Project No. 030348

AGROBIOGAS

An integrated approach for biogas production with agricultural waste

Instrument: **Specific Actions for SMEs: Collective Research Projects**

Thematic area: **Sustainable development, global change and ecosystems**

FINAL REPORT
Deliverable 48

Due date: 1st June 2009
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Period covered: 01.06.2006 to 31.05.2009
Start date of project: 01.06.2006 Duration: 36 months

DAAS
Project Coordinator Final version

Preface

This is the Final Activity Report of the Collective Research Project AGROBIOGAS – An integrated approach for biogas production with agricultural waste. The main objective of the report is to summarise the project activities and results over the full duration of the project from 1st of June 2006 to 30th of May 2009.

The information in the report is based on inputs from all partners in the project. The information is gathered and presented in this report by the project coordinator, DAAS.

Aarhus, Denmark
October, 2009

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Project Coordinator,
Danish Agricultural Advisory Service, DAAS

Table of Contents

1. PROJECT EXECUTION

The benefits of anaerobic digestion

Anaerobic digestion of agricultural waste is a cost-effective way of reducing green house gas emissions and thus a useful tool against global warming. As a source of renewable energy biogas can replace part of the fossil fuels in the energy sector and thereby reduce CO_2 emissions. In addition, when manure from animal production is used for biogas production unintended emission of the strong green house gasses CH_4 and N_2O is controlled.

Anaerobic digestion is a sustainable way of handling agricultural waste materials and the environment benefits in several ways. Treatment of organic wastes in biogas plants results in increased nutrient uptake by the crops when the digested material is applied to the fields. Thus, anaerobic digestion is a way of reducing nutrient losses to surface and ground waters.

Production of renewable energy is a growing source of income for European farmers and investment in biogas production can be a relevant business opportunity for farmers throughout Europe.

Barriers for development of the European biogas sector

The theoretical potential of methane achieved from animal manure and energy crops (5% of the arable land in EU-27) produced through an anaerobic digestion process could supply 59 Mtoe, which equals to more than a third of Europe´s natural gas production or 13,5% of the consumption in 2006 (438 Mtoe, Eurostat – Statistical books – Energy -Yearly statistics 2006). Thus, increased biogas production is a way to reduce Europe´s dependency on natural gas imports.

In many European countries large quantities of agricultural wastes suitable for anaerobic digestion are available. As a result there is in Europe a great potential to increase the farm based biogas production to the benefit of climate, environment and farmers.

There are, however, serious barriers for the widespread establishment of farm biogas plants in Europe. Both with regard to technical, process and management challenges as well as the economical and organisational framework under which the plants operate – on a local and national level.

The European Commission supported 6th Framework project AGROBIOGAS is focused on revealing these issues and – most important – to develop means and tools to overcome the barriers.

Objectives of the AGROBIOGAS project

The overall objective of the AGROBIOGAS project is to enhance the European development of farm based anaerobic digestion plants utilising agricultural waste materials for production of renewable energy. This will be achieved by implementing the following activities:

1. To increase the efficiency of AD with agricultural waste in co-digestion with other organic residues by:
    - undertaking laboratory/pilot scale experiments on co-fermentation in order to support the results obtained by simulation.
    - developing an European co-fermentation substrate database.
    - developing a specific AD Simulation Toolkit in order to predict the most convenient mixtures of co-substrates for decentralised agricultural biogas plants taking into account the wide variety of farmers and conditions in Europe.
    - performing large scale experiments to evaluate and optimise the AD Simulation Toolkit.

2. To gather the scattered information about biogas from local projects and make it accessible to farmers and farmers associations, ensuring a successful performance of current and future AD plants. This will be achieved by:
    - developing an European Agricultural Helpdesk Network for decentralised AD plants (farmers with a biogas plant).
    - developing an Investment Decision Tool based on the AD simulation toolkit to advise farmers interested in AD.
    - developing an European Operational Guidelines of Good practices in AD processes in 5 different languages

3. To reduce the uncontrolled disposal of AD sludge by the development of recommendations for the use of it as bio-fertiliser.

