measures the methane leakage after state of the art | will be performed by external measurement service | not applicable | annual | measured to calculate PLFy |
| $MC_y$ | % | Fraction of methane in the biogas | gas analysator | digital | Gas analysator in front of CHP/flare measures the gas composition | maintainance / calibration after manufacturers specification | >99% | continiously | Gas analysis of CH4, H2S, O2 |
| $BGP_y$ | m³ | Biogas amount before CHP | gas flow meter | digital | A gas flow meter will measure the amount of biogas before the CHP/flare automatically | No calibration neccessary but annual maintainance | > 99% | continiously | |
| $EG_{thermal,y}$ | TJ | Net supplied heat by project activity in year y | heat meter | digital | A heat meter continously measures the heat produced by the CHP | regularly maintainance, calibration as needed | > 99% | continiously | |
| $EG_{elec,y}$ | MWh | Net supplied electricity by project activity in year y | electric meter | digital | A heat meter continously measures the electricity produced by the CHP | Owned by the grid operator | > 99% | continiously | will be used für invoicing as well |
| $FC_{i,i}$ | Mass or Volume | Amount of fuel "i" in the year y | invoices | manual | Fossil fuels will be bought externally. The amount is proven by invoices | not applicable | not applicable | at delivery of the fuels | |
| $TR_y$ | # | Number of biomass transports in year y | operation journal | manual | Every transport will be noted in the operation journal | not applicable | not applicable | at delivery | |
| $D_{i,y}$ | km | Distance of biomass source i from project location in the year y | navigation software | manual | The driving distance will be calculated by a navigation software | not applicable | > 99% | once per source | |
| $G_y$ | t | Amount of digestate in the year y | weighing plattform | digital | Trucks drive on the plattform empty and loaded. Difference is weight of the Co-Substrate. | Weighing systems in this scale are very robust. Annual Check | > 99% | at delivery | |
| $GN_y$ | % | Fraction of Nitrogen in the digestate | external service | digital | Samples of the digestate will be given to a laboratory and their composition will be analyzed | will be performed by external service | not applicable | semi-annual | |
| TEPm,y | kWh | Amount of heat used by the heat consumer in the year y to replace fuel typ m | heat meter | digital | A heat meter will measure the amount of heat consumed by the heat consumer | regularly maintainance, calibration as needed | > 99% | continiously | is expected to equal EGthermal,y |
| F | h | hours of operation of the flare | runtime counter | digital | the flare is equpied with an automatically runtime counter | maintainance / calibration after manufacturers specification | > 99% | continiously | |

**Table 26: Data measured for the Monitoring plan**

## 6.2 Monitoring of Additionality

The accounting of the biogas plant will give the persons in charge on a monthly basis the required figures for calculation of the IRR according to the formula from the manual as used above.

Additional and unforeseen costs and revenues associated with the project activity have also to be considered and justified.

The IRR will be calculated on basis of these figures in order to prove that the project is still financially additional. The figures will also be cross checked with the estimations ex-ante.

## 6.3 Persons in charge of the Monitoring

Two people work in alternating shifts at the plant, a technician and the chief engineer. They are responsible for the daily operation and the quality assurance. A programmable panel operates and supervises the facility automatically. All supervised process data will be saved electronically.

Persons in charge for data collection and archiving are listed in the following table:

| name | task to be performed | phone |
|---|---|---|
| Berki Gyula | Data collection Bicsérd | +36 30 3369 613 |
| Lukács Mihály | Data collection Tiszaszentimre | +36 30 9500 342 |
| Gál József | Data collection Kaposszekcső | +36 30 645 3805 |
| Csaplár János | Data collection Bugyi | +36 30 9349325 |
| Varga Tibor | Data collection Kisbér | +36 305672509 |
| Ország László | Data collection Nagyrécse | +36 30 33 74 120 |
| Hegedűs Viktor | Data collection Pusztahencse | +36 20 315 1078 |
| Szajkó Lóránt | Data collection Kapuvár | +36 20 953 -4668 |
| Szajkó Lóránt | Data collection Nagyszentjános | +36 20 953 -4668 |
| Jakab Béla | Data collection Bonyhád | +36 30 698 3861 |
| Szegedi Katalin | Collection of data from all projects of the bundle | +36 30 828 6625 |
| Marius Bossen | Plausibility check, Monitoring report | +49 40 809063 109 |

## 6.2 Quality assurance of measured data

All measurement equipment mentioned in the monitoring plan is maintained and calibrated according to the specifications of the manufacturer. Employees will receive training in the operation of the plant (mechanical parts, SPS control, CHP and flare, process supervision and leakage detection) which will be renewed as state of technology and knowledge. Collected data will be checked for plausibility. For the evaluation of values from literature only reliable and established sources will be chosen and country specific values are used where possible and applicable.

