Farm biogas plants in Austria – An economic analysis

Landwirtschaftliche Biogasanlagen in Österreich – eine ökonomische Analyse

Christoph WALLA and Walter SCHNEEBERGER

Zusammenfassung

Die Anzahl landwirtschaftlicher Biogasanlagen nahm in den vergangenen Jahren stark zu und es kann angenommen werden, dass sich dieser Trend weiterhin fortsetzt. Um interessierte Landwirte und Entscheidungsträger mit Daten zu unterstützen, wurde 2002 eine Befragung der Biogasanlagenbetreiber über die Motive zum Bau, die Verfahrenstechnik, die Investitionskosten und den Arbeitszeitbedarf durchgeführt. Die Kofermentation von Gülle und Mist mit Energiepflanzen und/oder organischen Abfällen ist das verbreitetste Anlagenkonzept. Das Biogas wird in Blockheizkraftwerken verwertet, wobei der Strom ins öffentliche Netz eingespeist und die Wärme im landwirtschaftlichen Betrieb genutzt wird. Wenige Betreiber verkaufen Wärme an Fernwärmenetze. Der Arbeitszeitbedarf hängt von den fermentierten Rohstoffen ab. Die Investitionskosten steigen proportional zur Leistung, die Kosten je Einheit unterliegen einer Degression. In drei Fallstudien wurde die Wirtschaftlichkeit unter den geltenden Rahmenbedingungen überprüft und eine Amortisationszeit zwischen 7,5 und 11 Jahren ermittelt.

Schlagworte: Biogas, Investitionskosten, Arbeitszeitbedarf, Wirtschaftlichkeit

Published 2005 in the *Jahrbuch der Österreichischen Gesellschaft für Agrarökonomie*, Vol. 13, pp. 107-120. Available on-line: www.boku.ac.at/oega

Summary

The number of farm-based biogas plants increased rapidly in the recent past, the interest in this technology is expected to continue. A survey was carried out in 2002 to provide information for farmers and decision makers about motives, plant concepts, investment costs and labour requirement. In most plants slurry and manure is co-digested with energy crops and/or organic waste. The trapped biogas is utilized in CHP-units and the electricity is sold to the grid. The heat is supplied to the farm and farm house; a few operators sell it for district heating. The labour requirement depends on the fermented feedstock. The investment costs per unit decrease. At the present price for electricity a payback period between 7.5 and 11 years has been calculated in three case studies.
Keywords: Biogas, investment costs, labour requirement, cost efficiency

1. Introduction

The directive 2001/77/EC of the European Parliament and of the Council intends the promotion of electricity produced from renewable energy sources. The directive classifies as renewable energy source wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas. The national targets concerning electricity from renewable energy sources (see figure 1) are consistent with the global target of 22 % of total community gross electricity consumption by 2010.

Agriculture can contribute to the Kyoto targets by preventing uncontrolled emission of methane (CH_4) and laughing gas (N_2O) during manure storage by the sealed process of fermentation in biogas plants and using the CH_4 for generating electricity and heat (AMON et al., 2001). The reduction of emissions and the substitution of fossil energy sources by biogas are considered as a very cost efficient possibility of achieving the targets (NEUBARTH and KALTSCHMITT, 2000, 398; NIELSEN and HJORT-GREGERSEN, 2002, 4 and NILL et al., 2003, 43).

In Austria 86 farm-based biogas plants were in operation by the end of 2001 the number increased to 110 by the end of 2002. The capacity is 7,446 kW_{el} (JAUSCHNEGG, 2003, 2). The number of biogas plants is expected to increase further. Austria's biogas production potential is about 180 MW_{el} (NEUBARTH and KALTSCHMITT, 2000, 393). Prices for electricity generated form biomass are regulated by the Green Electricity Act 2002 (BGBl. I Nr. 149/2002) for 13 years. This enables the farmers to long-term investment strategies for biogas production. Biogas plants using organic waste get 25 % less for electricity compared to those fermenting only agricultural feedstock. Investment grants for farm biogas plants up to 40 % are possible within the scope of the rural development program which is co-financed by the EU (BMLFUW, 2003, 83) or within the national technology promotion program (BGBl. I Nr. 149/2002).