4. To train the IAGs in utilisation of the Helpdesk components, the Co-fermentation Substrate Database and in applying the bio-fertiliser recommendations. In a second step the IAGs will present the Helpdesk Network, its components and the benefits to their member SMEs.

5. To disseminate the generated knowledge by:
    - development of a project website.
    - undertaking specific training activities for IAGs, partners related with the agriculture development, partners involved in consulting services and dissemination of new technologies.
    - undertaking specific training activities for SMEs core groups of farmers and SMEs related with the provision of AD technologies and consulting.
    - undertaking an information campaign performed by IAGs.

The AGROBIOGAS Consortium

The Consortium behind the AGROBIOGAS project consists of 24 partners from 10 European countries. The partners are can be divided into 3 groups:

- Industrial Associations and Groupings (IAG) representing 8 partners
- Small and medium Enterprises (SMEs) representing 10 partners
- Research and Technology Development Institutions (RTDs) representing 6 partners

The AGROBIOGAS administrative manager is Danish Agricultural Advisory Service (DAAS, Denmark) and the scientific manager of the project is Verein zur Förderung des Technologietransfers an der Hochschule (TTZ, Germany). A complete list of all project partners is given in the table below.

Profile	**Partner name and short name**	**Country**
Co-ordinator:	1. Dansk Landbrugsrådgivning Landscentret (DAAS)	Denmark
IAG – Partners	2. European Biomass Industry Association (EUBIA)	Europe
	3. Fachverband Biogas e.V- German Biogas Association (GBA)	Germany
	4. Asociación Agraria Jóvenes Agricultores (A.S.A.J.A.)	Spain
	5. Slovenska Asociacia pre biomasu (SK-BIOM)	Slovak Republic
	6. Deutsche Gesellschaft für Sonnenenergie e.V.(DGS)	Germany
	7. Coordinadora de Organizaciones de agricultures y ganaderos (COAG)	Spain
	8. Panhellenic Confederation of Unions of Agricultural Co-operatives (PAS)	Greece
SME – Partners	9. Anneberg Gård (AG)	Sweden
	10. Hagaviks Gård AB (HG)	Sweden
	11. Azienda Agricola Testa Lara (AAT)	Italy
	12. Polnohospodarske druzstvo Agricultural Cooperative (PD-K)	Slovak Republic
	13. Biomasse Energie GmbH (BME)	Germany
	14. Elbe Bioenergie GbR (ELBE)	Germany
	15. Reliable Environmental Solutions (RES)	Italy
	16. Santiago Apóstol SCA (SA)	Spain
	17. Bioazul S.L.	Spain
	18. EARL des Brimbelles (EARL)	France
RTD – Partners	19. Verein zur Förderung des Technologietransfers an der Hochschule Bremerhaven e.V. Unweltinstitut (TTZ)	Germany
	20. Syddansk Universitet (SDU)	Denmark
	21. Sveriges Lantbruksuniversitet (SLU)	Sweden
	22. Universität für Bodenkultur Wien (BOKU)	Austria
	23. Centre Wallon de Recherches Agronomiques (CRA-W)	Belgium
	24. Universitat def Barcelona (UB)	Spain

Table 1 List of AGROBIOGAS project partners.

Project activities and results

The AGROBIOGAS consortium has developed a number of different decision supporting tools to be used in the planning phase by farmers considering investing in a biogas plant. However, the tools developed can also be used by owners of existing plants to optimise the process and economy of the biogas production.

AGROBIOGAS Substrate Database and Process Simulation Toolkit

The core element of the AGROBIOGAS decision supporting tools is a standalone software application comprising a substrate database and a simulation tool. Through the database the user gets access to a wide range of qualitative information on the 28 different substrates included. For instance the user can find information on the availability of a given substrate in the local area together with a number of biological, chemical and physical characteristics. The database also contains comprehensive data from the batch and continuous lab-scale experiments carried out in the AGROBIOGAS project.

