Manure Management in Europe
Annotated Bibliography
August 9, 2007

This list includes references arranged by country and includes:

Denmark
France
Germany
The Netherlands
Spain

Denmark

1. "Study Tour Visiting Biogas Plants in Denmark 21-26 February 2004", Central Kazakhstan Education Biogas Center, March 2004, 8 pages. Accessed on the Internet at http://www.inforse.org/europe/kz_biogas.htm on May 1, 2006.

> This report summarizes the visits made to six Danish biodigesters, three of which were community systems, two for individual farms, and one with no further information.

2. "Environmentally Efficient Technologies in Agriculture", Danish Institute of Agricultural Sciences, http://www.ecoinnovation.dk/Topics/Research+and+technology/Danish+Institute+of+Agricultural+Sciences/, accessed May 1, 2006

> This web page lists 13 projects – with summaries – including the following that are related to the management of animal manure:
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> - Absorption in water droplets of odours, ammonia and dust from livestock buildings (Farm wet scrubber)
> - Alternative additives for fuel or combustion chamber in biomass fuel kettles
> - The use of straw in biogas plants and the possibilities of increased energy use
> - Precision management of biogas plant
> - The future common biogas system – concepts and economy
> - Improving phosphorus utilisation in Danish agriculture – from digestibility to loss
> - Intelligent Sensor for Autonomous Cleaning in livestock buildings (ISAC)
> - Operational models for ammonia emission and distribution from livestock keeping
> - Real time modelling, monitoring and management of ammonia emission from livestock buildings
> - Pigsty with source separation and optimised storage of liquid and solid manure
> - Technologies for reduction of environmental effects and nitrogen loss from animal manure
> - Development of manure treatment technology concepts for the reduction of environmental impacts and optimisation of fertilizer value of animal manure
> - Odour from Animal Production

3. "Mastering Manure Management. An Ecological and Economic Viable Concept for 100% Fermentation, Advanced Oxidation and Ultra Filtration of Pig Manure", LIFE – Environment, 2005 Projects, European Commission, Accessed on the Internet on April 24, 2006 at http://europa.eu.int/comm/environment/life/infoproducts/lifeenvcompilation_05_highres.pdf.

This is a 30-month € 3.5 million research project funded by the European Union in 2005 to a private business in Denmark to turn pig manure into bio-gas with an advanced method of oxidizing ammonium, organic constituents, metals and colloidal particles.

However, on the web page http://europa.eu.int/comm/environment/life/project/Projects/index.cfm, using the search term of "manure", it said that this project was to a fodder production firm in Estonia that also has 25,000 pigs, with the project summary giving the objectives as:

> The project aims to demonstrate an innovative technological solution for turning pig manure into bio−gas for "green" electricity and heat, water and, in smaller amounts, solid bio−fertilizer. If successful, the system will prevent the spreading of nitrates on agricultural soil and eliminate ammonium emissions, thereby representing a clear improvement in existing best available techniques (BAT).
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> The proposed system consists of an anaerobic digester, a bio−gas cogeneration engine and a digester effluent process, which includes an advanced method for oxidising ammonium, organic constituents, metals and colloidal particles.

4. "Promotion of Biogas for Electricity and Heat Production in EU Countries. Economic and Environmental Benefits of Biogas from Centralised Co-digestion ", University of Southern Denmark, et. al., web page http://websrv4.sdu.dk/bio/probiogas.htm accessed on May 11, 2006

This is a project that runs until June 2007 with funding from the European Community to do the following:

Aims and objectives

The PROBIOGAS project aims to transfer experience of the best practice of utilising RES and by this to promote the production of biogas for electricity and heat in EU countries. The project aims to raise awareness by proving that biogas is economically and environmentally beneficial to local communities and to the society as a whole and can contribute to achieving national climate and environmental protection objectives. The main objective is to transfer and apply existing knowledge to selected case studies in partner countries and to disseminate the obtained results to the project target groups and to a broad European level.