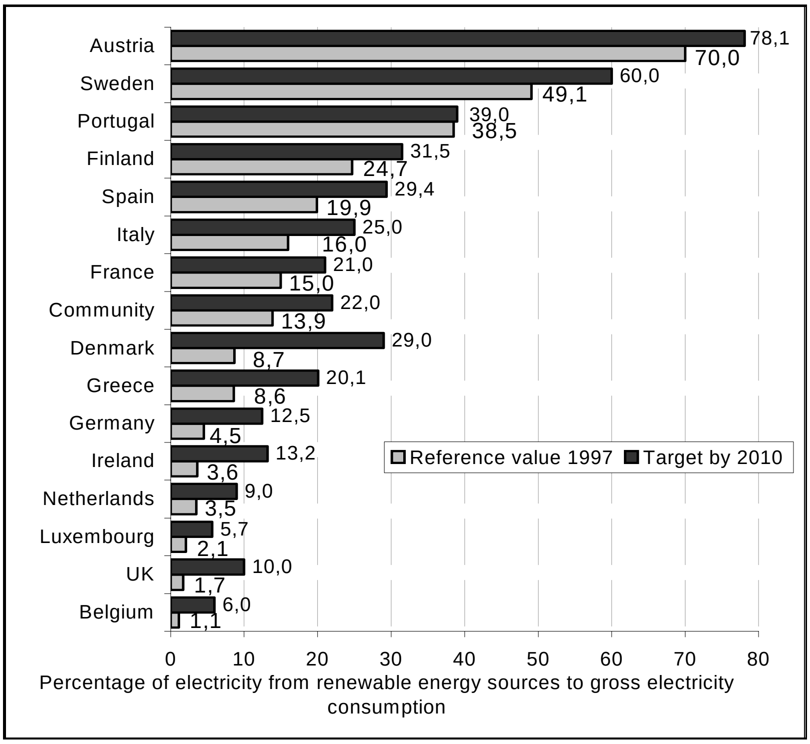

Fig. 1: Reference values for the contribution of electricity produced from renewable energy sources to gross electricity consumption by 1997 and national indicative targets by 2010

Source: European Parliament and European Council 2001

Most of the Austrian biogas plants are farm-based as shown in figure 2. Before 2001 the farm-based biogas plants were not registered separately, so only the total number of biogas plants is known. The total capacity of the biogas plants increased fast, the capacity of farm-based plants nearly doubled between 2001 and 2002.

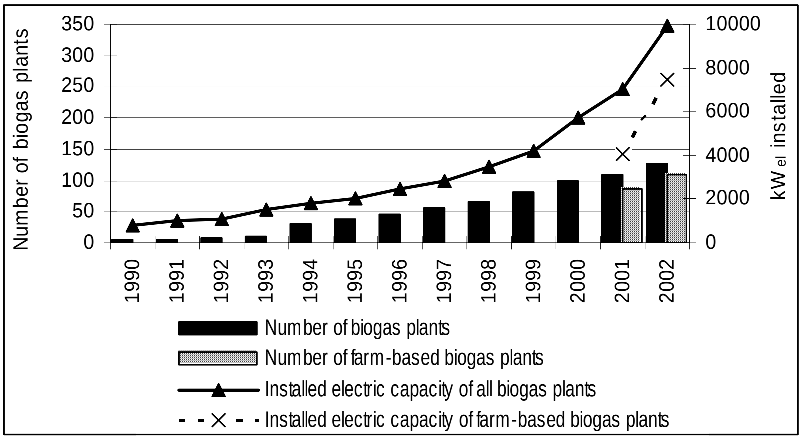

Figure 2: Number and capacity of biogas plants in Austria
Source: ARGE Biogas 2000, s.p.; E-control Ltd. 2003 and JAUSCHNEGG, 2003, 2

2. Objectives

Farmers interested in building a biogas plant require data and know-how concerning the efficient organisation of biogas plants and the costs. Only a few studies address the technical equipment, feedstock efficiency and investment costs of small scale farm-based biogas plants relevant for Austrian conditions. Therefore a survey was carried out to assess the significance of feedstock, chosen technology, investment costs and labour requirement connected with different plant concepts. The results of the survey will provide information for farmers and decision makers.