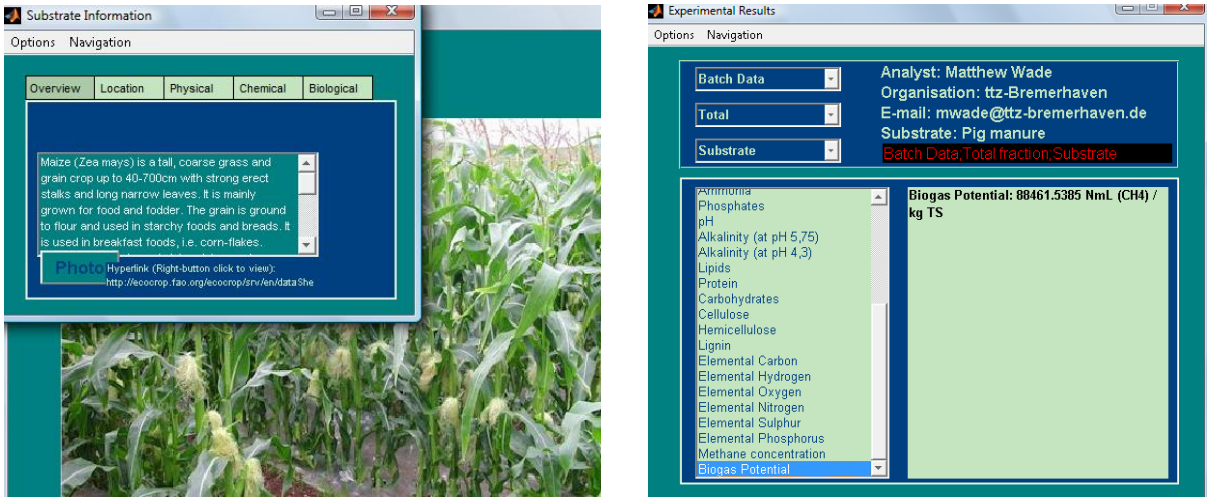

Figure 1. Screen shots from the AGROBIOGAS Substrate Database showing qualitative substrate information (left) and results from the AGRGBIOGAS laboratory experiments (right).

An important element of the decision supporting tools is the AGROBIOGAS Process Simulation Toolkit. The user specifies the types and amounts of the substrates available together with information on the biogas plant in question (e.g. reactor size, temperature, hydraulic retention time etc.). The simulation is based on an adapted version of the internationally recognised Anaerobic Digestion Model No. 1 (ADM1) and the output from the model is a number of key parameters characterising the biogas process (e.g. methane yield, pH, ammonia, inhibitions).

The outputs from the simulation can be visualised in different charts or saved as a separate file by the user. Some of the achievements of the AGROBIOGAS Simulation Toolkit compared with other simulation tools are that this tool takes into account the effect of co-digestion. Furthermore, validation of the toolkit was done using data from a number of large-scale biogas plants within the project and combined with data from literature.