### 6.3 Implementation of the monitoring plan

Every project keeps a operation journal in which every delivery of (Co-)Substrates is measured with amount and origin. Technical equipment of state of the art CHPs already contains the needed measurement instruments and can be supported by computer based controls. The computer based Management allows the data collection and archiving as mentioned above. The maintenance schedule will contain the daily, monthly and annual Monitoring tasks. The operating persons are committed to obey this schedule. The data will be collected and checked for completeness by the project developer Biogaz Unio Zrt. and send to the writer of the monitoring reports, the Greenstream Network GmbH, where the data is checked for plausibility and the monitoring report is written based on the data.

All data will be collected for at least two years after creation of the last certificates.

# 7 Impact assessment

A variety of benefits for humans and environment can be expected from the construction of a biogas plant. They can be divided in political, social, economical and ecological benefits.

**Political benefits**

- Electricity from biogas is $CO_2$ neutral. This helps Hungary to improve its Greenhouse gas balance and therefore meeting the international obligations arising from the ratification of the Kyoto Protocol.
- Biogas from indigenous sources will reduce the dependency on the imports of fossil fuels.

**Social Benefits**

- Biogas stands for decentralized energy production under participation of regional agricultural enterprises.
- Farmers become more independent from international agricultural market prices. Biogas as a renewable energy has the advantage that existing facilities and equipment can be used.
- Existing enterprises were modernized by new Investments.
- Farmers are able to utilize the generated heat to heat their stalls or create new business opportunities.
- The digestate smells considerably less than the manure does, resulting in a reduction of odor for the affected people, especially during time of spreading on the fields.

**Economical benefits**

- Construction and maintenance of the facilities creates and secures employment in the construction industry and at the supplying manufacturers.
- Operation of the plant creates 2-3 permanent jobs.
- The transfer of knowledge creates highly qualified jobs und strengthens Hungary's position in international competition.

**Ecological benefits**

- Biogas plants will make the manure management more professional resulting ion less impact on the environment
- The nutrience cycles were closed. Nutrients from the industry can also be sanitized in the plants and used as a fertilizer
- Nutrients in the digestate have a better availability as normal manure. This is a result of the mineralization of Nitrogen. Artificial fertilizers, which are produced with a high amount of energy and commonly under usage of fossil fuels, can be saved.
- Resources are used more effective: Utilization of heat leads to efficiencies above 90%
- Biogas is the only available technology to use the energetic potential of manure and liquid organic wastes

# 8 Summary of the stakeholder consultations

## 8.1 Information on the publication of information concerning the project and on the access to project documentation

Data of project activities will be made public available at the website of the ministry for environment and water, according to 323/2007. (XII. 11.) Sektion 10; (3). Financial data is not included for it concerns the private economical interest of the project owners. They were made avaible to the Validator though.

## 8.2 Information on the public hearing held or the other measures taken in order to inform stakeholders

In Hungary every building project must have the agreement of the neighboring residents as a part of the building permit. This even applies to simple office buildings. Residents get informed by a formula in which they will have the possibility to object to the building project.

The community and representatives have been informed. Public relations for the construction will be done via newspapers and Internet. Some Newspaper articles have already been published (see Appendix VII).

Plants in Kaposszekcsői and Tiszaszentimre are located in an industrial area so local residents are not concerned.

A good visible sign at the facility informs about the project activity as it is recommended for projects aided by the EU.

### 8.3 Summary of the stakeholders comments, identification of the comments accepted and justification for the refusal of comments.

None of the residents asked in connection to the building permit objected to the project activity.

# 9 Summary of the project (for non-experts)

## 9.1 Description of project activity

In total ten agricultural enterprises spread over Hungary take part in project activity. They all are running farms for pig breeding and/or dairy cattle. At the moment the manure of the animals is stored in deep open lagoons or earth basins. Methane escapes unobstructed to the atmosphere where it works as a greenhouse gas and contributes to global warming.

Each of the enterprises in this bundle plan the construction of a biogas plant which will use the methane from the manure energetically. Instead of storing manure in the lagoons, manure will be digested in the biogas plant to produce $CO_2$ neutral energy. The product of the biogas process, the digestate, is a very good natural fertilizer and can be used instead of artificially produced fertilizers.

## 9.2 Introduction of impact areas and impact processes

An impact on the environment would theoretically be possible in the following areas and by the following parts of project activity:

**Air pollution**

Odor or air pollution by transport, processing and storage of the substrates, the fermentation, process, the biogas burning, and storage and spreading of the digestate.

**Noise, vibration**

Annoyance of residents by noise from the transport of substrates and digestate or operation of the CHP

**Soil and Water Conservation**

Pollution of soil or water from transport or storage of the substrates or the spreading of the digestate.

**Landscape townscape, recreation**

Change of the landscape by buildings like the CHP or the digesters.

