Manure Processing Activities in Europe - Project reference: ENV.B.1/ETU/2010/0007

FUTURE TRENDS ON MANURE PROCESSING ACTIVITIES IN EUROPE

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Technical Report No. V to the European Commission, Directorate-General Environment

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Front page photos	Upper left: Decanter centrifuge for after-digestion separation of digestate. Upper right: Composting of separated solid fraction of slurry in roofed store. Lower left: Dried and pelletized separation fraction from biogas plant. Lower right: Reception facilities at biogas plant.
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PREFACE

Manure processing is presently a subject that enjoys considerable attention in the EU due to the ongoing revision of the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs (BREF), as well as due to current efforts to implement policies and legislation on EU and Member State level. There are for instance made considerable efforts to reach renewable energy targets, targets for reducing the loss of plant nutrients to the environment, targets for reduction of greenhouse gases, and targets for manure handling in agriculture in relation to legislation about water protection and manure surpluses in livestock intensive areas.

This report was elaborated on the basis of a roundtable discussion on future trends for livestock manure processing held in Brussels on 12 October 2011, and involving 22 livestock manure experts as well as DG ENV. The report suggests that locally based biogas production (anaerobic digestion of livestock manure) is a focal technology in the future because it aims at better recycling nutrients while at the same time it has other benefits, such as production of renewable energy. Product standards should be introduced as a way to support the development of the market infrastructure for end and by-products. A number of knowledge gaps require that additional research is carried out.

The report is prepared for the European Commission, Directorate General Environment, as part of the implementation of the project "Manure Processing Activities in Europe", project reference: ENV.B.1/ETU/2010/0007. The Report includes deliveries related with Task 5 concerning "Future trends on manure processing activities in Europe".

Tjele, 28 October 2011

Henning Lyngsø Foged

Project Manager

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TABLE OF CONTENT

EXECUTIVE SUMMARY

It is generally considered that manure processing is associated with better management of manure; a key solution to improve water quality. Livestock manure processing is regulated by several EU regulations and directives and DG ENV has supported technical discussions on this topic in several occasions, such as the workshop organized in Brussels in 2006, the conference in the Netherlands in November 2010 and the current study on "Manure processing activities in Europe". The study has established an inventory of manure processing, described the state of the art of processing technologies, classified end and by-products and their feasibility for marketing, and assessed the economic and environmental feasibility of different technologies via seven case studies.

The current report on "Future trends on manure processing activities in Europe" has been developed primarily on basis of a roundtable discussion, held in Brussels on 12 October 2011. 22 livestock manure experts with widely different geographical and institutional background as well as DG ENV participated to the discussion.

The following considerations were highlighted by experts:

- The world population is growing, the energy prices will increase and the phosphorus is depleting; also larger livestock concentrations are expected. Priority should be given to livestock manure processing technologies like biogas production and pyrolysis, which produce energy and recover nutrients.
- Anaerobic digestion is a preferred technology to reduce the environmental impact of pig farming because it increases the bio-availability of the nitrogen in the manure. Where relevant, i.e. in areas with high livestock density, the anaerobic digestion should be combined with mechanical separation to avoid excess fertilisation with phosphorus. In all cases the farms should be required to apply an efficient phosphorus management, including maximal phosphorus fertiliser norms, P-indices[1] and standard coefficients for livestock manures.
- Development of livestock manure processing requires an appropriate regulatory framework, so that (inter)national trading of end and by-products from livestock manure processing would be regulated and facilitated. Policies should stimulate a transition to a bio-based economy, with maximum recycling and valorisation of nutrients from manure and energetic valorisation of manure. Financial support mechanisms could be made available to develop technologies and market mechanisms for recycling of nutrients, even though the polluter pays principle should always be taken into account.
- The Netherlands has introduced an innovative way to promote biogas production via financial incentives. The agreements about subsidisation of the plans are called Green Deals. The purpose of the Green Deal is to provide environmental incentives to the most economically sound projects. The plants must apply for subsidies by offering to produce energy with a certain level of subsidisation. The plants that are able to produce energy with the smallest contribution

[1] From Foged (2910): "The purpose of a P index is to assess the risk of P delivery to surface waters. The index is a tool to help conservation planners, landowners/land users and others to evaluate the current risk from P reaching surface water from a specific site, and to determine factors which dominate the risk due to P transport to surface waters. It will also assist landowners/land users in making management decisions to reduce the risk. The P-index has an erosion component, which considers shell and rill erosion, P enrichment, total soil P, filter strip, sediment delivery, distance to a stream, and the long term biotic availability of particulate P in surface water ecosystems. A runoff component considers water run-off based on a modification of the runoff curve number, soil tests, rate time and method of P application. An internal drainage component considers the presence of tiles, water flow to tile lines, surface water recharge to subsurface flow, and soil tests. Establishing of non-cultivated buffer zones along streams, and terraces in the steep fields, would dramatically reduce the P-index. The whole index is a formula, which is easily calculated annually once the specific parameters for the given field have been determined."

receive the subsidies. Already 59 renewable energy plants, whereof several biogas plants, have been granted subsidies in this way.

Roundtable participants identified the following topics that should be made subject of additional research as an important pre-requisite for continued sustainable dissemination of livestock manure processing activities:

- Setting up an EU-wide network of livestock manure processing plants to serve research needs.
- Support to optimally configure full-scale plants for research.
- Optimal change of commonly used techniques.
- Long-term research on the effects of heavy metals on soil, due to applications of treated manure.
- Improve gaseous emissions sampling methodologies.
- Innovative technologies.
- Investigations on livestock manure qualities and amounts available for processing.

1: BACKGROUND

It is generally considered that manure processing is associated with better management of manure, a key solution to improve water quality.

- Livestock production systems have various effects on the environment. Most of these effects are related to emissions of nitrogen and phosphorus from livestock manures to the environment.
- Pressure on the environment by intensive livestock farming systems is high[2] and this has led to environmental legislation aimed at minimize the impact of this pressure.
- Manure processing is part of the solution to improve the use of nutrients in manure and to decrease emissions to the environment in regions with intensive livestock farming systems. Improvement of nitrogen balances in livestock farming systems includes also the optimization of feed composition. The whole chain from feed to manure application should be considered.
- Increased attention to phosphorus sustainability. Phosphorus in manure should be fully reused as crop fertiliser, so to decrease use of rock phosphate-based fertilisers.

Bio security and the risk for human health and safety are other matters with relation to manure management via its influence on water pollution with pathogens, some with antimicrobial resistance.

1.1: EU's legislation

The Nitrates Directive (ND – 91/676/EEC) is the main legislative instrument the EU has established to tackle nitrate pollution of waters from agricultural sources. The Water Framework Directive (WFD - 2000/60/EC) has widened the scope of measures to be implemented in order to protect water bodies, requiring Member States to ensure a good quality status of all European water bodies by 2015.

