EU AGRO BIOGAS PROJECT

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Key word: *Biogas, Feedstock Database, Technological innovations, Environment, Economy, Sustainability*

Summary

EU-AGRO-BIOGAS is a European Biogas initiative to improve the yield of agricultural biogas plants in Europe, to optimise biogas technology and processes and to improve the efficiency in all parts of the production chain from feedstock to biogas utilisation. Leading European research institutions and universities are cooperating with key industry partners in order to work towards a sustainable Europe. Fourteen partners from eight European countries are involved. EU-AGRO-BIOGAS aims at the development and optimisation of the entire value chain – to range from the production of raw materials, the production and refining of biogas to the utilisation of heat and electricity. The online European Feedstock Database was developed from all participant countries, a substantial amount of data (more than 10 000 analyses) was generated and collected. The online European Feedstock Database is designed as an open database where new data can always be fed in. It contains essential information on the quality of feedstock utilizable for fermentation including their methane production

capacity. The online European Feedstock Database allows an initial testing of biogas potentials of regionally available substrates and substrate mixtures. The set up of quality definitions for feedstock enables the economic and energetic optimisation of substrate mixtures for biogas production.
Field demonstrations of all technologies and methods developed in course of EU-AGRO-BIOGAS are the core element of the project. EU-AGRO-BIOGAS includes the following demonstration activities at commercial plant level: Innovative approaches of feeding technologies, monitoring, management and early warning system, newly developed sensors, approaches to improve the degree of efficiency of the fermentation steps (enzymes, micro-organisms, stirring technologies), a floating system which recovers a significant amount of methane from the digestate storage tank without requiring changes to the A.D. management chain.
A crucial task within the EU-AGRO-BIOGAS project is the economic and environmental assessment of the demonstration measures on selected medium- and large-scale biogas plants across Europe.
EU-AGRO-BIOGAS started in January 2007 and will be finalised in January 2010

1. Aim

EU-AGRO-BIOGAS aims at the development and optimisation of the entire value chain – to range from the production of raw materials, production and refining of biogas to the utilisation of heat and electricity. All developments and strategies are demonstrated and proofed at real life conditions. An efficient utilisation of raw materials is achieved through the definition of raw material quality, an increased input of secondary agrarian raw material components and by-products of the food and biofuels industry, and energy and economically optimised raw material mixtures (incl. pre-treatment). The state of technology, management, economy and environmental effects is assessed through benchmarking on selected medium- and large-scale biogas plants across Europe. The improvement of biogas efficiency, conversion and utilisation (technical, economical, ecological) is shown by demonstrations on selected biogas plant across Europe. Heat utilisation is improved through optimised management. Demonstration activities (technical, economical, ecological) are benchmarked and recommendations for an efficient biogas production are developed and widely disseminated.

2. Results

2.1. European Feedstock Database and EU - Methane Energy Valuation Model (MEVM) standard methodology

Based on intensive literature surveys by all project partners and lab-scale experiments of feedstock from all participant countries, a substantial amount of data was collected and the main aim, the development of the new and comprehensive online European Feedstock Database (http://daten.ktbl.de/euagrobiogas/) on feedstock for biogas plants, was fully achieved. The online European Feedstock Database is designed as an open database where new data can always be fed in. It contains essential information on the quality of feedstock utilizable for fermentation including their methane production capacity. The following feedstock groups are represented in the database: energy

crops, animal manures, by-products of the food, feed, and biofuel industry and harvest residuals. The database contains information on feedstock, which are most important for European biogas production from a quantitative and qualitative point of view. The database depicts the existing variety of available feedstock in Europe. In the database, 667 data on biogas yield, 767 data on methane yield and 9,291 data on substrate analysis from energy crops, animal manures, agricultural residues, other waste materials and substrate mixtures are currently available.
Methane energy value models (MEVM) were developed for the prevailing feedstock of maize silage, sorghum silage, triticale silage, and sun flower silage. The same was done for feedstock mixtures containing remains from bio-refinery systems, agricultural residues and energy crops. The online European Feedstock Database allows an initial testing of biogas potentials of regionally available substrates and substrate mixtures. The set up of quality definitions for feedstock enables the economic and energetic optimisation of substrate mixtures for anaerobic digestion. Hence, the online European Feedstock Database is a basis for the planning of biogas plants and is organised as an expert database to support planners, consultants, plant operators, plant breeders and advisors of agricultural biogas plants.

