BIOGAS PRODUCTION POSSIBILITIES AND TECHNOLOGICAL BACKGROUND (MANURE AND CARBON MANAGEMENT) IN THE HUNGARIAN ANIMAL HUSBANDRY

KOVACS, Attila – Assistant Professor of School of Economics and Social Sciences, SZIE, Godollo
BOROCZ, Maria – PhD. Student of the Doctoral School of Economics and Business Administration of SZIE, Godollo
FOGARASSY, Csaba – Associate Professor of School of Economics and Social Sciences, head of research group, SZIE, Godollo
HALASZ, R. – PhD. Student of the Doctoral School of Economics and Business Administration of SZIE, Godollo

Introduction

The Hungarian animal husbandry is forced by the agricultural subsidy system of the EU effected heavy pressure on the market. Furthermore the ecologically sustainable, low-pollution agricultural production has become more and more priority of the European Union's Common Agriculture Policy. The emissions related directly to the intesive animal husbandry are notably straining the soil, the surface water and groundwater and the atmosphere. From the environmentally relevant gases with origin of animal husbandry the most important ones are the ammonia (NH_3), the nitrous oxide (N_2O) and the methane (CH_4). Approx. 15% of the greenhouse effect gases (those of methane and nitrous oxide) that go into the atmosphere, have agricultural origin. With subscribing to the UNFCCC (The United Nations Framework Convention on Climate Change) in 1992, Hungary commited itself to reduce the emission of greenhouse effect gases arising from human activity. According to the biogas production those economic species are worth to consider, which have the most convenient manure and the largest stock. Such species are cattle, swine, sheep, chicken and the turkey, since these species are kept in a concentrated large scale production system in a stable keeping way. In connection with these species the problem of manure treatment appears also concentrated with the claim of suitable manure treatment and placement. From these species the swine and the cattle is the most merited to analyze the problem of the manure treatment. In Hungary the headcount of cattles is constantly reducing, however the animal stock still reach the 710.000 head. In the last few years the animal stock of swine didn't pass the 3,7 million pieces. In the case of cattle the annual individual quantity of manure is about 9,5t, whereby approx. 156 m3 biogas could be produced in case of optimal conditions. It means 0,9t manure and approx. 136 m^3 biogas in the case of swine. In environmentally way the biggest problem is the dawn of the liquid manure, and its treatment. In these sectors this is a huge problem, because it arise mesurably, but it can be solved by biogas technologies.

Climate change aspect of the manure management

The voluntary agricultural protocol developed by Hungarian Biomass Competence Centre is the first one to allow European farmers to enroll in emission-reduction programs. Farmers that consciously harmonise specific agricultural production systems may now undertake emission reduction programs on a voluntary basis. The basic character of the protocol's is that it consciously harmonizes these specific system elements to achieve the highest possible emission reduction. The protocol is based on carbon-dioxide equivalent (CO_{2e}) accounting, where the reduction of greenhouse gases is primarily due to avoided methane (CH_4) and the nitrous oxide N_2O emission associated with production. The avoidance of CH_4 and N_2O associated with agricultural activities (e.g. manure management and fertilizers) coupled with efforts to minimize production related carbon (C) is o ne of the most cost-effective greenhouse gas (GHG) emission reduction strategies. These gases have a global warming potential (GWP) many times that of CO_2. Methane has a GWP of 21, while the GWP of nitrous oxide is 310. Since these gases are associated with agriculture, if avoided, the derived revenue to farmers may be significant. The protocol has a very positive feature: it rewards participants as a function of the volume of avoided GHGs, i.e. it is a performance-based system favoring those that avoid emissions in the most efficient way. This integrates new market elements into the fundamental agricultural production systems.

The emission reduction is carried out and monitored according to a well-defined methodology. The so called energy-farm emission and manure management protocol focuses on the handling of the greenhouse gases collectively in the agricultural activities and the accurate accounting of the emission units, defining four new optimalizing factors that are coherent with one another. The accounting protocol has been elaborated in accordance with the IPCC recommendations and it is based on the related greenhouse gas project descriptions and the strict mechanism of Joint Implementation of the Kyoto procedure (Lukacs et al, 2009). According to the protocol, there is project-based accounting, resulting in marketable emission avoidance credits as final products.