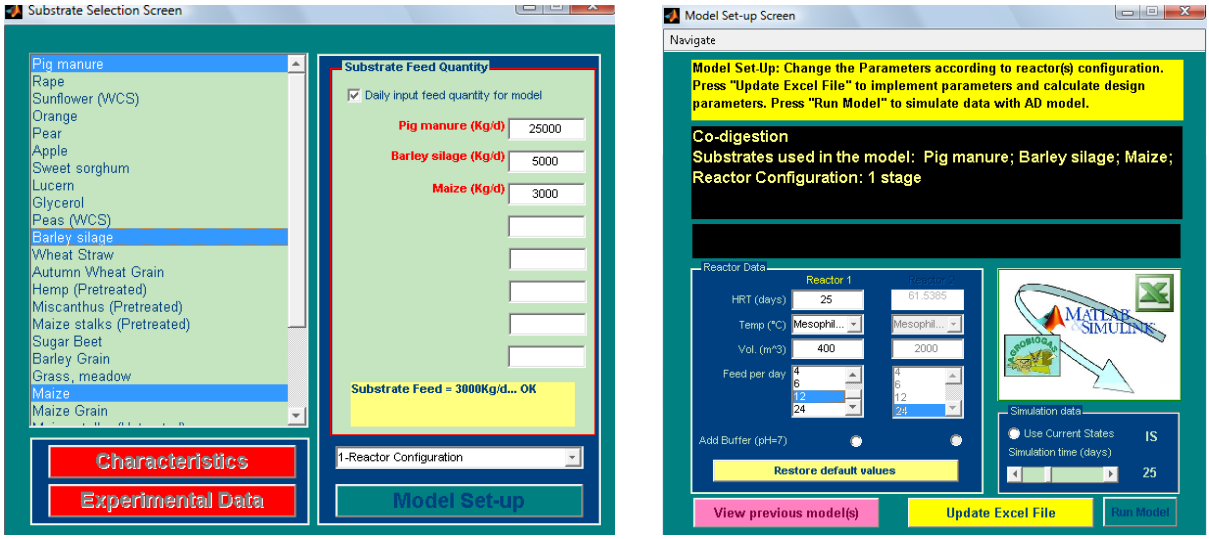

Figure 2. Screen shots from the Agrobiogas Process Simulation Toolkit. Substrate selection screen (left) and reactor configuration screen (right).

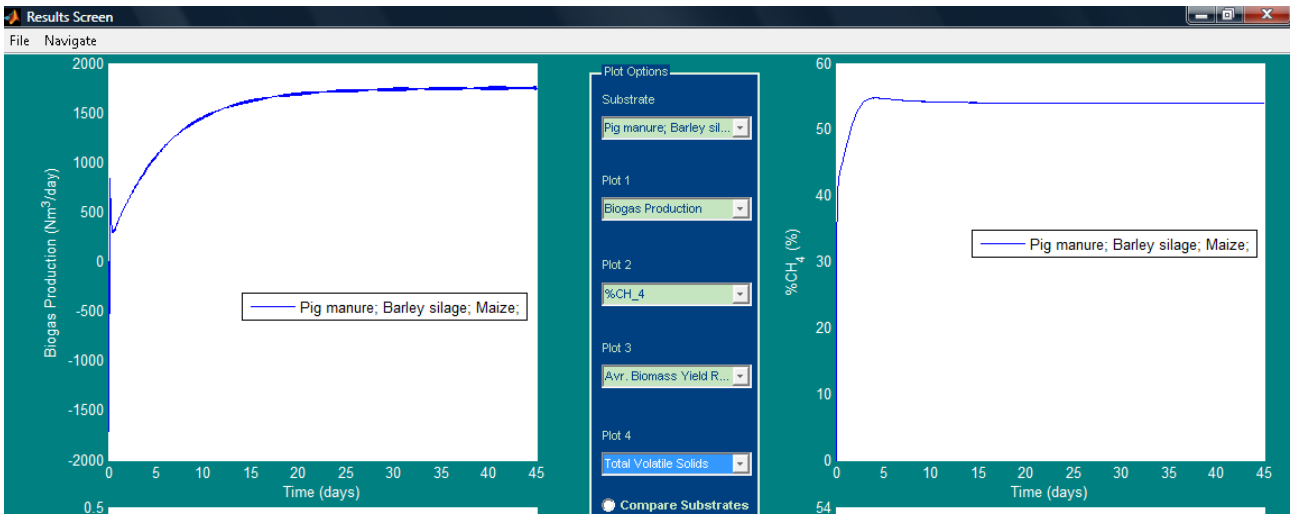

Figure 3. Screen shots from AD Process Simulation Toolkit showing examples of the results from a simulation based on pig slurry, maize silage and barley silage.

The result is a very powerful process simulation toolkit to be used both during the planning phase of new biogas plant and for optimisation of the process and economy of existing plants. For instance, the model can be used to analyse process problems and identify possible solutions. As a positive side effect the AGROBIOGAS process simulation Toolkit is very useful for teaching purposes to be used at university level to demonstrate the dynamics of biogas production.

A manual for the AD process simulation toolkit has been developed to explain and give instructions on how to use the toolkit. In addition a case study has been prepared showing examples on the use of the toolkit and demonstrate how to interpret the results.