Short-term objectives:

- To asses and quantify a range of environmental and economic costs and benefits for the selected biogas case studies.
- To give a clear picture of the specific incentives and non-technical barriers for the development of biogas in the respective area
- To disseminate, transfer and implement and at European level knowledge, positive results and experience in the area of biogas.
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Long-term objectives:

- To provide a platform of documentation and to offer incentives for the decision makers and the biogas investors to initiate and develop biogas projects
- To create platforms for the development of new policy initiatives
- To motivate decision and policy makers to initiate necessary legal changes to remove non-technical barriers
- To enable the Target Group Networks to form the organisational structure necessary for initiating specific biogas projects.
- To further develop the European biogas market and the market for biogas based electricity and heat
- To accelerate the development of biogas systems all over Europe

5. Danish Ministry of Food, Agriculture and Fisheries, Institute of Agricultural Sciences, web page http://www.agrsci.org/navigation/om_djf, accessed May 11, 2006

This agency does research on a variety of agricultural issues, and publishes results in a variety of languages, including English. A search for the term "biogas" turned up 28 publications. Examples include:

Hansen, J.D., Møller, H.B., Holm, V., Hartmann, H. & Raju, C.S., 2005. New process designs of biogas plant treating solids from dewatered pig manure. Proc. 4th int. symp. on Anaerobic Digestion of Solid Waste Water, Copenhagen, Denmark. Vol. 2, 346-350. http://www.agrsci.org/jbt

Møller, H.B., 2004. Pretreatment of manure by separation as a method to improve gas production and economical performance of biogas plants. Ramiran 2004. 11th int. conf. on Sustainable Organic Waste Management for Environmental Protection and Food Safety, Murcia, Spain. Book of Abstracts, p. 155. http://www.agrsci.dk/jbt/index_uk.shtml

Takai, H., 2003. The development of biogas plants and its background in Denmark. Proc. int. symp. on Issues concerning biogas plants in cold-snowy regions. Civil Engineering Research Institute of Hokkaido, Sapporo, Japan. ISBN 4-9901495-0-5, p. 7. http://www.agrsci.dk/jbt/index_uk.shtml

France

1. "Nitrogen and odours destruction, and sterilisation of manure spreadings (Smelox process)", LIFE – Environment project. Accessed on the Internet on April 28, 2006 through http://europa.eu.int/comm/environment/life/project/Projects/index.cfm, using the search term of "manure"

This project was funded by the European Union to a research institute in France, with the goals of:

− the optimisation of the level of nitrogen in pig manure
− the deodorisation of this manure
− and its disinfection so that it can be spread onto fields.

The aim of the project was to construct two pilot units, one at a fixed location and a mobile unit for the treatment of smaller quantities of manure.

The project is now complete and achieved the following results:

1. Removing the odours caused by sulphur compounds (mercaptans) contained in the manure liquids. The process was adapted from gasoline sweetening and other light fraction freedom sweetening, already used by IFP. It is based on the oxidation of mercaptans to disulphides. This reaction is activated by contacting the manure liquids with a lean oxygen air stream in presence of an homogeneous catalyst.

2. Reducing the nitrogen content of the manure liquids. Owing to accretion of the manure liquids, part of the ammonia, which is the main contribution to the nitrogen content of the manure liquids is stripped from the liquids. The fraction of the ammonia, in the vapour phase, which represents the amount one wants to remove, is oxidised into gaseous nitrogen and water. The reaction takes place on a solid phase catalyst. A supply of oxygen is required to match the oxygen consumption. Nitrogen introduced with the reaction oxygen, and nitrogen produced by the reaction are purged to the atmosphere.

3. Sterilising the manure liquids and the off−gas. The temperatures of the mercaptans liquid phase oxidation (around 900 C.) and of the vapour phase ammonia oxidation (over 2500 C.)

have a strong bactericidal effect: strains of bacteria are destroyed. The treated liquid effluent can be spread on the soil without fear of contamination.