As regards the Nitrates Directive, results of action programmes implemented in EU starts to be visible in terms of water quality. 70% of surface waters and groundwater showed in 2004-2007 period stable or decreasing trends in EU, compared to the period 2000-2003. Results for the period 2008-2011 are due to be reported in 2012. Exceeding of the limit 50 mg/l in water bodies is mainly found in intensive livestock areas. Consequently measures to improve water quality are especially needed there.

The Industrial Emissions Directive (IED - 2010/75/EU), replacing the former Industrial Pollution Prevention and Control Directive (IPPC Directive – 2008/1/EC) sets demands to environmental permits of intensive livestock farms, by using of Best Available Technologies (BAT's). The National Emission Ceilings Directive (NEC Directive - 2001/81/EC) sets upper limits for each Member State for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia).

Other legislative instruments have been adopted, such as Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RE Directive), which sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy. Also, the RE Directive introduces, among others, sustainability criteria for biofuels and requires Member States to implement certification systems for biomass. Within this context, it is emphasized that livestock manure is a sustainable biomass by definition and the RE Directive identifies biogas production from livestock manure and other livestock by-products as one of the most efficient greenhouse gas reducing biofuels.

The mentioned directives establish, on one hand, obligations for different sectors, including agriculture, and, on the other hand, provide incentives for technology development, such as manure processing.

[2] There is in particular a high livestock density in certain areas of the European Union, for instance in certain areas of The Netherlands, Flanders (Belgium), Brittany (France), Aragon and Catalonia (Spain), and Denmark.

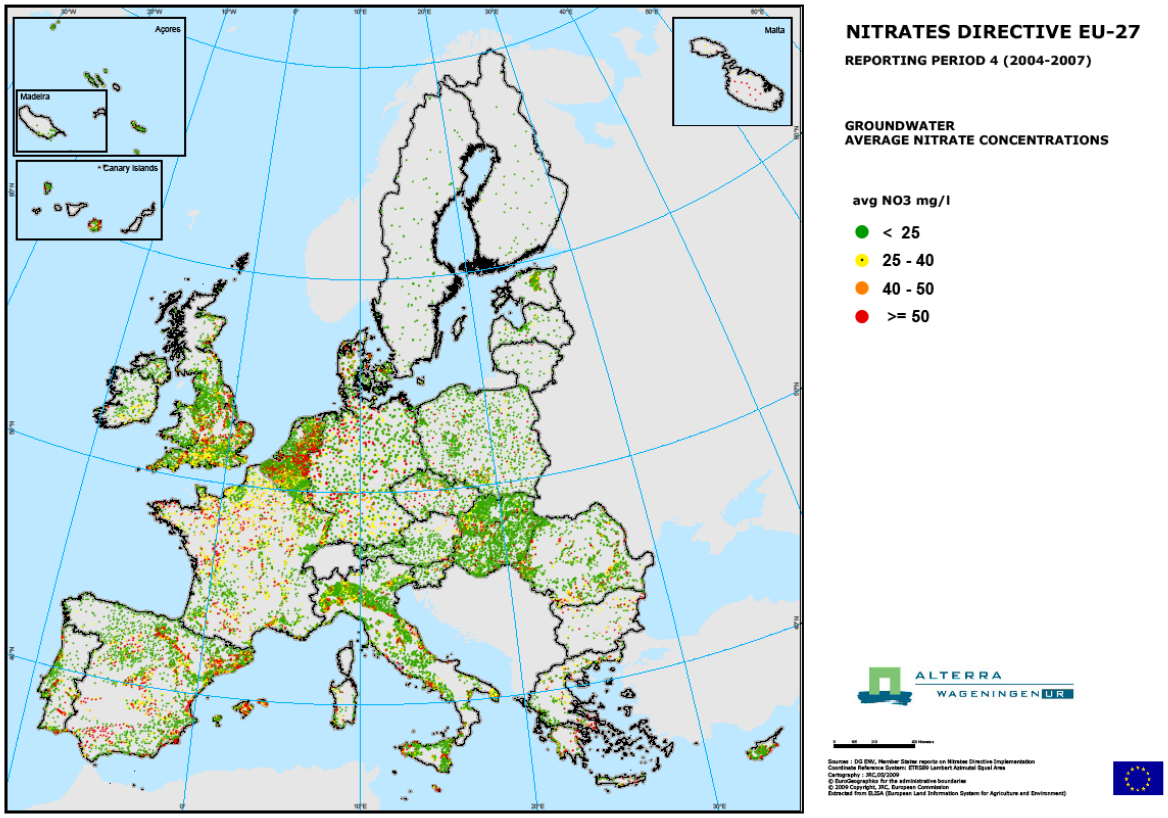


Figure 1.1: Average nitrate concentration in groundwater (Report of the European Commission to the European Council and Parliament on the implementation of the Nitrates Directive in the period 2004-2007, 2011)

The Animal By-products Regulation (1069/2009/EU) has been supplemented with Regulation (142/2011/EU), which clarifies rules for placing livestock manure or processed products thereof on the market, including provisions related with exports and imports. Livestock manure is classified as a Category 2 product and is not to be considered as an "End point"-product, meaning that it must be disposed of in the correct way. Raw manure can be applied to land without processing provided that the competent authority does not consider this practice as risky in terms of human or animal health. A pasteurisation (at least 70°C for at least 60 minutes) is required before exporting livestock manure, although trade of unprocessed manure is possible if it is notified in advance in EU's Trade Control and Export System (TRACES) and approved by the competent authority in the Member State of destination.

2: METHODOLOGY

The objective of the present report is to estimate the future trends for manure processing taking into account the influence of the progress in implementation of existing directives such as the Water Framework Directive, the Nitrates Directive, the Industrial Emissions Directive and the recently adopted Directive on promotion of the use of energy from renewable sources, which boost the processing of manure for energy purposes.

A roundtable discussion was organized to formulate such estimates to which selected experts with diverse background working on livestock manure processing participated.

2.1: Roundtable

The final agenda for the roundtable is shown in Annex A and the list of participants in Annex B.

The agenda comprised four parts:

1) Background information provided by short keynote presentations,

2) technical facts compiled in four technical reports,

3) case-based inspiration from roundtable participants in relation to five pre-defined key topics, and

4) estimation of future trends, based on roundtable participants' individual suggestions.

In relation to the fourth part, the participants were requested to formulate one or several statements about the future direction of manure processing activities in the European Union. These statements relate to the following issues:

- The technological solutions (Removal or recovery? Local or global solutions? Holistic demands to climatic and environmental effects? Etc.)
- The markets for end and by-products (Self propelled or supported with infrastructural development? Commercial or market support? Etc.)
- The regulatory framework (Continued integration in several directives and regulations? Directives or regulations? Current legislation is insufficient or needs higher flexibility? Etc.)
- The intensive livestock production and the society (The industry or the society pays? Accumulation of the intensive livestock production or maximum threshold on herd sizes? Bio-security or cheap food? Etc.)

The answers from the participants are summarized in section 4.

The roundtable participants were invited to provide additional suggestions for research needs after the meeting. A summary of these communications is included in section 5.