Figure 4. Front pages of Manual 1 – Agrobiogas Database Toolkit Software (English version) and Manual 2 – Investment Decision Tool (English version).

Investment Decision Tool

The AGROBIOGAS Substrate Database and the Simulation Tool are linked to an Investment Decision Tool to facilitate a first economic evaluation of a given biogas project. Based on the specific substrate mix selected (amounts and costs) and taking into account the capital and operating costs together with the local price of the sales products (electricity and/or heat) the internal rate of return of the project and the payback period are calculated. This is useful information for European farmers considering engaging in biogas production.

INPUT FEEDSTOCKS / SUBSTRATES - ABP

No.	Type	Quantities (tons/year)	Feedstock cost type	Gate Fees - income (€/ton)	Gate Fees - expenses (€/ton)
1	Fresh pig manure (sows)	35.000	Income	20	
2	Maize sillage	10.000	Expense		15
3	Peas sillage	6.000	Expense		15
4	Grass sillage	6.000	Expense		13
5					
6					
7					
8					
9					
10					
11					
12					
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14					
15					
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21					
22					
23					
24					
25					
26					
27					
	TOTAL	57.000			
	Solids content in the digester	14,11%	!OK!		

INPUT OF KEY PROJECT PARAMETERS

No.	Products for sale	Unit	Price
1	Electricity sales	€/MWhe	100,00
2	Compost sales	€/ton	40,00
3	Heat sales	€/MWhth	27,00

No.	Financial parameters	Unit	Price
1	Own equity	%	25,0%
2	Grants - subsidies	%	30,0%
3	Loan	%	45,0%
4	Interest rate	%	6,0%
5	Debt payback period	years	10
6	Tax rate	%	30,0%
7	Required IRR	%	12,0%
8	WACC	%	8,1%

OUTPUT DATA - QUICK CHECKING

No.	Plant key performance data	Unit	Price	
1	Installed power	kW	1.534	
2	Electricity sales (exports to Grid)	MWhe/year	9.128	
3	Fiber fraction (compost) sales	tons/year	3.126	
4	Feedstocks generating Income	tons/year	35.000	
5	Feedstocks requiring Expenses	tons/year	22.000	
6	Capital Cost	€	7.948.444	
7	Payback period	years	9,76	
8	IRR own equity, 10 years	%	12,35%	!acceptable!
9	IRR own equity, 20 years	%	19,53%	

Figure 5. Section from the Investment Decision Tool demonstrating a potential biogas project.

Operational guidelines and recommendations for utilisation of AD sludge as bio-fertiliser

The AGROBIOGAS decision supporting tools also include a set of operational guidelines developed as part of the project (AGROBIOGAS Guideline 1). The operational guidelines include a general introduction to anaerobic digestion, a troubleshooting section to be used by biogas plant operators and advice on how to undertake effective process control.

In addition, the AGROBIOGAS decision supporting tools comprise recommendations on utilisation of AD sludge as bio-fertiliser to secure optimal storage, handling and application of AD sludge (AGROBIOGAS Guideline 2). The main purpose of the recommendations is to reduce the uncontrolled disposal of AD sludge. Following the recommendations secures that the potential benefits (for the farmer and for the environment) of using AD sludge as bio-fertiliser is actually achieved.

Both AGROBIOGAS Guideline 1 and 2 have been translated so they are available in 7 European languages including English.

Figure.6.The front pages of Guideline 1 - Operational Guidelines (German version) and Guideline 2 - Recommendations for utilisation of AD Sludge as Bio-fertiliser (Spanish version).

The European AD Helpdesk Network

All together the AGROBIOGAS decision supporting tools constitute the basis of the European Agricultural Helpdesk Network of advice for investors in farm based biogas plants (the European AD Helpdesk).

The European AD Helpdesk gives access to information and advice through a number of biogas experts located in 8 different European countries. Name and contact details of the local biogas experts are found on the European AD Helpdesk website which is available on the following address: www.adhelpdesk.eu. The website is available in 7 different languages.

