BIOGAS IN AGRICULTURE AND INDUSTRY POTENTIALS, PRESENT USE AND PERSPECTIVES

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ABSTRACT:
The biggest potential for biogas technology lies in the agricultural sector. According to the technical availability of biomass from agriculture at least 220.000 biogas plants could be operated in Germany alone. The energy obtained could cover the 3% of the present end use of stationary consumers or the equivalent of 11% of the gas consumption in Germany. 86% of the technical biogas potential can be obtained through agricultural organic waste such as liquid and solid manure. In the last year biogas technology in German agriculture has had its biggest boom ever with the construction of over 250 new biogas installations adding up to 1250 in total and the creation of nearly 2000 new jobs. Reason for that is the recently passed renewable energy act, with a 20 year guaranteed minimum price for electricity generated from biogas and a long term investment grant programme with maximum 30% subsidies for the building of biogas plants. In some European neighbouring countries to a lesser extent similar conditions occur e.g. Austria, Luxemburg and Denmark. Compared to other countries with no minimum price system, where biogas technology is rather minimal, these countries have a rapid growth in interest for the technology, in number of installations (10 times as high) and in technology development.

1. INTRODUCTION

When organic waste is stored under the absence of air a microbial degradation process is started, where biogas is deriving. The process of anaerobic digestion is running at its optimum at a temperature range of 25 to 38°C (mesophillic conditions), but also up to 55°C in the thermophillic range - however more and more unstable with rising temperatures. The produced gas contains 55 to 70% methane, 30 to 45% carbon dioxide and trace gases. One cubic meter of biogas has the energy equivalent of 0.6 l of fuel oil or 6.36 kW/h. Depending on the efficiency of the cogeneration plant up to 2 kW/h of electricity can be produced.

2. BIOGAS POTENTIALS

In Germany after careful estimates over 220.000 farm and central biogas plants could be realised purely with the input of farm waste. There would be a capital investment of 50 to 80 billion DM (US$21.7–34.7 billion). Farmers could earn a subsidy free income and rural areas cold be economically strengthened. It is estimated that small and medium sized businesses and suppliers could create 130.000 new jobs in the short and medium term.

2.1.The technical energy potential of biogas production

Landfill Gas, which is recovered from landfill sites, as well as sewer gas from water purification plants and biogas from organic household waste make only a small fraction of the available potential for biogas production. However, at the moment, most of the energy from these biological gases are derived from these sources (landfill and sewer gases).

Based on the existing figures of animal husbandry in Germany there are 16 mil. cattle, 26 mil. pigs, 114 mil. poultry and about 4 mil. horses and sheep. Their excrements of 57.500 t organic dry substance per day could be digested. Technically from an organisational and economical point of view over half of the excrements from farm animals could be used energetically in farm or centralized biogas plants.

2.2 Unrecorded biogas potential

In communities, in landscape maintenance, in food processing and canteens organic waste is produced to a rising extent, which can't be easily disposed off via the traditional ways of composting, dumping, animal feeding or further processing. Reasons are high environmental standards, full landfill sites as well as the spreading of animal diseases.

2.2.1 Biogas from waste of food processing and preparing

Organic waste from the food processing industry as well as left over food from canteens were seen as waste which had to be disposed and rarely came into further processing. The energy potential of organic waste from industry is difficult to estimate, because the digestibility of some substrates is not yet examined enough. On the other hand the recycling paths and also the availability of the substrates can change very quickly. Experts reckon, that the available amount for anaerobic digestion will reach 25% in the long run on those kind of substrates.

2.2.2 Biogas from grass and green cuttings

More and more towns and communities have to deal with landscape- and road edge-maintenance. The grass and other organic cuttings have to be composted with considerable effort. If the costs for composting raise over 100,- EUR/t, anaerobic digestion in many cases can be the preferred option.

For the reduction of food surplus especially in Germany agricultural land has been taken out of production through EC-regulations. On this area of land biomass such as grass, maize, fodder beets and other energy crops are already grown and used for energy production through anaerobic digestion; in the year 2000 almost 200 operators in Germany have utilized these crops for energy production. The recycled slurry and the constant soil cover have a positive influence on soil structure, humus build up and plant growth. The biomass can be produced in an organic nutrient cycle without additional fertiliser.