3. Method

A standardised questionnaire was sent in November 2002 to 86 farm-based biogas plants in Austria. 44 questionnaires were available for an analysis. The questions cover the characteristics of the farms and the biogas plants, the feedstock and the techniques used, labour requirement and the investment costs. The biogas plants are grouped for the analysis according to the operation starting date: the ones implemented before 2000 and those operating since 2000. This cut off date was chosen due to the Austrian Electricity Act of 1998 which liberalised the Austrian electricity market. In 2000 the plants could benefit first from the regulations of this law. 20 out of the 44 biogas plant owners in the survey started the biogas production before 2000 (here named old plants) and 24 plants operate since 2000 (named new plants).

4. Farm characteristics

The biogas plants are operated by farmers, who manage on average 70 ha agricultural land, which is much above the Austrian average of 16.8 ha (BMLFUW, 2002, 209). Farmers who started before the year 2000 cultivate on average 52 ha and those producing since 2000 manage 85 ha. Most farms are provided with grassland and arable land, but 16 % have only grassland and 16 % only arable land. More than 90 % of the farmers keep animals, on average 64 livestock units. About two thirds of the farmers with livestock keep dairy cows, every second fattens cattle or pigs and every fourth keeps poultry.

23 % of the biogas plants are operated by organic farmers although only 9 % of the Austrian farmers are organic (BMLFUW, 2002, 215). This may indicate that degassed manure is of high quality and of high value for organic farms. The organic farms mostly manage grassland and cattle. On average organic farms are smaller than the conventional farms. Approximately 15 % of the biogas plants are organised as cooperatives; all of them are in the group of the new biogas plants.

5. Motives for investment

In the questionnaire several motives for building a biogas plant were mentioned. On average more than three motives out of the possibilities were selected by the respondents. The majority stated the "improvement of manure" as one of the motives (see figure 3). All organic farmers indicated this motive. Other motives were the possibility to produce the own energy demand and to "diversify" the farm income. The operators of new biogas plants stated the motives “diversification” and “odour reduction” more often than the operators of old plants. The motive “changes of the farm organisation” was mainly named by organic farmers. Some of the farmers built the biogas plant in combination with shed investments.

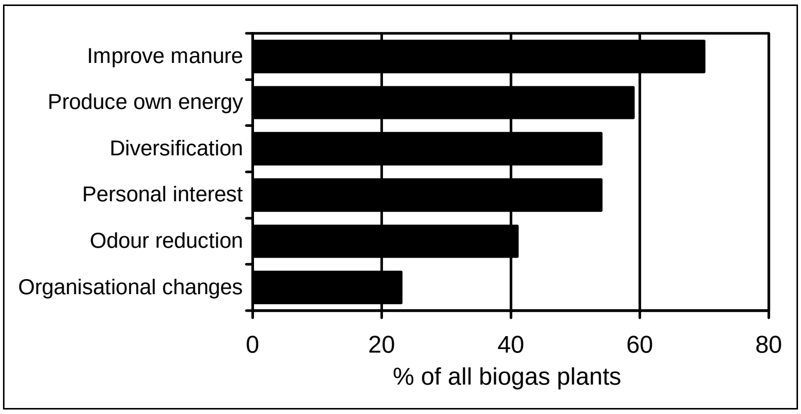

Figure 3: Motives for investment

6. Planning and constructing period

The planning period lasted between 9 months (old plants) and 14 months (new plants), on average one year. The construction period lasted 10 months on average, no difference within the two groups was found. The shortest planning and construction period was half a year, the longest more than three years. Most biogas plants were planned by specialized planners in co-operation with the farmers. Only a few plants were planned by experts or local civil engineers. The construction was mainly done by local enterprises, supported by craftsmen and the owners. Two biogas plants were handed over as turn key facilities and seven small plants were constructed by the farmers themselves.