The roundtable discussion was thus considering future trends on manure processing from different perspectives. However, this report is solely the responsibility of the authors, who have reviewed and analysed roundtable participants' presentations and discussions etc. with own viewpoints, data and information.

2.2: Assumptions

In this report we consider trends until 2020. This seems relevant, as EU has set targets for 20% renewable energy, a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels and 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency. RE Directive (2009/28/EU) requires Member States to prepare and implement plans to reach these goals.

3: DECISIVE FACTORS FOR FUTURE TRENDS – CASE-BASED INSPIRATION IN RELATION TO FIVE PRE-DEFINED KEY TOPICS

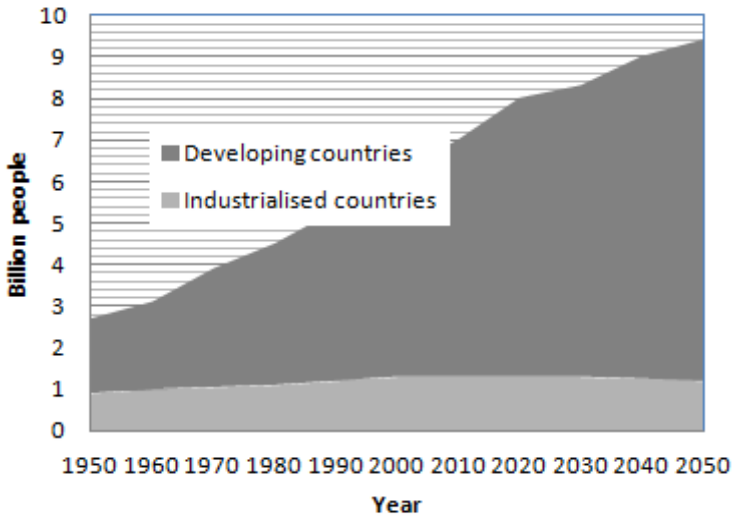
The following sections present analyses of decisive factors for the future trends of livestock manure processing in Europe. The analyses are based on experts contributions during the roundtable discussion (see Annex A).

3.1: Likely future scenarios

During the roundtable discussion, this topic has been introduced by NEFCO, which is a credit facility, set up by Nordic Council of Ministers. NEFCO has special focus on investment projects with positive environmental value, such as manure processing plants.

3.1.1: Population growth

By 2050 there will be more than 9 billion people in the entire world, around 30% more than today – see figure 3.1. This sets pressure on the food production, including livestock production, to become larger and more efficient.



Picture 3.1: Expected development in world's population, divided on developing countries and industrialised countries (after Jørgen E. Olesen, Vækst No. 3 2010).

Hence, use of livestock manure for renewable energy production and efficient use of nutrients in fertilisation of crops is required in order to meet the increasing food demand from a growing global population.

The potential win-win solutions, given the above future scenarios, demands that:

- food or feed is not used for energy production; and
- by-products from agriculture are used for closing cycles of nutrients and production of renewable energy.

3.1.2: Phosphorus

Phosphorus is, as a major plant nutrient, of special concern; phosphorus is a limiting factor for food production and in the same time a major reason for eutrophication of waters.

The majority of the world's phosphorus resources of 65,000 million ton are located in Morocco – see figure 3.2.

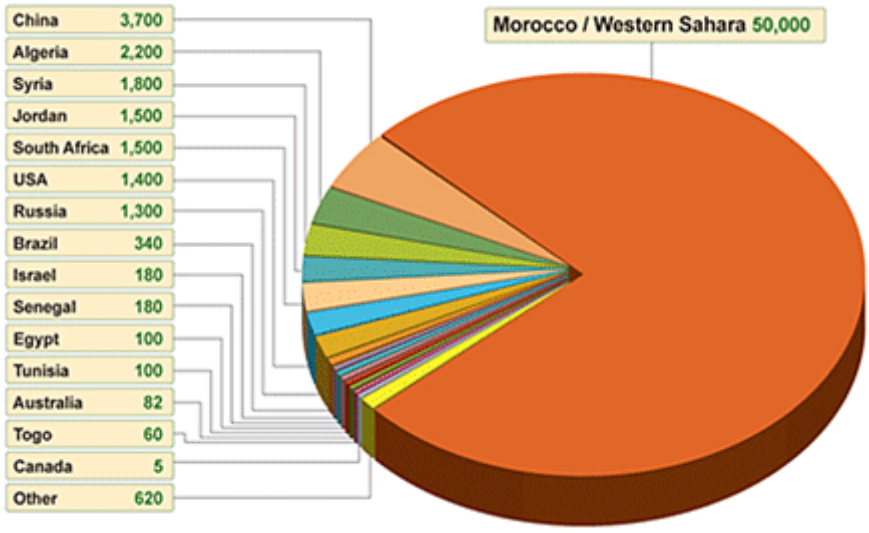


Figure 3.2: World phosphate rock reserves – 50,000 out of 65,000 million tonnes are in Morocco. Source: http://www.worldresourcesforum.org/.

Figure 3.3 shows that the production of phosphorus accelerated after the end of World War II in 1945. Scientists have forecasted that peak production will happen in 2034, where after the production will go down along with increasing difficulties and costs to excavate the remaining resources.

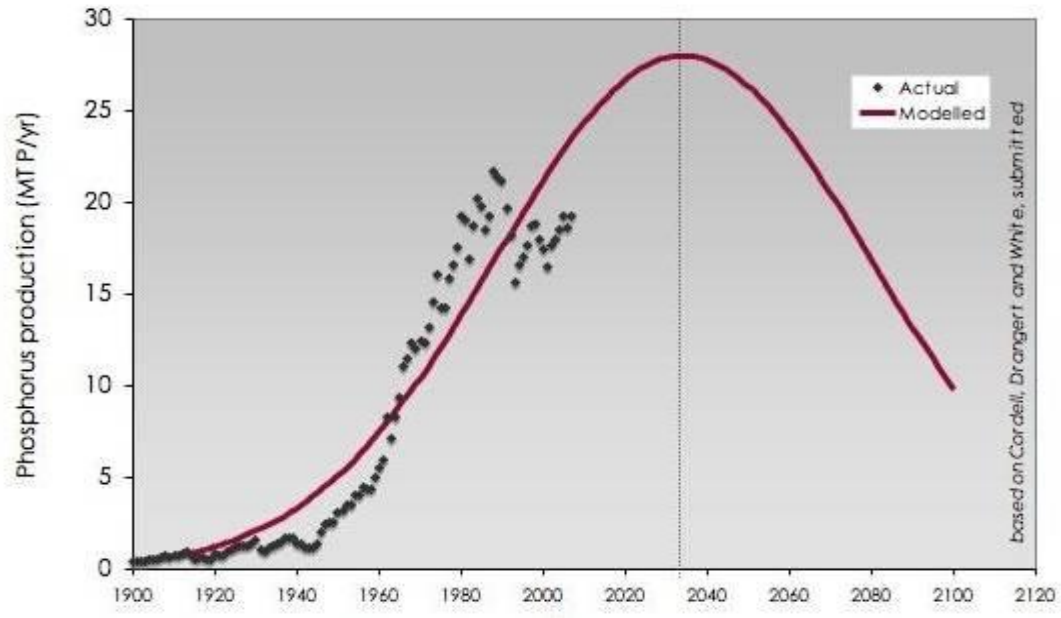


Figure 3.3: Peak phosphorus "Hubbert" curve, indicating that production will eventually reach a maximum, after which it will decline (from http://ing.dk/artikel/89792-overset-fosfor-mangel-truer-fremtidens-foedevareproduktion, based on Cordell, Drangert and White).