All together from the known potential 8.7 bil.m^3/a of biogas could be obtained. The energy could cover 3% of the present end use of stationary consumers or the equivalent of 11% of the gas consumption in Germany. 86% of the technical biogas potential can be obtained through agricultural organic waste such as liquid and solid manure. Out of the available possibilities of using grass, green cuttings and biomass as well as organic waste from food processing and left over food additional 3% of the present energy consumption in Germany could be covered.

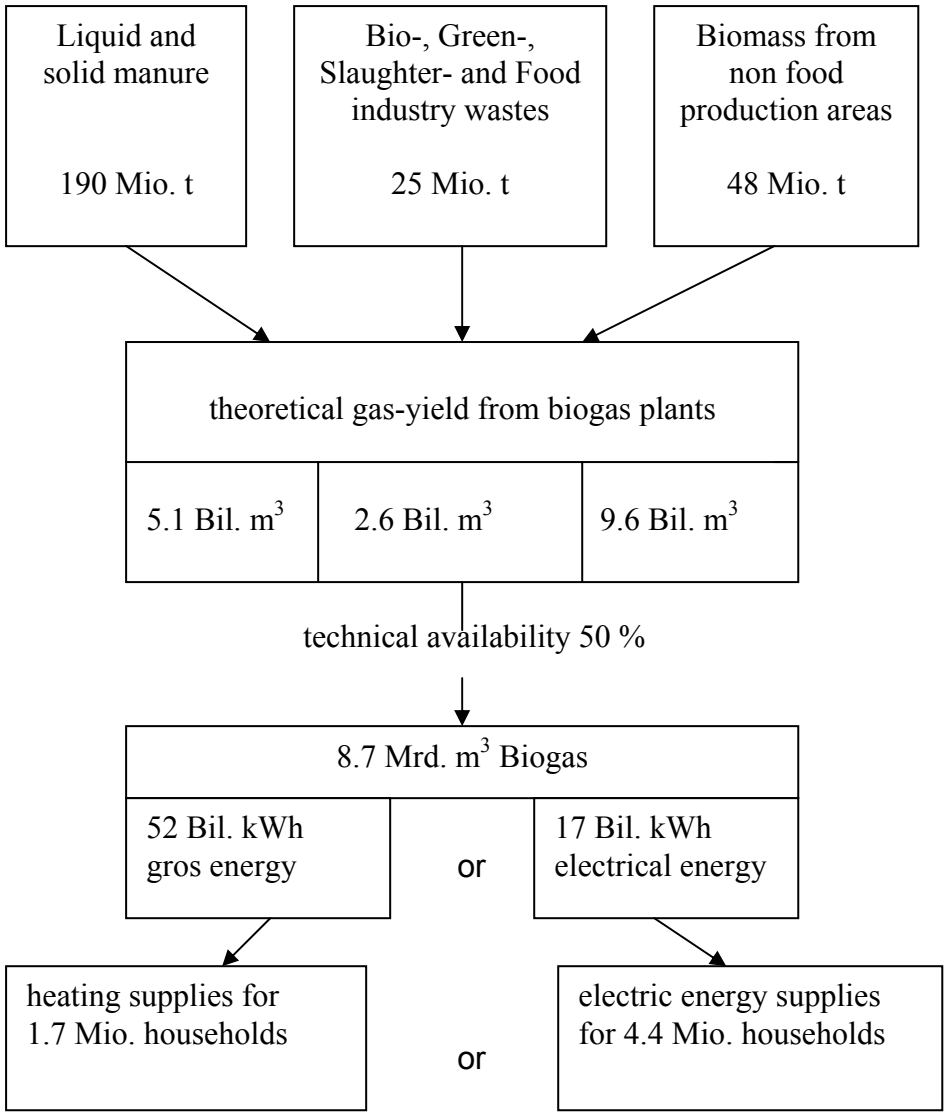

Fig 1: Estimated biogas potentials in Germany

3. PRESENT USE

The advantages of this technology are not only the CO_2-neutral generation of energy (e.g. electricity and heating) but also the avoidance of odours, methane- and nitrous oxide emissions, the saving of fertiliser and chemical sprays, the reduction of landfill area and the protection of ground water. The aim of the Kyoto protocol to tackle greenhouse gases can be effectively supported. The treatment of household waste water, organic residues from food processing and organic household waste offers a wide range of further applications for agricultural biogas plants. This is conforming with requirements of a sustainable waste recycling system.

In countries where the supply of electricity to the grid is a possible option, the produced biogas is mostly utilized in cogeneration plants for heat and electricity generation. The digested slurry is spread on to the fields as an odourless, organic fertilizer with a high nutrient value or is undergoing a further treatment of separation and nutrient stripping in areas with high livestock density and a manure surplus.