7. Plant concepts and feedstock

Nearly all farm-based biogas plants operate as co-digestion plants with slurry as basic feedstock. Most plants ferment slurry from cattle or pigs, some use a mixture of several animal species. Pig slurry as basic feedstock increased recently. About two thirds of the biogas plants ferment energy crops. The most used crop is maize; it is part of the feedstock in every second plant. Other materials for biogas production are grass silage, green rye, alfalfa, clover, sunflowers, Sudan grass and sugar millet. The energy crops are mainly grown on the farm, only a few operators of new biogas plants buy maize or grass silage. The agricultural conditions allow producing energy crops on set aside land (2461/1999/EC). 23 % of the farmers make use of this possibility for biogas production. Organic waste is mostly processed in old plants. 57 % of the biogas plants use fat and oil waste, 50 % catering waste, 27 % source-separated organic municipal solid waste and some other organic wastes (see figure 4). Half of the farmers collect the organic waste themselves. Most use tractors and trailers, farmers with small plants use a car with a trailer; farmers specialized in fermenting waste use garbage collecting lorries.

Most operators use the same feedstock mix year-round. Seasonal differences in the feedstock mix may be caused by a varying waste supply in tourist regions or by grazing cattle in summer. The number of co-digested materials differs according to the date of implementation. On average new plants co-digest three and old plants two different materials.

All farm-based biogas plants use wet fermentation with continuously fed digesters. Plug-flow digesters are used up to a capacity of 150 m^3. The predominant system is a total-mixed digester. Usually a post-digester is attached and connected to the gas collecting system. The feedstock is pumped from the pre-storage tank into the digester and the degassed manure is stored in a storage tank until it is spread on the fields. All biogas plants are equipped with enough storage capacity for the degassed manure to fulfil the rules of the ÖPUL (Austrian program to promote an environmentally conscious, extensive and natural habitat protecting agriculture) (BMLFUW, 2000b, 3). The ÖPUL prohibits the fertilisation during four months in winter and on frozen soil (BMLFUW, 2000a, 207). The average storage capacity of the biogas plants lasts for six months, which is enough capacity in case of bad weather conditions for spreading degassed manure.

Nearly all biogas plants are equipped with a mixing pit. Additional pumping and service pits partly exist. Biogas plants operated cooperatively are equipped with an additional pit to store the collected slurry. Old biogas plants use the mixing pit for several functions: collection of the feedstock, pre-storage and housing the central pump station. Most of the new plants are equipped with separate pits for each function.

All respondents use the biogas for electricity generation in combined heat and power (CHP) units. Most farm-based biogas plants use a gas engine in the CHP-unit. Modified petrol engines are used in small plants because of lower investment costs. In most plants two aggregates are installed to guarantee working reliability. The surveyed biogas plants have an installed capacity of 77 kW_{el} and the CHP-units have an average working period of 18.6 hours per day. The efficiency of the CHP-units reported by the operators increased slightly in the past from 28 % to 29 %. A progress in electricity generation efficiency is important for the cost efficiency of a biogas plant (LUSK, 1998, 5).

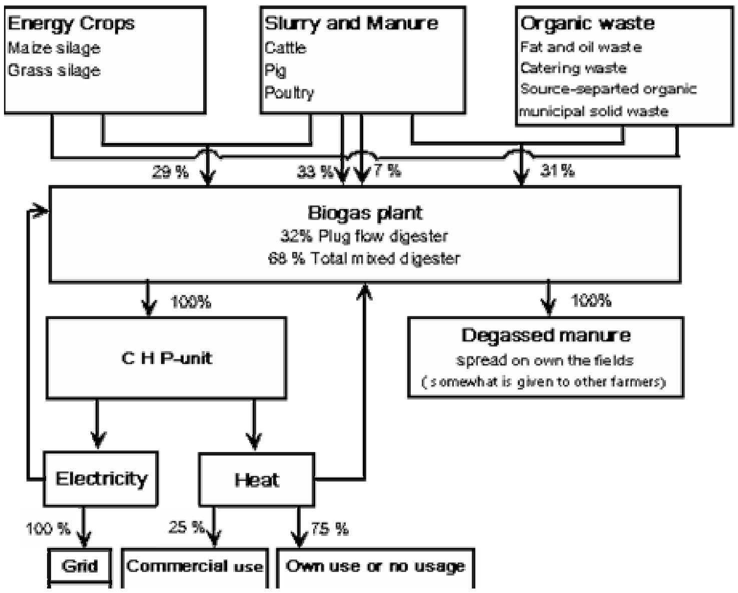

Figure 4: Overview about feedstock, plant concept and biogas utilisation of the biogas plants surveyed

The generated electricity is sold to grid. 20 % of the biogas operators sell the heat year-round and 5 % during the winter months. 75 % of the operators use the produced heat on the farm to heat the living and stable buildings. The proportion of electricity and heat used by the biogas plants decreased in the recent past due to more efficient equipment for mixing, pumping and heating. The fermentation process needs 11 % of the produced electricity and 27 % of the heat on average.