However, new forecasts, also taking into account possible future discoveries of new, yet unknown resources of rock phosphate predicts the possible peak to happen much later than shown in Figure 3.3.

A nervous reaction on the market made producers of feed and mineral fertiliser hamster phosphorus when the current global financial crisis started in 2008, which together with the general increase of commodity prices made the phosphorus prices increase substantially in 2008 – see figure 3.4. Phosphorus prices has since then stabilised at a more steady level. However, the general price trend for phosphorus is clearly increasing more than other prices, and figure 3.4 shows a price increase of around 400% in the period from 2000 to 2011.

The paradox for phosphorus is that, despite being a scarce resource and at the same time a pre-condition for food production, it has been used in an un-sustainable way during the last decades, which has caused important losses to waters, leading to eutrophication.

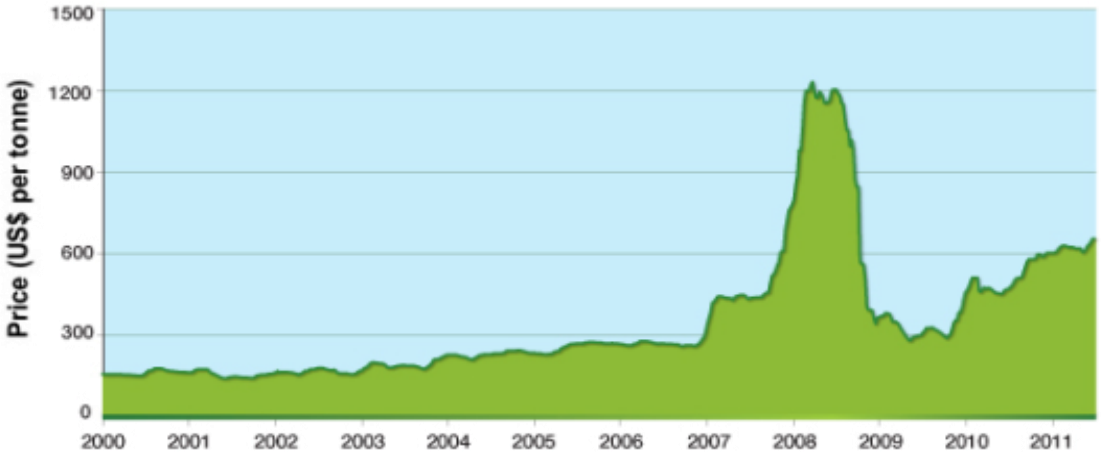


Figure 3.4: Price of di-ammonium phosphate (DAP). Source: FMB weekly Phosphates Report. Updated 7 July 2011. DAP is a downstream fertiliser product manufactured from phosphate rock concentrate.

The ability to ensure recycling of phosphorus in the agricultural production is important and the livestock manure processing technologies might significantly contribute to closing the recycling loop. The use of raw and unprocessed livestock manure as fertiliser on the fields will in many cases lead to overdosing with phosphorus.

3.1.3: Energy

Oil is also a non-renewable resource. The peak production was probably already seen around 2006. In 2001, IEA, US Dept. of Energy, EIA, EU, Canadian Department of Energy, Standard & Poor and Deutsche Bank made estimates that oil barrels would cost 17-21 USD/bbl in 2010 and 18-27 USD/bbl in 2020. In reality, the price has been between ca 80-115 USD/bbl for a long time. Energy consumption and food production are connected.

Figure 3.5: Development in oil prices from 1996 to 2008, expressed in US$ per barrel. Source: NYMEX.

The financial crisis starting in 2008 has demonstrated a clear connection between oil prices and other energy prices and a clear connection with virtually all commodity prices via commodities' dependence on energy consumption during production.

Future livestock manure processing technologies will therefore be evaluated on basis of their net energy production.

3.1.4: Farming structure

The need for food for an increasing population cannot be met by subsistence farming or small-scale operations.

If the production is concentrated, industrial solutions could be developed to deal with increased manure production. However, the large livestock concentration could cause higher risks for transmittable diseases. If no industrial solutions are found, large farmland areas would be needed for spreading manure, which is impossible, as no large net increase of farmland is likely.

Future livestock manure processing will therefore favour technologies that can be scaled up and in the same time operate with a minimum of risks for spreading transmissible diseases.

3.2: Possible best technologies for future scenarios

During the roundtable discussion, this topic has been introduced by the private Swedish foundation BalticSea2020. This foundation has initiated a number of studies[3] as part of their Intensive Pig Production Programme. The studies showed that well conceived combinations of technologies and measures can reduce N and P losses significantly:

- Safe storing of manure - prevent emissions to air and water
- Anaerobic digestion - increase nitrogen plant availability
- Separation of manure/digestate - facilitate proper balancing of nutrients
- Timely spreading of manure/digestate - maximize uptake of nutrients by crops

[3] All reports available at www.balticsea2020.org

- Dosing of N and P according to plant need – to reduce the risk for loss/leaching/run-off via
    - Fertiliser norms
    - National maximum application standards for both N and P
    - Risk indices for P-loss (P-indices)
    - Standard values for livestock manure[4]

But of course, there is no "One fits all" combination. The choice of overall concept and specific technologies depend on the specific situation – the local and country specific opportunities and barriers.

According to the Swedish foundation BalticSea2020, some prerequisites for efficient nutrient recirculation:

- Maximizing biogas yield is the most important factor for viable installations.
- Nutrients in co-substrates, probably needed to boost biogas production should be included in the nutrient balance.
- Spreading of manure should always occur preferably in spring and early summer to maximize nutrient uptake of growing plants.
- As the nitrogen components in digestate leaches more easily than in raw manure, time for spreading is even more important.

[4] The legal framework established by EU and its Member States, such as the Nitrates Directive, the Water Framework Directive and the Directive on Industrial Emissions (follower of the IPPC Directive) can principally not be effectively implemented without official standard values for livestock manure. The standards are required for calculation of the limit of 170 kg N per ha as given by Annex III.2 of the Nitrates Directive, and similarly for calculating necessary size of manure storages, and the available amounts of N & P for fertilising. The subject is further discussed by Foged, Henning Lyngsø. 2011. Need for standard values for livestock manure in the Baltic Sea region. In: Innovative Agro-Environmental Technologies for Sustainable Food Production in the Baltic Sea Region, No. 3, June 2011, page 3-4, http://agro-technology-atlas.eu/images/bc_wp4_technologies_newsletter_3_june_2011.pdf.