2.2. Benchmarking, weak point analysis and early-warning system

A selection of commercial plants has provided information on the fermentation parameters, economics, monitoring instrumentation and plant schematics. These parameters were benchmarked and compared to identify weak points from a statistical perspective. Additional weak point analysis was provided by the plant operators. These information were used to define the needs of the early warning system and to highlight the demonstration activities. The constrictions of which parameters can be measured and those needed for process control were balanced and the means of process control and management of the biogas plant by software control were identified. The method involves the use of a soft-sensor which is a means of using easily acquired data and mathematically constructing a more appropriate parameter. New means of process control have been identified that provide early warning of process failure and ultimately will lead to better biogas production.
A pilot scale system was used to investigate both, different sensors for fermentation monitoring and mathematical solutions to process control. The influence of different feedstock on biogas output, process control and monitoring is being investigated. Feedstock will include manure that is quickly digested and energy crops which are less easy to hydrolyse and may require different operational parameters. Our generic approach will enable adaptation to these needs. Successful mathematical models of process control are being progressively identified and validated.

2.3. Technological innovations in process optimisation

Tests and experiments at lab-scale and also at plant level have been accomplished to improve the degree of efficiency in producing biogas. The efforts concentrated on the optimisation of feedstock pre-treatment, the use of enzymes and new approaches in feeding technology.

Many plant operators in Europe use lingo-cellulose-rich raw materials such as solid manure, grass silage or similar feedstock as input in their biogas plants. In order to increase the availability of this feedstock for digestion, it is necessary to pretreat the material. A promising method could be the pretreatment with fungal enzymes, which will support the hydrolysis of the ligno-cellulose complex (Fig.1).

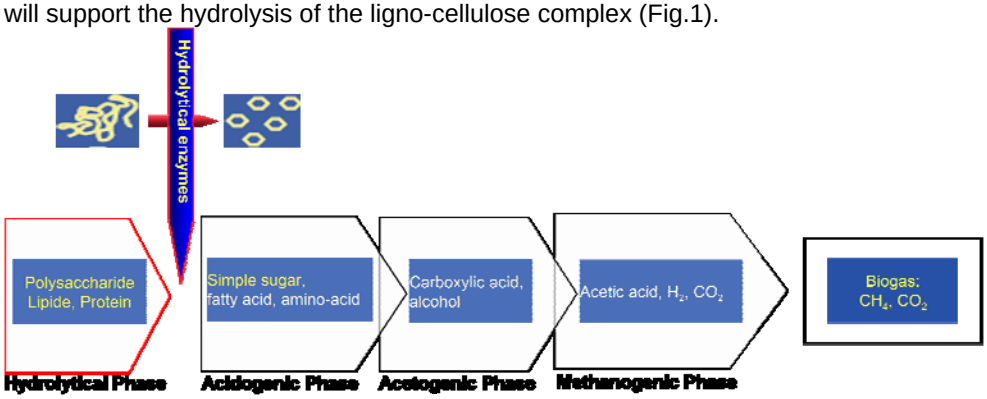

Figure 1: Support of hydrolytical segregation of polymers by fungal enzymes

Experiments at plant level have been conducted at the biogas plant of Rhinmilch GmbH, Fehrbellin, Germany, based on results of lab-scale experiments from Suárez Quiñones et al.. The focus of this experiment is an improved biogas production from given substrate (grass silage) and to enhance the activity of the fermentation process, to reduce formation of swimming layers and to decrease agitation power.

Table 1: Data of biogas plant

Substrate amount	[m³/d]	183
Hydraulic retention time	[d]	33
Biogas production	[m³/d]	13 600
Methane content	[%]	54
Electricity production	[kWh/d]	32 400
Heat production	[kWh/d]	37 200

In a first step, both components have been mixed together by a fodder mixer to achieve a sufficient contact surface of the enzymes and the grass silage. Owing to the standards of the manufacturer, the enzymes-substrate-ratio was fixed to 1:25 referred to the content of volatile solids (VS) of the grass silage. After mixing both components, the enzymes require some time to develop the optimum effect. This latency time has been optimized in the lab scale experiments and depends on the temperature of the mixture (optimum: 37°C).
In the following, the pretreated substrate mixture was fed to the digester by a drag-belt conveyor. The effect of the pre-treatment will be evaluated within the EU-AGRO-BIOGAS project by measuring the biogas production and the power consumption of the

agitation device. Additionally optical surveys of the swimming layer in the digester will be done.
Lab-scale experiments for the optimisation of feedstock mixtures, the pre-treatment of feedstock and the addition of additives have been performed and partly transformed to pilot-scale level to achieve further information. To avoid methane emissions from the digestate storage tank, a coverage system was developed and is already tested at pilot scale to upgrade tanks which have not been build gas tight.