8. Labour requirement

The labour requirement does not differ according to the date of implementation. Differences were found regarding the feedstock. Biogas plants using exclusively slurry and manure require on average 1.1 hours per day, the data vary between 0.35 and 1.75 hours per day. The biogas plants fermenting energy crops needed on average 1.25 hours per day, varying between 0.5 and 2 hours per day. Biogas plants using organic waste reported the highest average labour requirement (1.7 hours per day), the dispersion is highest too (between 0.5 and 5.3 hours per day). The large dispersion results from the different degree of impurity of waste and the technical equipment for conditioning. Biogas plants with complex automatic control systems need less labour than those without.

9. Investment costs

The analysis of the investment costs was confined to 34 plants built since 2000. The capacity of the plants measured in kW_{el} was the criterion to form five groups of plants for the analyses (see figure 5).

The survey results indicate a distinct decrease of investment costs per unit as the size increases. Various reasons are responsible for the deviation of the investment costs for plants of similar capacity. The contribution of the owners, purchasing in cooperation, precise planning, site and construction of the plants, the distance between the biogas plant, the stable and the farm house, the availability of farm buildings and the technical equipment of the plant concerning stirrers, pumps, controlling devices are some of the examples mentioned in the survey (WALLA and SCHNEEBERGER, 2003, s.p.). In Austria the plant operator is responsible for the establishment of a transformer station and the reinforcement of the grid (BGBl. I Nr. 149/2002).

The farmers were also asked to report the operating costs of the biogas plant: Maintenance and repair costs, insurance and administrative costs and feedstock costs. The data varied very much. In some farms no additional costs of insurance occur, because the biogas plant is covered by the overall insurance. As a result the survey data are not appropriate to derive the operating cost of biogas plants for calculations, they have to be taken from the available literature (EDER and AMON, 2002; LUSK, 1998, 3-13 and SCHULZ and EDER, 2001).

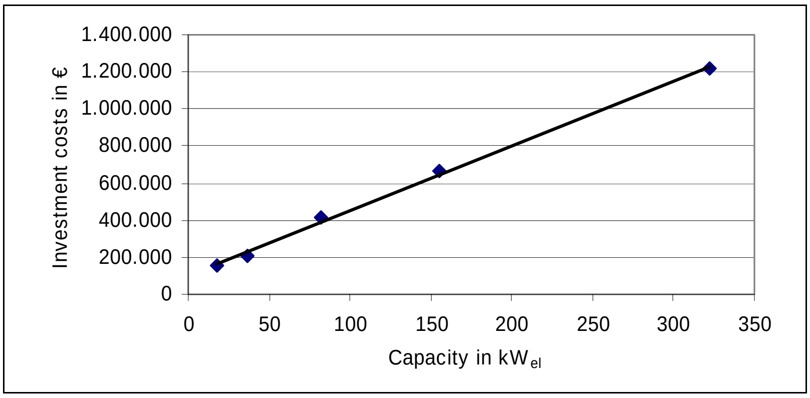

Figure 5: Investment costs per biogas plant from data of 34 plants
Source: WALLA and SCHNEEBERGER, 2003, s.p.

10. Capacity use

About one third of the farm-based biogas plants utilise the capacity fully. Table 6 presents the rates of capacity utilization. New plants have significant lower utilization rates, obviously the farmers did not adjust the biogas plants to the immediate supply of feedstock, supposable they expect an increase in feedstock supply in the future. The average rate of utilization of the plants with information to this topic is 75 %. The plants implemented before 2000 use the capacity to 80 %, those started since 2000 to 70 %.

11. Conditions stimulating the capacity utilization

Farmers who under-utilize the plant were asked for incentives to raise the utilization rate. Most farmers would intensify the energy production if the electricity price increases. Another reason for more biogas production stated by the respondents refers to the growth of the farms (livestock and/or land). More farmers tend to increase biogas production by using additional grassland than to use additional arable land.