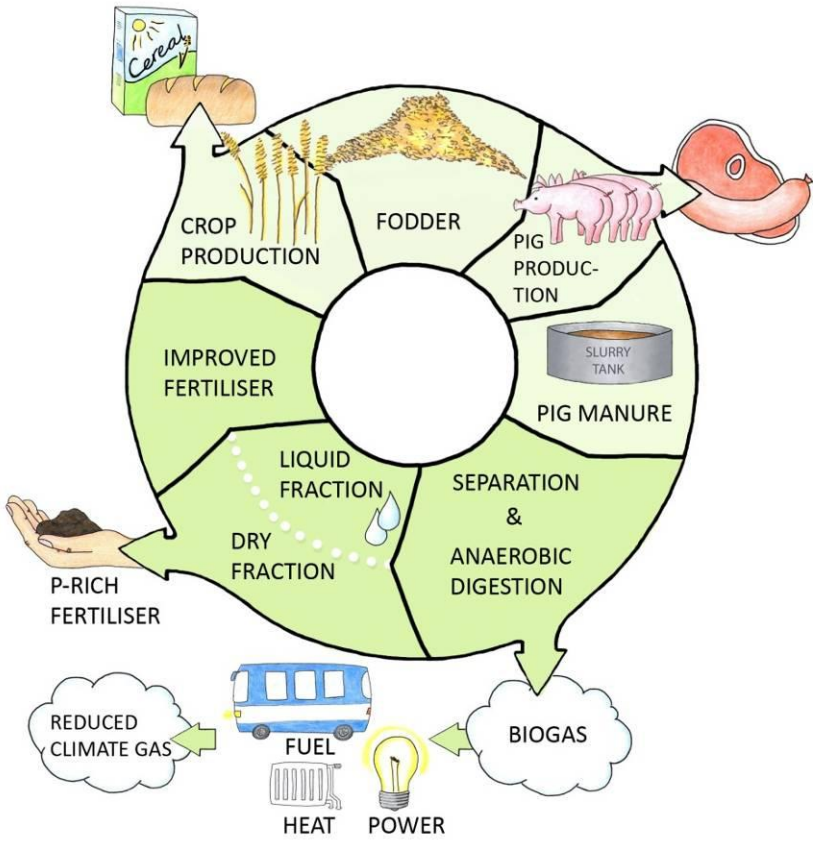


Figure 3.6: Components of an optimal processing of pig slurry (Figure provided by Lotta Samuelson, Baltic Sea 2020).

The prioritisation of anaerobic digestion, where relevant in combination with mechanical separation, and considering efficient phosphorus management, is based on an analysis of a long list of manure processing technologies. Technologies with substantial negative environmental, climatic or other impacts were disregarded, as well as those with un-validated effects, and those not proven to be economic and implemented in practice on commercial scale.

The selected technologies cater for a win-win approach. Pig manure based biogas production can benefit society, pig farmers, biogas companies and the environment.

It is important not only to make conclusions on basis of theoretical analyses, but also to make people aware of the best technologies, for instance via demonstration plants, information campaigns and farm advice. EU financed projects, such as a number of projects financed via EU Baltic Sea Programme, are important vehicles for awareness raising, information dissemination, demonstration activities and governance dialogues.

3.3: Markets for end and by products

During the roundtable discussion, the Flemish Coordination Centre for Manure Processing has introduced this topic.

Belgian law requires manure in excess to be processed. VCM (Flemish Coordination Centre for Manure Processing) is an intermediary platform between the government and the livestock sector, established in order to assist with identification of the best and most cost effective ways to process the manure.

Food production has traditionally been based on recycling of plant nutrients via livestock manure. Trade of raw and processed livestock manure products is a phenomenon, that has emerged during the last few

decades, triggered by specialisation of farming along with introduction of agro-environmental measures, for instance via the Nitrates Directive.

The current market in Europe in relation to livestock manure is dominated by organic fertilisers and soil conditioners, for instance based on composting, and use of manure for biogas production. A majority of the livestock manure products are traded locally at a price far below the value of their content of plant nutrients.

All expectations are that a higher and higher share of the livestock manure will be processed in the future. It is therefore becoming more and more important that markets for such products are functioning, i.e. used by both producers and users of the livestock manure products.

The markets for end and by-products will in the future be larger and could serve more functions, for instance

- handle trade of fertilisers that in physical form and concentration resemble mineral fertilisers;
- ensure marketing possibilities of products from energetic valorisation of livestock manure: e.g. pyrolysis;
- re-use of water in livestock manure; and
- cultivate algae, turning livestock manure into animal fodder or biomass for energy production.

The market value of end and by-products is mainly linked to their fertilising value, which depends on the market price of mineral fertilisers. Some customers, however, also value the organic matter content in manure for the soil conditioning effect or for energy production. The regulatory status of the product is also important, as current EU legislation does not allow mineral fertilisers being produced from manure.

According to the Flemish Coordination Centre for Manure Processing, the revision of the Fertilisers regulation (2003/2003/EU) could widen the scope of the Regulation to include also organic fertilisers; however, it is very difficult to reach the required standards for mineral fertilizers.

For the development of the markets of end and by-products it is recommended to consider how they could

- facilitate (inter)national trading of products from livestock manure;
- stimulate transition to a bio-based economy, with maximum recycling and valorisation of nutrients from manure and enable energetic valorisation of manure; and
- enable financial support mechanisms to develop technologies for recycling of nutrients.

If an amended 2003/2003 Regulation would include mineral fertiliser replacement products originating from livestock manure, then the Regulation should regulate their content of heavy metals, which are currently not foreseen.

3.4: Role of the society

ADAP (Asocoatión de empresas para el desimpacto ambiental de los purines) is an association of 27 large pig manure treatment plants in Spain. During the roundtable discussion, ADAP has introduced a keynote on the role of the society in relation to manure processing.

Manure processing activities have in general positive impacts, and in any case close links with:

- Environmental contamination, for instance in relation with
    - emissions of nitrogen and phosphorus to air, water and soils; and
    - emission of greenhouse gases and NOx;
- Renewable energy production, which is also reducing dependence on imported energy sources;
- (Local) job creation;

- Infrastructural development in rural areas;
- Quality of life;
- Innovation and business development.

All these issues use to be very sensitive for the society and in the public opinion, wherefore the society has to take an important and responsible role in regulating and controlling these activities.

The EU environmental legislation is based on the "Polluter pays" principle. However, manure processing technologies have been developed without official requirements, even though boosted by legislation. There are many examples of manure processing plants that have been established by public-private partnerships, for instance with involvement of municipalities, which highlight the society's interest.

Social benefits that are provided by manure processing plants can typically not be capitalised to the benefit of the private investors. A good example of this is the production of EMUs - Emission Reduction Units. Figure 3.7 shows the value of EMUs on the market. The income from sale of EMUs would contribute considerably to the economy of a biogas plant, but only companies with a CO_2 quota are able to sell the EMUs on the market. Production of EMUs also benefits the national CO_{2e} accounts in relation to international climate agreements.