## 9.3 Estimate and evaluation of environmental impacts

**Air pollution**

Transport: transport of substrates is performed with special trucks, if the substrate is not produced at the site of the biogas plant. Manure from external sources will be transported in closed tanks and does therefore not emit any odor. Co-substrates like corn silage do not emit considerable odors while being fresh. The digestate will have a significantly lesser odor than the manure while it is stored or spread on the fields.

Processing: Liquid substrates with an odor potential will be pumped directly into the mixing tank. The solid co-substrates will be stored under a plane.

Fermentation: The fermentation process is gastight und does not emit odor.

Storage of the digestate: Volatile, odorous composites of the substrates will be reduced by the fermentation resulting in a reduction of the odor potential. No odor can be expected even in case of storage for a longer time.

Spreading of the digestate: The spreading of the digestate close to the soil further reduces its odor potential.

Operation of the CHP: Combustion of biogas in the CHP does necessarily result in a emission of pollutants. Those emissions are in no relation to the avoided pollutants from methane emissions though.

Because nearest housings are located several hundred meters away from all project activities, annoyances from odor or pollutants can be excluded. On the contrary, emissions will decrease due to project activity as explained above.

**Noise, vibration**

Transport: the main substrate is the manure which is produced on the site of the biogas plant and directed to the fermenter in pipelines. Only external biomass is brought by trucks.

CHP: The CHP is located in a specially adapted and prefabricated container with noise insulation. The pumps are also housed in a closed building and therefore not emitting much noise.

Because nearest housings are located several hundred meters away from all project activities, annoyances from noise or vibration of the plant can be excluded.

**Soil and water conservation**

Proper operation of the plant will not lead to any entry of pollutant or excessive nutrient concentrations to soil or water. This is avoided by measures described below.

**Landscape, townscape, recreation**

Perceptible new buildings are the digesters and the CHP building. They fit in the already existing picture of the agricultural enterprise and are not able to change the characteristic landscape.

## 9.4 Description of measures planned or realized for the prevention and mitigation of negative environmental impacts

Measures to mitigate negative environmental have to be taken for the areas air pollution and Soil and Water Conservation only.

**Air pollution**

Transport + processing

Handling of manure takes place in a completely closed system. It is pumped from the trucks directly into the closed system. Therefore no odor does appear. Project activity will in this aspect have a big advantage to baseline scenario.

Fermentation: Digesters are gastight. Double membrane roofs will ensure, that no methane will leak unintentionally.

Storage of digestate: Post digester and digestate storage are built gastight.

Operation of the CHP: The CHP fulfills the standards according to manufacturer specifications. If the CHP is not able to combust the biogas due to non-operation or maintenance, an amount of biogas can be stored under the double membrane roof of the digesters. If the storages are full the gas will be sent to a flaring unit where it is burnt. Effiency of the flare is about 99% resulting in not significantly higher emissions than combustion in CHP.

**Soil and Water Conservation**

The storage of substrates will take place on concreted areas with a draining. Leachate and waste water is discharged into the cesspit. To avoid slopping of the cesspit a sufficient buffer is implemented. Unintentional leakage of pollutants or high concentrations of nutrients can be avoided this way.

## 9.5 Potential changes in the health, life quality or lifestyle of people affected by the environmental impacts

Concerning former manure management systems in lagoons the project activity will lead to a positive change regarding the odor. The digestate spread on the field has a considerably less odorous potential than fresh manure. It comes to a positive impact regarding odor.

As described above no negative impacts can be expected for the local residents, as the project activity is too far away to recognize the low noise or vibrations.

The positive impacts as described in 7 will strongly outweigh over eventual negative impacts.

## 9.6 Measures to be taken in order to protect the environment and human health

Negative impacts only appear in case of an accident. A variety of measures are taken in order to avoid those.

The security concept bases on prevention as the first step and minimizing of impacts as the second step. Three measures are mainly involved to prevent accidents from happening:

- choice of appropriate technology
- regularly maintenance
- training of employees
- building only following national health and security rules and laws

### Choice of appropriate technology

The choice of technology has been done also under consideration of security aspects. Double membrane roofs and an emergency flare prevent uncontrolled methane emissions or explosions due to gas overflow and allow measurement of leaks in the roof. Automatically computer based systems supervise process parameters constantly and give an alert in case of unexpected values. The state of the art technology chosen profits from the experiences of hundreds of similar plants installed worldwide.

### Regularly maintenance

Machinery will be controlled daily by the employees. Maintenance will be performed by strictly following the manufacturers' specification.

### Training of employees

Employees are responsible to ensure security of the plant. They receive intense training and preparation for emergency cases. Working in shifts ensures that someone in charge is always available.

### Other security measures

To exclude to risk of fire or explosions good visible signs where installed at the endangered areas. Smoking in this area is strictly forbidden. Every employee of the agricultural enterprise is informed about the measures and ordered to follow them.

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