The European AD Helpdesk provides information about technical, economical and regulatory issues both for farmers considering establishing biogas plants and for owners of existing plants. Both the Operational Guidelines and Recommendations for utilisation of AD sludge as Bio-fertiliser are available for download directly from the European AD Helpdesk website.

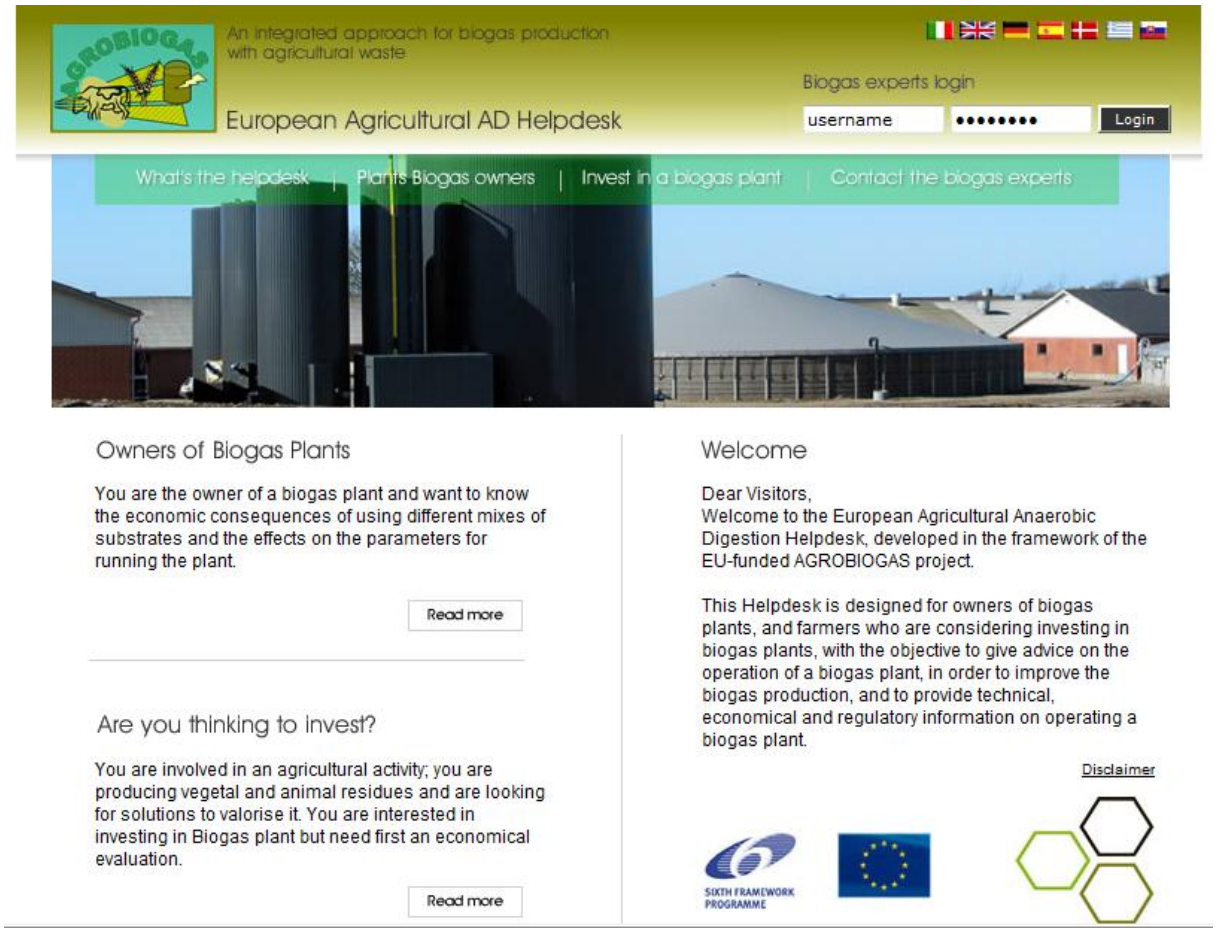

Figure 7. The welcome page of the European Agricultural AD Helpdesk.