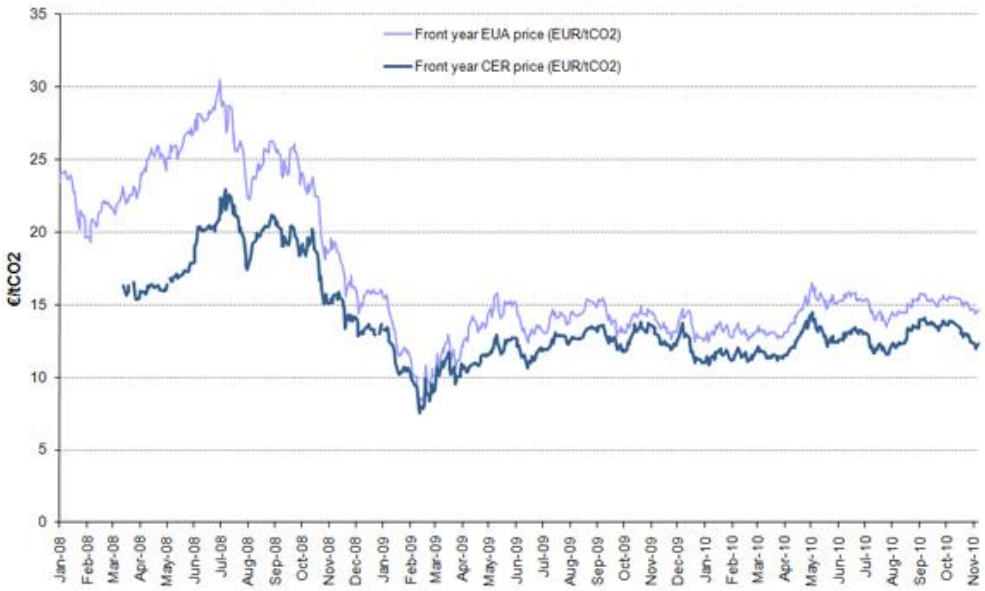


Figure 3.7: Development of market prices for CO_{2e} emission reduction units in the period from January 2008 to November 2010.

3.5: Biogas production as a tool for reaching strategic goals – the Dutch example

The Netherlands aims at reaching a biogas production of 1,500 million m^3 biogas in 2020, equal to around 400 co-digestion installations; there are presently 130 biogas plants in the Netherlands.

The biogas production strategy is based on the recognition of anaerobic digestion beneficial effects on the environment, the climate, the diversified energy production and the waste handling. A large pilot project is currently ongoing, with the aim to investigate possibilities for production of mineral fertiliser replacement products from livestock manure. The challenge is still to find the best technological processes for further treatment of the digestate from biogas plants.

The livestock density is very high in the Netherlands and farmers pay around 20€ per m^3 to service providers for taking over the slurry; these service providers transport the slurry to less livestock dense areas of the Netherlands, or export it after pasteurisation or other processing. The trend is therefore

going toward mono-digestion of livestock manure, rather than co-digestion with other products, in order not to bring into circulation more plant nutrients than necessary. If livestock manure is co-digested with more than 50% other biomass, then the resulting digestate is considered as waste that cannot be used as fertiliser on the fields.

The probably most innovative aspect of the biogas production strategy in the Netherlands is the way the financial incentives are provided. The agreements for subsidisation of the plans are called Green Deals. The plant must apply for subsidies by offering to produce energy with a certain level of subsidisation. The plants that can produce energy with the smallest subsidies will get them. Already 59 renewable energy plants have been granted subsidies in this way, whereof several biogas plants.

4: IDENTIFICATION OF FUTURE TRENDS

The following chapter is mainly based on written statements provided by experts, who participated in a roundtable discussion in October 2011 - see Annex A and Annex B.

4.1: Technology

Concerning the preferred technologies, the following general opinions were expressed:

- The technologies should primarily aim at nutrient recycling. Concerned nutrients are mainly N and P; N is expensive and has impacts on energy consumption and greenhouse gas emissions and P is a non renewable resource and is depleting. According to few experts, removal of nutrients could be justified in case this would be the only possibility. However, some experts mentioned that the removal strategy is not considered sustainable, as it has certain unwanted effects.
- Preferred technologies should produce energy or consume a small amount of it. This means that the net energy production should be taken into account. Few experts also included an economic dimension and said that energy recovery is beneficial because it generate incomes.
- Local solutions are preferred and more experts mentioned that the decisive factor for development of technologies is the transport cost and its associated impact on the climate, which has to be considered as part of the entire evaluation of a given livestock manure processing plant. Preferring local solutions is in line with the "proximity principle" on which the EU waste legislation is based. Regional plants are therefore justified if the economy of scale via higher efficiency outweighs the negative effects of transporting the livestock manure to the plants.
- Some experts said that possible financial incentives could be required for developing manure processing plants; however, requirements for the management of the plant should be a condition for subsidisation.

4.2: Market

One general conclusion can be drawn from the roundtable discussion, namely that product standards should be established as a way to support the development of market infrastructure. Product standards are understood as default chemical values for groups of end and by-products, including the content of plant nutrients and carbon, as well as maximal values for unwanted substances like heavy metals. Product standards could also be linked to the trans-boundary movement possibilities.

Other statements from experts expressed rather diverse opinions about the future development of the market. Some expert suggests product standards could be made subject to market support, meaning that subsidies for manure processing technology could be given entirely or partly to marketed end and by-products, according to defined quality standards.

4.3: EU's legislation

Most experts supported the view that EU legislation should be developed in order to take into account last developments in manure processing. This mainly concerns the Nitrates Directive (91/676/EEC) and the Fertilisers Regulation (2003/2003/EU). However, experts agreed that any development of legislation should be underpinned by scientific research, which is, at this stage, not yet complete.

Also, it was mentioned that it could be relevant to develop a specific BREF for manure processing plants, also taking into account combined technologies for manure processing. It was also mentioned that new legislation is needed concerning trade of end and by-products.

4.4: Intensive livestock production and the society

Since livestock production will continue to grow, experts recognized the need that industry contributes to the development and to the costs of manure processing, if it is envisaged to expand the livestock production in an already high livestock dense area.

Many experts suggest that consumers should pay their share of the costs via taxes, even though the “polluter pays” principle should always be respected.

Most experts think that bio-security and sustainable growth of the livestock production are more important than cheap food.

5: ADDITIONAL RESEARCH NEEDED

The study, including the roundtable discussion, has identified biogas production as a focal manure processing technology. Biogas plants can, however, be configured in numerous ways and must operate in different regional contexts, different livestock production structures, climatic conditions, energy infrastructure and emerging demand from markets for end and by-products.

Manure processing is complex, based on organic material and biological processes and its management becomes an important parameter for achieving the envisaged environmental and climatic goals.