The greenhouse gas accountings in agriculture, supported by the protocol are as follows:

- carbon tie with change in cultivation and carbon-storing biomass production
- CH_4 avoidance during manure handling
- N_2O avoidance during manure handling
- replacing fossil energy sources (with electric green energy or biomethane fuel).

The management protocol currently supports primarily such an agricultural basic system, which takes up the energetic utilization of by-products and waste in addition to the food production functions, optimalized on the input and output factors, operating a system complement the biogas plant.

Efficient CO_{2e} reduction and multi-channeled sales

The so called manure and carbon management protocol is the most cost-effective emission accounting system, that intends to achieve that those agricultural farmers could also participate in the emission reduction programs who „are able to" avoid just a few thousand tons CO_{2e} per year. One of the principles of the protocol is the greenhouse gas-related performance and accounting, thus it requires each farm to collect data and to apply an emission management system. The authentication by a third party and preparation of monitoring reports are the prerequisites of participation in the accounting system. The minimum period of participation in the agricultural emission saving system is 5 years which allows the greenhouse gas reduction strategies to become lasting elements of the system and the safe handling of the finances. The safe emission reduction and the manure and carbon management realized due to the protocol results that the emission saving units or the carbon credits achieved by the energy farms are marketable products, therefore their price on the carbon market will be high. The traceable emission reduction and the emission reduction originated from the reliable performance can be accounted in the different mechanism of the Kyoto protocol and it represents a very high value in the Voluntary Emission Reduction (VER) markets as well, thus it can be sold even in advance (carbon crediting).

The methodology and the quantitative parameters of the emission reduction

The agricultural manure and emission management system supported by the special protocol focuses primarily on the changes in the cultivation and manure handling, and it takes into account the emission reduction effects of the green-energy production. Considering the IPCC recommendations, we provide the emission reduction summary and the accounting methodology related to the following fields:

- carbon tie with change in cultivation and carbon-storing biomass production
- CH_4 avoidance during manure handling and N_2O avoidance during manure handling
- replacing fossil energy sources (with electric green energy or biomethane fuel).

Carbon sequestration with conservation tillage and carbon capturing biomass production

The targeted application of the agricultural systems related to carbon tie and storage has not really spread in Hungary so far. Avoiding the carbon-loss of the soil basically depends on the cultivation, so increasing the carbon content of the soil and reducing the carbon and carbon-dioxide leaving the soil can be significantly influenced due to the change in the cultivation (Fogarassy et al, 2008).

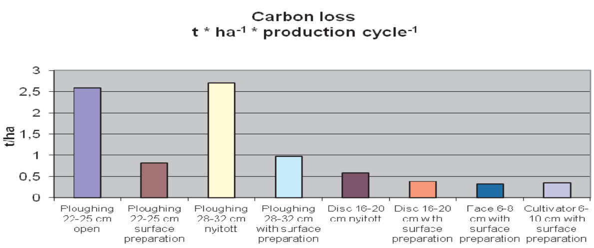
The strategy for carbon-storing biomass production originates from the same principle, so its aim is to create positive balance during the crop production, i.e. to allow more CO_2 to build in the organic matters with the agricultural biomass production than it leaves them. In order to provide the positive carbon balance, we need to return the stalk residues of the crops into the soil.

Avoiding the carbon-loss of the soil

Based on the scientific results of the Szent István University we can state that more than 2 tons of carbon (C) can be saved with carbon-saving cultivation on one hectare, which means ≥7,33 t CO_{2e} per hectare in the CO_2 balance (with applying the 44/12 conversion multiplication).

In a carbon-saving cultivation, a deeper tillage is necessary only once in four years, so we can achieve significant carbon-saving in the case of a crop which is supposed to be cultivated each year (considering a four-year term). Based on the calculations, this amount is ((4*2,7)-(0,975+3*0,39))/4 = 2,1637 t C/ha per year on average, which results in 7,93375 t CO_2 savings per year in the case of corns.

The figure below shows the carbon-losses due to the different soil-preparations based on Hungarian researches. The highest values originate from primarily the differences between the open and cultivated methods.



Sources: Birkas, M. (2008) and Birkas-Gyuricza (2004)

In a pilot emission reduction program 27 farms take part and the land cultivated by them in each year is (owned and rented) cc. 75.000 ha. Based on the crop structure, we define the maximum size of land for corn in a year as two-third of the arable land. In that case, about 50 000 hectares can be taken into CO_2 trading from corn to reduce carbon emission, thus the savings can be 396 687,5 t CO_2. However, it is a criteria that at least 30% of the stalk residues over the surface must be returned in the case of a cultivated area.