Training workshops throughout Europe

In order to secure effective dissemination of the information generated and the decision supporting tools developed in the project a two-step training approach was used. On a 2-day training workshop for project partners the decision supporting tools including Manuals and Guidelines were presented and evaluated. Based on feed-back given the different tools and the corresponding training material (power point-presentations, etc.) was updated and translated.

In the second step 16 local training workshops were undertaken in 6 countries (Spain, Greece, Slovakia, Germany, Italy and Denmark) counting more than 566 participants in total. During these training workshops the information and the decision supporting tools were presented to potential investors in biogas plants, representatives from local authorities, representatives from biogas industries and other interested persons.

Figure 8. Photos from the local AGROBIOGAS training workshop in Slovakia (left) and in Greece (right).

Dissemination of project results

In addition to dissemination via the European AD Helpdesk Network and via the 16 local training workshops the AGROBIOGAS project and it´s results have been presented throughout Europe by project partners in articles, on web sites, on conferences and fairs. For instance, AGROBIOGAS had an oral presentation on the 17th European Biomass Conference in Hamburg, July 2009.

An introduction to the AGROBIOGAS project is given on the project website, which has the following web address: www.agrobiogas.eu.

Impact of the AGROBIOGAS Project

During the 3-year project period there has been a growing interest for anaerobic digestion among politicians, farmer associations and researchers throughout Europe. The growing interest is closely linked to the growing concern for climate changes and the challenge of identifying alternative sources of energy to fossil fuels.

As an example of the growing political focus an ambitious plan for expanding the biogas production in Denmark can be mentioned. In April 2009 the Danish government launched the 'Green Growth' action plan, which targets the agricultural sector. In 2009 around 5% of animal manure is used for biogas production in Denmark. A goal has been formulated that by the year 2020, 50% of the manure from animal production shall be used for the production of renewable energy and biogas is the key instrument to achieve this goal.

The AGROBIOGAS project has contributed with new knowledge and data as well as some concrete decision supporting tools to be used by future and existing owners of biogas plants. And the AGROBIOGAS project has contributed to raise the awareness of anaerobic digestion in several European countries.

2. DISSEMINATION AND USE

The table below contains a list of publishable results of the AGROBIOGAS project. The AGROBIOGAS Intellectual Property Committee has discussed the IPR status of each of the results and decided to make all results available for the public.

Some of the results are available for free download from the AD Helpdesk website. Some of the results (e.g. AGROBIOGAS simulation toolkit), will be available if the interested party contact the biogas expert directly.

Exploitable knowledge (description)	Exploitable products or measure	Sector of application	Timetable for commercial use	IPR protection	Owner and Other Partners involved
Final version of the AD simulation toolkit	Standalone Software tool	Researches, industry, end users	2008	Public at the end of the project. Distributed via Agrobiogas expert group.	AGROBIOGAS consortium
Investment Decision Tool ready to use	Excel tool	Industry, end users	2009	Public at the end of the project. Distributed via Agrobiogas expert group.	AGROBIOGAS consortium
Recommendations for utilisation of AD sludge as bio-fertiliser in agriculture	Report	Industry, end users	2009	Public	AGROBIOGAS consortium
Operational Guidelines	Report	Policy makers, industry, end users	2009	Public	AGROBIOGAS consortium
European Agricultural AD Helpdesk network working	webpage	Industry, end users	2009	Public/Restricted. Part of the site is only available for Agrobiogas experts through log-in.	AGROBIOGAS consortium
Training material	Various	Industry, end users	2009	Public at the end of the project. Distributed via Agrobiogas expert group.	AGROBIOGAS consortium
Project Website	website	Policy makers, industry, end users	2009	Public/Restricted. Part of the site is only available for Agrobiogas experts through log-in.	AGROBIOGAS consortium
Draft bio-fertiliser market penetration plan	report	Industry, end users	2009	Public	AGROBIOGAS consortium
Report of advice in AD for local governments	Communication report	Policy makers	2009	Public	AGROBIOGAS consortium

Table 2. List of publishable results of the AGROBIOGAS project.