About 50 % of the respondents consider no expansion of the capacity of the biogas plants. The rest would enlarge at an electricity price of 16.5 cent/kWh. Abandoning livestock husbandry would be another reason for expanding the biogas plant capacity. Farmers would change their crop rotation, if they receive additional direct payments for energy crops. Figure 6 shows the prices at which farmers would expand their plant capacity compared with the recent prices. By the time the survey was conducted, nearly each Austrian province had different electricity prices which were generally below the recent prices (CERVENY and VEIGL, 2002, 16).

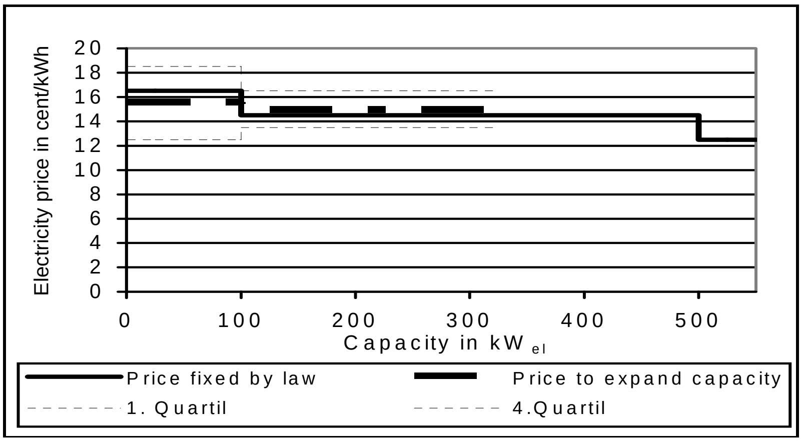

Figure 6: Recent electricity prices and capacity stimulating prices

12. Determinants of plant capacity

The capacity of biogas plants depends on various factors. A correlation and regression analyses was conducted to find out factors influencing the capacity of the biogas plants chosen by the farmers. The correlation analyses found significant correlation between the installed capacity and the arable land, number of livestock units, the rate between energy crops, manure in feedstock and the fermented amount of energy crops. Some of these variables had to be dismissed in the multiple regression model because of autocorrelation. According to the final regression model the variation of the capacity can be explained by the variation of the hectares of agricultural land, amount of purchased feedstock and the amount of fermented organic waste. The coefficient of determination is 0.671 and highly significant. The coefficients of the regression variables are significant too.

13. Cost efficiency

Only a few biogas plants in operation have detailed records of revenue and expenses. Three farmers were asked for data about investment costs, annual costs and annual revenue of their biogas plants (A, B and C) to calculate the cost efficiency (see *Table 1*). Plant A is the smallest one with a capacity of 18 kW_{el} and was built together with a new stable. Therefore the investment costs are comparatively low. Investment grants received to plant A and B. Costs for replacing the CHP-unit after 10 years in plant B and after 5 years in plant C were considered. No replacement of the CHP-unit was calculated for plant A, caused by the low utilisation ratio of 30 %. About half of the capacity uses plant B, only plant C runs on full capacity. Manure from 30 up to 230 livestock units is fermented. Energy crops are used in plant B and C additionally. Plant B sells all waste heat to a district heating. The two other plants use the waste heat partly for farm buildings.

Table 1: Economic analyses

Characteristics	**Plant**		
	A	**B**	**C**
Capacity (kW_{el})	18	100	330
Investment costs (1,000 €)	137.5	450	1,160
Investment grant (%)	40	30	0
Interest rate (%)	4	4	4
Electricity price (Cent/kWh)	16.5	16.5	14.5
Revenue per year (1,000 €)	10	84.5	406.5
Operating costs per year (1,000 €)	1.8	34.1	222.4
Payback period (years)	11	7.5	9

According to the Green Electricity Act (BGBl. I Nr. 149/2002) the price for electricity generated from biogas is agreed for a duration of 13 years depending on the capacity and the feedstock used. Operators with plants up to 100 kW_{el} capacity receive a price of 16.5 Cent/kWh and plants with a capacity between 100 and 500 kW_{el} obtain 14.5

Cent/kWh. The payback period for all three plants is less than 13 years. The shortest payback period has the biogas plant B with a capacity of 100 kW_{el} because of the received investment grant, the high electricity price and the commercial heat usage.