2.4. Transforming biogas into heat and power

Extensive R&D and pre-demonstration activities are performed to reach improvements in the field of biogas utilization with Combined Heat and Power Plants (CHP). New technologies, like the Organic Rankine Cycle (ORC), add on power plants, and optimized technologies for heat utilisation or life cycle cost reduction through adjusted gas qualities are developed, designed and pre-validated. The drying and removal of ammonia from biogas with an improved gas scrubber has already shown the significant impact of gas impurities to the availability and operating costs of a CHP. A new more sulphur resistant type of exhaust gas heat exchanger has been developed; the validation phase already started. On two other plants the validations of advanced heat utilization technologies, e.g. grain dryer, wood chips dryer or fermentation residue dryer, are carried out. Two guidelines and reports respectively, regarding the optimized CHP use in agricultural biogas plants and best practice and standard for using heat to feed the public network will be produced.

2.5. Demonstration at commercial plant level

Field demonstrations of all developed technologies and methods during the EU-AGRO-BIOGAS project are the core element of the project. The researchers and companies from all participant countries validate their inventions, ideas and products under real time and rough field conditions. Demonstrations include innovative approaches of feeding technologies, a monitoring, management and early warning system and newly developed sensors at commercial biogas plant level, approaches to improve the degree of efficiency of the fermentation steps (enzymes, micro-organisms, stirring technologies), a floating system which recovers a significant amount of methane from the digestate storage tank without requiring changes to the A.D. management chain and measures to improve the degree of efficiency of the CHP and feeding into the heat network technologies.
First results of a new feedstock mixture for high glycerol input, new systems for on-line measurements of process parameters (pH, conductivity, redox), NIR for process monitoring, thermo-chemical pre-treatment of feedstock, first validations of drying of poorly storable fodder for cows with belt dryers, improvements of the biogas quality with gas scrubber and demonstrating the ORC technology, are very promising in improving the biogas yield and efficiency at the selected commercial biogas plants.

2.6. Improvement of economic output and environment protection

A crucial task within the EU-AGRO-BIOGAS project is the economic and environmental assessment of the demonstration measures. Most of the demonstration actions have been launched recently and main results will be available at the end of the project in spring 2010. The partners agreed to use the following indicators to assess the environmental effect of the different demonstration activities:

- energy balance
- emission of CO2 equivalents and CO2eq mitigation costs

An existing tool used for the calculation of these parameters will be adapted for the requirements of the project, while for the economic part the ECOGAS tool will be applied. The economic and environmental impact of the demonstrated activities are clearly lined-out and assessed against the current status quo – comprising the whole biogas production process from feedstock provision (esp. cultivation of energy crops) to the feed-in to public power or heat supply systems. The results of the assessment will serve as a decision support for biogas planners and consultancy, plant operators as well as regulatory public bodies. The assessment will provide easily available sound economic and ecologic information (costs, benefits, potential side-effects) on a range of different optimisation measures.

Both assessment tools (ecologic footprint tool, ECOGAS tool) will be designed in an open and flexible way so that the whole range of biogas plants can be depicted and assessed in the future – independent of feedstock, technical equipment, process solutions etc. Consequently, an evaluation of new, innovative approaches at plant level will already be possible during the planning process. Together with the online European Feedstock Database, this will substantially improve planning security and thus provide an important decision support to the biogas community as a whole.

3. Conclusions and outlook

The EU-AGRO-BIOGAS project will optimize the biogas process, beginning with optimized feedstock mixtures, pre-treatment of the feedstock and the addition of enzymes and develop a system for the automated process control. The efforts improve the possibility to control the biogas process and raise the yield of the produced methane. The efforts give the plant owner an improved possibility to control the process and to produce biogas at a higher level of efficiency while minimising greenhouse gas emissions. A crucial task within the EU-AGRO-BIOGAS project is the economic and environmental assessment of the demonstration measures. All results of the project will be presented at the final conference “Biogas 09” on 26th November 2009 in Wels (Austria).

Acknowledgement. EU-AGRO-BIOGAS: Contract No.: 019884. An European specific target RTD project supported through the sixth framework Program of the EC (DG TREN)

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