5.1: Setting up an EU-wide network of livestock manure processing plants to serve more research needs

On this background, it is suggested to set up a (temporary - for instance for a five year period) EU-wide network of livestock manure processing plants, in order to collect information on their economic and environmental performances, with the aim to clarify the following:

- The optimal configuration in relation to regional and local policies related with environment, waste handling and renewable energy production goals, for instance under which circumstances technologies like for instance composting are justified.
- The effect of pre-treatment technologies on the performance of the plants, e.g. how flotation influences the performance of filtration technologies.
- Development of methodologies and proposal of guidelines to assess environmental performance (emissions, renewal energy production, CO_2 emission reduction, etc.) of manure processing plants, so to compare different treatment technologies on basis of such uniform methodologies.
- Analyse the importance of the management of the plants on their environmental performance as well as their impact on the climate, e.g. the management decision about use of various type and quantity of co-digested biomasses, such as maize silage.
- Development of configurations to produce specific end and by-products, such as manure pellets
- Analyse the effect of the location of the plant with respect to transport needs
- Analyse the energy needs on various configurations, including the possibility to use heat from CHP units.
- Good Management Practices should be formulated on basis of the above-mentioned analyses.
- The efficiency in relation to the production of envisaged qualities of end and by-products, including bio-security properties of these products, in particular the effect of the use of chemicals like flocculation agents and the possibilities to produce concentrated end and by-products like compost with low levels of Cu and Zn.
- The fertiliser value and environmental performance of end and by-products: Digestate, separation solids, manure concentrates such as concentrate of reverse osmosis, etc. Demonstration to farmers of the fertiliser value of such end and by-products would especially favour the development of markets for such products.
- Analyse the most efficient technological ways to recover nutrients such N and P from organic origin, with the purpose of exporting them to other regions.

The knowledge gained from the research would be instrumental for development of a specific BREF for livestock manure processing plants.

5.2: Optimal change of commonly used techniques

It is generally recognised that some manure processing technology has been installed before all their impacts on environment and climate were clear. This is for instance the case for nitrification-denitrification plants with composting of the separation solids, which cause emissions of ammonia and di-nitrous oxide, which contribute to air pollution and climate change. Another example is pelletizing of dried manure, which consume large amounts of energy during the process, which is unsustainable and becomes more and more socially unacceptable in case energy is subsidized.

Hence there is a need for research to identify the best methods for conversion of such manure processing plants. For instance one should analyse whether partial nitrification, also called autothrophic anammox denitrification, is a relevant technology for replacing classical nitrification-denitrification.

5.3: Research on soil

Research should be dedicated to assess the long-term environmental effects on soils, due to heavy metals (especially Cu and Zn) present in manure and processed manure.

The research should clarify the needs for preventive measures, such as maximal application rates for different manure and manure processing end and by-products types, as well as how the content of heavy metals in the manure can be minimized.

5.4: Gaseous emissions sampling methodologies

Gaseous emissions of ammonia (NH_3), nitrous oxides (NO_x), methane (CH_4) and di-nitrous oxide (N_2O) are recognised as harmful for air quality and for their impacts on climate change. There exists a general consensus that manure processing technologies shall be assessed against their impacts on such gaseous emissions.

However, currently our knowledge on these emissions is insufficient and associated with uncertainties. The sampling is difficult, for instance due to the small concentrations and their variation over time and the identification of the locations of the emissions, which in some cases may stem from a quite large area.

There is therefore a need for development of standardised methods and guidelines for representative sampling of gaseous emissions from manure processing plants, for instance guidelines for the best sampling locations for given manure processing types and recommendations for needed duration of the sampling in order to secure its representativeness.

5.5: Research in innovative technologies

New ideas and opportunities are constantly being discovered, with respect to optimising of already existing manure processing technologies and concerning new technologies. Examples are for instance algae production from liquid manure products, to recover nutrients and energy, and bio-electrochemical systems to recover / produce new products and energy.

However, the research and development needed to validate such ideas and opportunities require large investments, which are returned after several years.

On this background it is suggested that the opportunities for obtaining of financial support for research in innovative technologies are improved.

5.6: Livestock manure qualities and amounts

Data from Member States shows a wide variation in qualities and amounts of livestock manure from comparable livestock productions. The pig slurry in Denmark has, as an example, much lower content of solids than in Belgium. The content of solids in slurry is a very important parameter for its use in manure

processing plants, such as biogas plants. In fact, their economy heavily depends on the biogas potential per cubic metre of slurry, as well as on the need to transport and to heat up the slurry before digestion.

A wider use of livestock manure processing is therefore depending on farmers ability to produce manure of good quality, as concentrated as possible and with high content of plant nutrients and low content of heavy metals.

It is therefore relevant to initiate research on feeding strategies and production/housing systems in relation to the quality of livestock manures.

6: REFERENCES AND FURTHER READING

- Accoe, Frederik. 2011. Ensuring functioning markets for end- and by-products. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keytopic_3_future_trend_roundtable_functional_markets_accoe.pdf.
- Bos, Henri. 2011. Anaerobic (co)digestion. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keytopic_5_future_trend_roundtable_biogas_bos.pdf.
- Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources.
- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
- Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.
- Directive 2001/81/EC of the European Parliament and the Council on National Emission Ceilings for certain pollutants.
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
- European Commission. 2005. Guidance note on the control of manure and digestive tract content under the EU Animal By-products Regulation (EC 1774/2002)
- European Court of Auditors. 2011. Is Agro-Environment Support Well Designed and Managed? Special Report No. 7. 82 pp.
- Flotats, Xavier. 2011a. Presentation of the Technical Reports to the European Commission, Directorate-General Environment. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/future_trend_roundtable_presentation_of_studies_flotats.pdf.
- Flotats, Xavier, Henning Lyngsø Foged, August Bonmati Blasi, Jordi Palatsi, Albert Magri and Karl Martin Schelde. 2011b. Manure Processing technologies. Technical Report No. II concerning "Manure Processing Activities in Europe" to the European Commission, Directorate-General Environment. 132 pp.
- Foged, Henning Lyngsø. 2011a. Future trends on manure processing activities in Europe. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/future_trend_roundtable_moderation_foged.pdf.
- Foged, Henning Lyngsø, Xavier Flotats, August Bonmati Blasi, Karl Martin Schelde, Jordi Palatsi, Albert Magri and Zivko Juznik. 2011b. Assessment of economic feasibility and environmental performance of manure processing technologies. Technical Report No. IV to the European Commission, Directorate-General Environment. Unpublished draft. 126 pp.
- Foged, Henning Lyngsø, Xavier Flotats, August Bonmati Blasi, Jordi Palatsi and Albert Magri. 2011c. Inventory of manure processing activities in Europe. Technical Report No. III concerning "Manure Processing Activities in Europe" to the European Commission, Directorate-General Environment. 78 pp.