14. Conclusions

In the recent past bigger biogas plants were built. Some co-operations were established. Old plants mainly use slurry and manure. Cattle are the main livestock on farms with biogas plants. For co-fermentation the operators use mainly maize, biomass from grassland and organic waste. The Green Electricity Act distinguishes between agricultural feedstock and organic waste. Recently energy crops became more important. New plants therefore are located in areas with high maize yields. The advantage to reduce the odor of slurry is mainly used by pig and poultry farmers. Most biogas plants are located in rural areas without the possibility to sell heat. Nevertheless farm-based biogas plants are an opportunity to increase the net income of the farm family. The size of the plants and the feedstock used determine the costs to a great extent. The plants should be planed carefully to avoid complications and to establish a viable enterprise.

Acknowledgments

The Austrian National Bank supports the research project called "Electricity and heat from biogas, an economic and ecologic analysis". The authors thank for financing the project, special thanks to the biogas plant operators who generously spent their time to complete the questionnaire and thus made this research possible.

References

AMON, T., JEREMIC, D. and BOXBERGER, J. (2001): Bau, Technik und Umwelt in der landwirtschaftlichen Nutztierhaltung. Hohenheim.

ARGE BIOGAS (2000): Spätstarter Biogas. In: EVA: Renewable Energy in Austria. Vienna.

BMLFUW (2000a): Österreichisches Programm für die Entwicklung des ländlichen Raums. Vienna.

BMLFUW (2000b): ÖPUL 2000, Sonderrichtlinie für das Österreichische Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft. Vienna.

BMLFUW (2002): Bericht über die Lage der österreichischen Landwirtschaft 2001. Vienna.

BMLFUW (2003): Sonderrichtlinie für die Umsetzung der „Sonstigen Maßnahmen" des Österreichischen Programms für die Entwicklung des ländlichen Raumes. Vienna.

CERVENY, M. and VEIGL, A. (2002): Einspeisungen elektrischer Energie aus erneuerbaren Energieträgern in das öffentliche Netz. In: www.eva.ac.at (10.05.2003).

E-CONTROL Ltd. (2003): Oral information about the electric capacity of the Austrian biogas plants. (6.2.2003).

EDER, M. and AMON, T. (2002): EcoGas, Programm zur Berechnung der Wirtschaftlichkeit von Biogasanlagen, Ausgabe Österreich (Stand 2002). Österreichisches Kuratorium für Landtechnik, Vienna.

JAUSCHNEGG, H. (2003): Landwirtschaftliche Biogasanlagen in Österreich, Stand der zahlenmäßigen Entwicklung per Ende 2002. Austrian Biomass Association, unpublished Skript.

LUSK, P. D. (1998): Methane recovery from animal manures, the current opportunities casebook. National Renewable Energy Laboratory Golden, Colorado.

NEUBARTH, J. and KALTSCHMITT, M. (2000): Erneuerbare Energien in Österreich. Vienna, Springer.

NIELSEN, L. H. and HJORT-GREGERSEN, K. (2002): Quantification and Pricing of Externalities Related to Centralised Biogas Plants. 12th European Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection, Amsterdam.

NILL, M.; WILFERT R.; KALTSCHMITT M. and WEILAND, P. (2003): Umweltaspekte einer Biogasgewinnung und –nutzung. In: VDI: Biogas – Energieträger der Zukunft. Düsseldorf, VDI Verlag.

SCHULZ, H. and EDER, B. (2001): Biogas-Praxis. 2. Auflage, Staufen bei Freiburg, Ökobuch.

WALLA, CH. and SCHNEEBERGER, W. (2003): Analyse der Investitionskosten und des Arbeitszeitbedarfs landwirtschaftlicher Biogasanlagen in Österreich. Berichte über Landwirtschaft, Volume 81, 4.

Affiliation

Dipl.-Ing. Christoph Walla
O.Univ.Prof.Dipl.-Ing.Dr. Walter Schneeberger
Institute of Agricultural Economics
University of Natural Resources and Applied Life Sciences, Vienna
A-1180 Vienna, Feistmantelstraße 4
Tel.: +43 1 47654 3550
eMail: christoph.walla@boku.ac.at, walter.schneeberger@boku.ac.at