4. The gaseous phase ammonia oxidation is sufficiently exothermal that, once started, only a small external heat input is required. This contributes significantly to the low operating cost of the SMELOX process.

Although the project met with several difficulties and failed to deliver the mobile unit in its life span, the demonstration of the feasibility of the process was achieved. The process is now marketed by one of the partners, APVCompost who had sold 3 units by the end of 2001. The Agence de l'Eau Loire Bretagne decided to add the SMELOX process to the list of treatment processes eligible for aid from the agency. Farmers who invest in the equipment will receive a grant, which should help the commercial development of this technology.

2. "ECOLIZ − Prevention of animal dejections related pollutions", LIFE – Environment project, Accessed on the Internet on April 28, 2006 through http://europa.eu.int/comm/environment/life/project/Projects/index.cfm, using the search term of "manure"

This project was funded by the European Union to a private business in France, with the project summary giving the objectives as:

The ECOLIZ process developed by this project aimed to bring an innovative solution and operational solution to the treatment of manure on the farm and the elimination of excess nitrogen and phosphorus spread in vulnerable areas.

It aimed to demonstrate via two units (one fixed, the other mobile), the capacity of a technique consisting of a mechanical separation of manure into two deodorized phases: a liquid phase which can be used in environmentally sound fertiliser irrigation and a solid phase of concentrated fertilising elements that can be recycled into fertiliser.

The project summary states that the following results were achieved:

In the end the project only dealt with the demonstration of the fixed station. The mobile station was developed commercially (bought by an agri−food company) since Grande Paroisse was satisfied that all the aspects of demonstration had been covered by the fixed station. A fixed station was demonstrated at the GIE, "La Pimosa", a joint operation run by four stockbreeders, in order to treat all surplus manure collectively.

The ECOLIZ tool is now available to stockbreeders, it is simple to use and relatively inexpensive. It is energy-efficient and requires little maintenance or labour. The first original feature entails the separation technology which uses an entirely novel concept of an automated twin piston press filter. The second original feature is the conditioning phase of the manure using specific agents which improve its filtrability. These technological innovations have been patented by both Grande Paroisse and Elf Atochem.

The technology which has been developed is reliable, safe and perfectly suited to the world of agriculture and with little economic impact on the profitability of the stockbreeding operations. It is highly flexible, which makes it suitable to treat other types of effluents (other animal waste and industrial effluents).

Germany

1. *Ergebnisse des Biogas-Messprogramms* [Results of the Biogas Measurement Program], Bundesforschungsantalt für Landswirtschaft [Federal Research Institute for Agriculture, Germany], 2005, 164 pages. Downloaded from the Internet http://www.fnr-server.de/cms35/index.php?id=1205&idtitel=223

This report gives summary data on 59 biogas plants in Germany, with more detailed (6-7 page) descriptions and data sheets on seven systems. There are 12 chapters to the report, plus three appendices, as follow:

Staff can be contacted for a translated version of a portion of the table giving the summaries of the 59 systems (the first 10) systems and two tables of data from one of the seven systems described in more detail.

The Netherlands

1. "Environmentally friendly phosphorus removal in anaerobe effluent by means of the struvite process", LIFE – Environment project, Accessed on the Internet on April 28, 2006 through http://europa.eu.int/comm/environment/life/project/Projects/index.cfm, using the search term of "manure"

This project was funded by the European Union to consortium of two businesses in the Netherlands. The project summary notes that:

> The treatment of wastewater with metal salts (e.g. iron chloride) is the most commonly used method for phosphorus removal in the wastewater treatment plants of the food industry in Europe. The process has a high chemicals input (iron chloride). Furthermore, the process generates a waste stream of sludge containing iron phosphates. This sludge can only be disposed of in landfills, by incineration or by dumping at sea. Furthermore, with these commonly used processes, the phosphorus is not reintegrated into the biological cycle and is a threat to the quality of surface water.
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> The struvite process consists of treating the phosphorus with magnesium oxide and forming a magnesium ammonium phosphate (MAP) sludge. The MAP can be used as a fertilizer in agriculture, and this results in a closed phosphorus cycle.
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> The struvite process has already been applied to effluents from an aerobic treatment plant for liquid manure and for sewage water.