- Foged, Henning Lyngsø, Xavier Flotats, August Bonmati Blasi, Jordi Palatsi, Albert Magri and Karl Martin Schelde. 2011d. Inventory of manure processing activities in Europe. Technical Report No. I concerning "Manure Processing Activities in Europe" to the European Commission, Directorate-General Environment. 132 pp.
- Foged, Henning Lyngsø. 2010, Best Available Technologies for Manure Treatment – for Intensive Rearing of Pigs in Baltic Sea Region EU Member States. Published by Baltic Sea 2020, Stockholm. 102 pp
- Klemencic, Matjaz. 2011. New animal by-products legislation. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keynote_3_future_trend_roundtable_animal_products_legislation_klememcic.pdf.
- Lehtinen, Karl Johan. 2011. Future scenarios on waste, energy and P from a NEFCO perspective. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keytopic_1_future_trend_roundtable_future_scenarios_lehtinen.pdf.
- Regulation (EC) N° 142/2011 of the Commission of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive ("IMPLEMENTING" REGULATION)
- Regulation (EC) N° 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products not intended for human consumption (ANIMAL BY-PRODUCTS REGULATION)
- Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers
- Samarelli, Luisa. 2011. Motivation of the relevance of the roundtable and the focus on "Manure processing activities in Europe". PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keynote_2_future_trend_roundtable_motivation_samarelli.pdf.
- Samuelson, Lotta. 2011. Pig manure based biogas production – Turning Waste into an Asset. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keytopic_2_future_trend_roundtable_best_technologies_samuelson.pdf.
- Suárez, Fernando. 2011. Role of society – incentives, regulations, supervision. PowerPoint presentation from roundtable discussion on future trends on manure processing activities in Europe. http://agro-technology-atlas.eu/keytopic_4_role%20of%20society_suarez.pdf.

7: ABBREVIATIONS AND ACRONYMS

ABP	Agro Business Park A/S
AU	Animal Unit, a Danish coefficient that expresses the nutrient load of livestock, where 1 AU = 100 kg N in livestock manure ex. storage = app. 36 produced slaughter pigs from 32 to 107 kg.
BAT	Best Available Technique, as defined in Directive 2008/1/EEC
BREF	Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs
Ca	Calcium - the conversion factor from CaO to Ca is 0.7146.
CO_2	Carbon Dioxide
CPH	Combined Heat and Power
DG ENV	European Commission, Directorate-General Environment
DM	Dry matter
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GIRO	GIRO Centre Tecnològic
IED	Industrial Emissions Directive 2010/75/EEC
IPPC	Integrated Pollution Prevention and Control, Directive 2008/1/EEC, now replaced by the Industrial Emissions Directive 2010/75/EEC
IRPP	Intensive Rearing Pigs and Poultry
IRR	Internal Rate of Return
K	Potassium - the conversion factor from K_2O to K is 0.8301.
Laughing gas	Nitrous oxide, N_2O – a greenhouse gas with a climate impact that is around 300 times that of CO_2
LSU	The livestock unit, abbreviated as LSU (or sometimes as LU), is a reference unit which facilitates the aggregation of livestock from various species and age as per convention, via the use of specific coefficients established initially on the basis of the nutritional or feed requirement of each type of animal (see table below for an overview of the most commonly used coefficients). The reference unit used for the calculation of livestock units (=1 LSU) is the grazing equivalent of one adult dairy cow producing 3 000 kg of milk annually, without additional concentrated foodstuffs. See also http://epp.Eurostat.ec.Europa.eu/statistics_explained/index.php/Glossary:Livestock_unit_(LSU).
MBE	Morsø BioEnergy
Mg	Magnesium - the conversion factor from MgO to Mg is 0.6031.
MS	Member State of the European Union
N	Nitrogen
Na	Sodium - the conversion factor from Na_2O to Na is 0.741839763.
NVZ	Nitrate Vulnerable Zone, as defined in Directive 676/91/EEC

OU	Odour Units
P	Phosphorus – the conversion factor from P_2O_5 to P is 0.4367
VS	Volatile solids

ANNEX A: FINAL AGENDA FOR ROUNDTABLE DISCUSSION

Future trends on manure processing activities in Europe

The closed, international roundtable discussion will take place on **12 October 2011 from 10:00 to 15:00 at DG ENV**, Avenue de Beaulieu 5, B-1160 Auderghem, Brussels. The meeting is held in **room 0/C, BU 5**.
The roundtable is held under auspices of the DG ENV financed project "Manure Processing Activities in Europe" and has the purpose to estimate future trends of manure processing taking into account the current state of affairs and legal framework.

Indicative Agenda

1. (10 minutes) Opening of the roundtable. Manure processing in the wider context of sustainable, climate friendly and eco-secure food production in EU. Michael Hamell, Head of Unit B1, Agriculture, Forests & Soil.
2. (10 minutes) Motivation of the relevance of the roundtable and the focus on "Manure processing activities in Europe", Luisa Samarelli, DG ENV
3. (10 minutes) Livestock manure processing in relation to the animal by-products regulation. Matjaz Klemencic, DG SANCO.
4. (5 minutes) Aim, programme and structure of the roundtable. Henning Lyngsø Foged, Agro Business Park (who also moderate the roundtable)
5. (40 minutes) Major findings of the project, by Xavier Flotats and August Bonmatí Blasi, GIRO Centre Tecnològic
    a. Inventory of manure processing activities
    b. Operational technologies
    c. End and by products
    d. Assessment of economic feasibility and environmental performance
6. Key topics that are decisive for future trends, introduced by four of the participants, followed by discussions (each subject of around 25 minutes)
    - Likely future scenarios - livestock density / concentration, energy and fertiliser prices, etc. Introduced by Karl-Johan Lehtinen, NEFCO.
    - Possible best technologies for future scenarios – recirculation, conversion, etc. Introduced by Charlotte Samuelson, Baltic Sea 2020.
    - Ensuring functioning markets for end and by products – mechanisms, legal framework, etc. Introduced by Frederik Accoe, vzw Vlaamse Coördinatiecentrum mestverwerking (invited).
    - Role of the society - incentives, regulation, supervision, etc. Introduced by Fernandeo Suarez, ADAP (association of the big pig manure treatment plants in Spain) (invited).
    - Biogas production as a tool for reach of strategic goals related with environment, climate, renewable energy production and waste handling, considering future scenarios, cost efficient technologies, markets and the role of the society. Introduced by Henri Bos, Department of Agriculture, Fisheries and Agribusiness, Ministry of Economic Affairs, Agriculture and Innovation, and Kaj Sanders, Ministry of Infrastructure and Environment, both The Netherlands (invited).
7. Summing up on key issues.
8. Concluding session to identify major decisive factors for future development of manure processing in EU, as well as major barriers and enablers for the development.

The project "Manure Processing Activities in Europe" is financed by European Commission, DG ENV, and undertaken by Agro Business Park in cooperation with GIRO Centre Tecnològic

AGRO BUSINESS PARK

GIRO gestió integral de residus orgànics centre tecnològic

ANNEX B: LIST OF PARTICIPANTS IN ROUNDTABLE DISCUSSION

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Manure processing is presently a subject that enjoys considerable attention in the EU due to the ongoing revision of the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs (BREF), as well as due to current efforts to implement policies and legislation on EU and Member State level, for instance concerning renewable energy targets, targets for reducing the loss of plant nutrients to the environment, targets for reduction of greenhouse gases, and targets for manure handling in agriculture in relation to legislation about water protection and manure surpluses in livestock intensive areas.

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