In the case of other crops produced on the rest of the land (one-third) (corn or sunflower, or others) the question is whether the cultivation is carried out in an open or closed way. The investigations showed carbon tie difference between the two methods of 2,6 t/ha – 0,8 t/ha, 1,8 tons on average. In the case of crops of non in the ear, the avoidance of 1,7425 x 44/12, i.e. 6,38 t CO_2 is expected. The value is 159 729,2 t/CO_2/year for 25.000 hectares.

Overall, the carbon-conscious cultivation of a land of 75 000 hectares results: the avoidance of 396 687,5 + 159 729,2 = 556 417 tons/ CO_2/year.

CH_4 avoidance due to manure handling

Reducing the emission due to manure handling is the greatest potential of the emission reduction of animal husbandry and it is also a must. Changing the manure handling ways might significantly improve the indicators related to the animal husbandry. Changing the manure handling technology may result great savings of the greenhouse gases, especially the methane and the nitrogen-oxide. While calculating the emission savings of manure handling, in the 27 plants we calculated with 19 919 pieces of cattle, 69 142,5 pieces of swine, 373 250 pieces of poultry. During the animal calculations, we converted the animal units submitted for the EU CAP registration in a way that we did not modify the value of the cattle, while we applied 0,2 conversion rate in the case of swine and 0,02 for the poultry. It was necessary because in the IPCC system the information refers to piece of animal and in certain cases more than one age group is defined for calculating the emissions. We did not considered these characterizations and we calculated with an average while defining the potential emission. The final information can be achieved only after the accurate investigation on the concrete plants.

The calculation was carried out according to the formula:

$$CH_4 \text{ Emission}_{(mm)} = EF * \text{piece of animal} / (106 \text{ kg/Gg})$$

where:

- CH_4 $\text{Emission}_{(mm)}$ = CH_4 emission from manure handling for the animal defined Gg/year
- EF = emission factor for the animal defined kg/piece/year
- piece of animal = number of pieces for the animal defined

The EF formula applicable in the IPCC procedure2 is the following. It is adjusted to the given economic system and changes:
where:

$$EF_T = (VS_T * 365) * \left[B_{0(T)} * 0{,}67 \ kg/m^3 * \sum_{S,k} \frac{MCF_{S,k}}{100} * MS_{(T,S,k)} \right]$$

- EF_T = periodical CH_4 emission factor for the category investigated T, kg CH_4/piece/year
- VS_T = daily excreted material in dry matter in each animal category T, kg animal unit/piece/day
- 365 = length of the period for VS calculations, day/year
- $B_{0(T)}$ = maximum capacity of methane production from the manure produced in each animal category T, m^3 CH_4/kg excreted VS

- 0,67 = conversion rate m³ from CH_4 to kg
- $MCF_{S,k}$ = methane conversion factor according to manure handling technologies S and climatic regions, %
- $MS_{(T,S,k)}$ = k value for those who apply the given manure handling system S for animal categories, regarding the climatic conditions.

The IPCC procedure2 takes into account the differences between the manure handling systems in the formula (S), resulting in different EFs can be applied. In this case, if a plant changes the way of manure handling, we can cause savings with changing the MCF value. In the case of one milking cow weighing 600 kgs, the daily excretion of dry matter is 5,1 kg/piece/day, out of which the methane production capacity is 0,24 m^3CH_4/kg VS, i.e. 299,3292 kg CH_4/year. If we multiply this with the MCF of the given manure handling method, we get the final EF.

The following table shows the data necessary to the calculations for cattle.