The project summary concludes the following:

> The project was successful in achieving its broad objectives through the innovative use of the struvite process to replace treatment of waste water with metal salts.

In terms of the economic, social and environmental benefits, the demonstration of the struvite process on an industrial scale achieved considerable cost savings and reductions in the environmental impact of the plant. It was found that removal of over 80 percent of the initial phosphorus load could be achieved, and that wastewater can be re−used after treatment (a problem was encountered in this respect because of scaling, but it is expected that this can be solved). The project has therefore contributed to reducing surface water pollution by producing higher quality effluent. Furthermore, using the process employed, the production of large amounts of sludge contaminated with heavy metals is avoided.

It was hoped that the struvite produced by the project could be supplied to the company Thermphos in Vlissingen. This company would use it in the production of pure MAP. However, this option was not judged economically viable. The beneficiary is looking into opportunities to market the struvite as a fertiliser for agricultural purposes, which should be possible as the process avoids the production of large amounts of sludge contaminated with heavy metals. Residue levels of heavy metals present in the struvite are within legal limits.

In the short term, the introduction of the struvite process is expected to lead to new jobs at the companies that supply process equipment and know−how. In the long term, the yearly operating costs for the struvite process at the beneficiary's site will be considerably lower than for conventional phosphorus removal – €107,500/year instead of €257,000/year during the project. This calculation includes the increase of the biogas production in the anaerobe reactor (before the struvite process) and the reduction of the sludge production in the aerobic reactor (after the struvite installation). During the monitoring period (March 2004 to May 2005), reliable measurements of the operating conditions were gathered. This data will enable the beneficiary to define exactly the limit of the process at industrial scale.

These advances will enable the process to be implemented in two other Lamb−Weston/Meijer plants. Several other operators in the potato industry have also shown an interest in implementing the technology, with the LIFE demonstration project contributing significantly to the choice of a struvite installation instead of a conventional one. These factors have demonstrated the sustainability of the project. Furthermore the test installation has remained in operation beyond the end of the project, and the struvite process is part of the daily operation of the wastewater treatment of the beneficiary.

The results of the project can also be directly applied in other food processing industries with waste water streams with high phosphorus loads: potato processing, starch, milling and sugar. In summary, the specific results from the process were:

- A decrease in the output of phosphate from 0.30 kg/ton to 0.05 kg/ton potato processed (expected result: 0.24 kg/ton).
- Phosphorus decrease in effluent of around 75 percent on average, and up to 90 percent (expected result 90 percent).
- Estimated recycling of 75 percent of effluent, equal to 1,450,000 m^3/ year (equivalent to the expected result).
- Legal constraints were experienced in development of sludge for use as fertilizer, which had been one expected result of the project.
- Estimated annual operating costs at the end of the project were €107,500 (operational costs were expected to be reduced from €275,340 to €203,800 per year).

Spain

1. “Treating Flies to Manure. Digestion Project and Later Decrease of Swinish Dung by Use of the Dipterans Fly”, LIFE – Environment, 2005 Projects, European Commission., project LIFE05 ENV/E/000302 ECODIPTERA., Accessed on the Internet at http://www.senternovem.nl/mmfiles/lifeenvcompilation_05_highres_tcm24-175095.pdf on August 9, 2007.

This is a 36-month, € 1.6 million research project funded by the European Union in 2005 to a regional authority in Spain to use dipterans flies to decompose swine manure into high quality fertilizer that can be applied without negative impacts on the environment or health. The research organization’s web page can be found at http://www.ecodiptera.info/.

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