MCF values

Average temperature	Lagoon	Liquid manure	Solid	Grazing	Daily distribution	Anaerob intermediary storage (digester)	Other
10	66%	17%	2%	1%	0%	10%	1%
11	68% 19%	2%		1% 0%	10%	1%	
12	70% 20%	2%		1% 0%	10%	1%	
13	71% 22%	2%		1% 0%	10%	1%	
14	73% 25%	2%		1% 0%	10%	1%	
MS values							
North America	15,0%	27,0%	26,3%	10,8%	18,4%	0,0%	2,6%
West EU	0,0%	35,7%	36,8%	20,0%	7,0%	0,0%	0,5%
East EU	0,0%	17,5%	60,0%	18,0%	2,5%	0,0%	2,0%

As for swine, the VS is 0,46-05 kg/piece/day for a breeding animal. The B_0 is 0,45, while it is 0,27-0,3, and 0,45 for a porker. In order to reduce the methane emission related to the manure handling, we need to close the system, thus its amount getting into the air will be less. The methane reduction is the difference between the baseline and the innovated system. The methane is a greenhouse gas with 21 multiplication, so the CO_2 avoidance has to be calculated with that rate.

N_2O avoidance with manure handling

We need to calculate the N_2O avoidance for manure handling as in the case of methane, therefore we need to consider the baseline and the emission after the development. However, the methodology for defining the categories for each animal type works in a different way. The formula applied in the IPCC procedure1 is as follows:

$$N_2O_{D(mm(} = \left[\sum_S \left[\sum_T \left(N_T * Nex_T * MS_{(T,S)} \right) \right] * EF_{3(S)} \right] * \frac{44}{28}$$

Where:

- $N_2O_{D(mm)}$ = direct N_2O emission from manure handling, kg N_2O/year
- N_T = the type of animal/number of pieces in the category
- Nex_T = average N selected animal/category, kg N/piece/year
- $MS_{(T,S)}$ = the share of animals producing and excreting in the manure handling system
- $EF_{3(S)}$ = emission factor for the direct N_2O emission in the manure handling system, kg N_2O-N/kg N
- S = manure handling system and T = animal type/category
- 44/28 = conversion rate from N_2O-$N_{(mm)}$ to $N_2O_{(mm)}$

Way of manure handling	**EF_3**
Grazing	0,02
Daily distribution	0
Storage on litter	0,02
Dry storage	0,02
Liquid manure technology	0,001
Anaerobe lagoon	0,001
Open storage with a storage under the animals	0,001
Anaerobe storage	0,001

If there is a change in the manure handling, the EF3 decreases from 0,02 to 0,001 kg N_2O-N/kg N), so we can save depending on the amount of liquid manure. The daily excretion of a milking cow is 0,35-0,48 kg N/1000 kg animal. In the case of an animal weighing 600 kgs it is 0,415 kg N/day * 365 days = 151,475 kg N/year. If we multiply it with the EF of the manure handling and the conversion rate, we get the real emission. We do this calculation for the new system as well, and the difference is the saving. The calculation has to be carried out for each animal category, climatic region, and the summed emission/saving has to be multiplied by 310, since it is the rate for N_2O. The following tables show the baseline levels and the value of the saving due to the technological change for both the methane and the nitrogen-oxide. The Baseline calculation means the current level of emission, while the target emission levels have to be achieved with the change in the technology. The difference between the two values mean the basis for calculations for both the methane and the N_2O.

Fossil energy-replacement (with green electricity or biomethane fuel)

In order to define the amount of energy to be replaced, we have used the document titled as „Guidelines to monitor the additionality of the jointly implemented projects and to define the baseline emission of the energetic projects".

The basis for the calculations have been the forecasts of the MAVIR 2003 for the years of 2005, 2010 and 2015 as well as the electricity-balances. After carried out the calculations, we get the following reference values for the period of 2008-12. In our case the period is 2010 and 2014, so the relevant reference values are to be defined in the future for the period of 2012-2014.

YEAR	Reference emission (Xy) g/kWh
2008	707,5
2009	710,6
2010	713,8
2011	703,9
2012	694,0
Average	706,0

The CO_2 emission reduction realized in a Joint Implementation project can be calculated for a given year in the following way:

$$CO_2 \text{ emission-reduction [tons]}_y = X_y \text{ [g/kWh]} \times E_{ki0;y}\text{[GWh]}$$

where

$E_{ki0;y}$ – The amount of electricity produced with the EV project with 0 net emission.

In order to get the total emission-reduction, we need to sum the yearly values, and provided the $E_{ki0;y}$ value is the same in each year, the following can be also used

$$CO_2 \text{ emission-reduction [tons]}_{2008\text{-}12} = 5 \times E_{ki0} \text{ [GWh]} \times X_{average}\text{[g/kWh]}$$

relation, where $X_{average}$= 706 g/kWh.

In this calculation we calculated with pessimistic estimations, with reduced values due to the date of the performance of 2014:

$$CO_2 \text{ emission-reduction [tons]}_{2010\text{-}14} = 5 \times E_{ki0} \text{ [GWh]} \times X_{average}\text{[g/kWh]}$$

coherence,

where $X_{average}$ = 700 g/kWh

We have calculated the use of gas energy sources produced by biogas plants for electricity production because based on our current technologies, we do not have enough experience with the technologies cleaning the biogas. However, the systems that are being elaborated, system development with gas-cleaning equipment is a possible option. Regarding these development processes may start depending on the energy market changes, therefore a more significant biomethane production can be expected between 2012 and 2014. The possible biomethane production can be regarded as a safety reserve in the program. In the case of biomethane production, the emission reduction can be further increased with 20-30% in each year.

Summary

The animal husbandry sector in Hungary has to meet the challenges of foreign and domestic markets, regulations, natural environmental conditions, and the requirements of ecological farming. The conditions of animal husbandry becomes harder and harder, because the farmers have to meet technical, higienic, and quality specifications, and they have to be in the black also. Biogas can be an alternative choice for the modern farmer who is able to use the byproducts of agriculture in an environmental-consciously way.

In the last years the National Renewable Energy Strategy placed emphasis on the use of biogas in Hungary. The Renewable Energy Strategy subsidises the feeding of biogas into the existing naturalgas pipeline network. The main resources for biogas are liquid manure, sevage sludge, and the waste of slaughterhouses.

Due to the manure and carbon protocol we managed to introduce the emission reduction process related to the biogas production with a well-defined methodology and monitoring system, focusing on the common handling of the agricultural activities producing greenhouse gases and on an accurate accounting of the emission units. This accounting system defines four optimalizing factors that are closely linked to one another:

- carbon tie with change in cultivation and carbon-storing biomass production
- CH_4 avoidance during manure handling
- N_2O avoidance during manure handling
- replacing fossil energy sources (with electric green energy or biomethane fuel).

In the immediate future, the ammonia, dinitrogen oxide and methane emissions of the Hungarian animal husbandry will depend on the number of the animals and the standards of technical background. To decrease these emissions there are possibilities in the areas of feeding, manure treatment, the number of the live-stock, and the change of productional level. According to the requirements of the climate friendly development, and the environment in these areas will be essential to decrease the emission levels.

The accounting methodology and management system applied are able to realize a safe voluntary emission and compulsory manure reduction, thus due to the programs, emission credits of high values can be created.

References

Birkás M., Gyuricza C. (2004): A talajhasználat és a klimatikus hatások kapcsolata. In: Talajhasználat, műveléshatás, talajnedvesség. Quality Press & Publisher Ltd. Gödöllő, 2004

Birkás M. (2008) Klímakár-enyhítés talajműveléssel. Józsefmajori Fajtabemutató és Gazdanap, 2008.

Fogarassy C., Lukacs A., Böröcz M. (2008) Basic structure of CO_2 emission management practice in agricultural land use. VII. Alps-Adria Scientific Workshop, Stara Lesna, Slovakia, 2008

Fogarassy C., Lukacs A., Huba B. (2008) GIS links to the voluntary market: CO_2 mitigation potential of agriculture manure management. „Facilitating Green Investment Schemes: first lessons learnt and way forward" 24-25 April 2008, Budapest, REC Hungary, 2008

Éghajlatváltozás (2007) Döntéshozói összefoglaló, KVVM, Budapest, IPCC Summary for Policymakers, 2007

Kyotó Vhr. (2007) 323/2007 Korm. rendelet (XII. 11.) az ENSZ Éghajlatváltozási Keretegyezménye és annak Kiotói Szerződése végrehajtási keretrendszeréről szóló 2007. évi LX. törvény végrehajtásának egyes szabályairól http://klima.kvvm.hu

Lukács A., Fogarassy C., Borocz M. (2009) Carbon management in the agricultural production and consumption:

Foodstuff production vs. nonfood agricultural production utilisation. In: Delhi Business Review – An International Journal of Society for Human Transformation & Research. Vol. 10, No.2, July-December, 2009

UNFCCC (1988) United Nations Framework Convention on Climate Change. The Kyoto Protocol to the Convention on Climate Change, 1988