The contribution of biogas technology in agriculture is still marginal, but continuously growing. At present in Germany over 1500 decentralized biogas plants are contributing 2,3 % to the total electricity production from renewable energies.

3.1 Single site plants

In the recent years the most farm scale biogas plants were realised with the farmer as the building owner and a biogas engineer as the planner in co-operation with local craftsmen and agricultural traders. Industrially manufactured components like slurry pumps and manure technology are used as well as normal steel or concrete storage tanks, which are combined to a biogas plant with slight modifications. The experiences of the last 15 years have shown, that up until today the best way to realise economically viable biogas plants is, to support and co-ordinate the local building activities together with the farmer or the site owner through a biogas planner or a specialized firm. Each of these plants must be individually fitted to the farms operation and be compiled from standardised components. To cut further costs, up to an average of 30% of the work can be done by the building owner himself. Recently a further standardisation for on farm biogas plants has been taken place, where farmers with little technical skills can also produce biogas through low cost turn key plants.

3.2 Community plants

Turn key plants are applied mostly in industrial and communal as well as in big agricultural enterprises. In Denmark there are 20 centralised agricultural biogas plants in operation at the moment the biggest number in Europe. These plants are digesting a big amount of animal excretions and residues from the food processing industry. In areas of a high biogas plant concentration, residues of high energy value like animal fat from slaughterhouses and food waste are becoming a rare commodity and have to be transported from far a field. For instance in Denmark where 95% of the digestible co-substrates and only 7% of the available liquid manure are utilised in centralised biogas plants. To insure their economic survival, residues from Germany and France have to be acquired.

Up until this point the single farm plants in Denmark, 20 in number, don't play an important role. But it seems to be proven, that, with a construction in reference to the standardised module construction system, the building costs of agricultural plants are drastically reduced and a higher economical efficiency is reached in comparison to plants where foreign organic residues are an economic necessity.

3.3. Bio-waste treatment plants

The anaerobic digestion of bio-waste from source separated household waste, has a high energy potential compared to the aerobic treatment in a composting plant.

Tab 1. Comparison between anaerobic digestion and composting of bio-waste

	Anaerobic digestion	**Composting**
Energy	production (300-600 kWh/t)	consumption (20-100kWh/t)
Sanitation	guaranteed under consideration of legal standards	guaranteed under consideration of legal standards
Emissions	low (odours, ammonia)	high (odours, ammonia, methane, nitrous oxide, hydrogen sulphate, germs)
N-Fertilising effect	fast	slow
Unsuitable substrates	tree and bush cuttings	half liquid substrates with no structure (fatty residues, kitchen waste, slaughter house waste, food processing waste) bio waste without structure con only be composted after wood or other structured bio waste has been added

Very few cities, towns and communities are using anaerobic digestion for treatment of their half liquid and liquid bio-waste and food residues. Most installations are on a large scale demonstration and pilot stage, but there is a growing interest in the technology especially in central Europe and Asia (China, India) for tackling the huge waste problems of the sprawling cities and metropolitan areas. At the moment it is still possible to dump or incinerate the waste, but more and more environmental and energetic problems arise. When there is a source separation of bio-waste, then composting is the traditional way of treatment, but liquid and half liquid organic waste cause emission problems, which lead to additional costs of a closed off treatment process. Even being more expensive, anaerobic digestion systems can offer a cost effective and environmentally sound alternative considering energy production for own consumption and selling to the grid. Often the combination of digestion and composting makes sense, where substrates with different moisture contents are separately treated and the energy production makes the operation completely energy self sufficient.

3.4. Anaerobic treatment of sewage sludge and landfill gas utilisation

These communal and industrial applications of anaerobic digestion have a relatively high degree of use at present in developed countries, where higher environmental standards have been applied for many years. Waste water treatment plants can be found in almost every town and bigger installations also have an anaerobic digester. The utilisation of sewer gas in cogeneration sets is only done in installations, where several 10.000 inhabitants are connected to the sewage system and a considerable amount of sewer gas is produced.

Sewer gas as well as landfill gas is already produced through the necessary installations and only has to be tapped and collected for energy production. Therefore industrialised countries already use 30% of these gases. But landfill sites in central Europe will be closed through strict environmental legislation in favour of recycling and energy production from waste.

4. PERSPECTIVES

The White Book of the European Commission proposes the 10 folded expansion of biogas technology compared to the present use, as an effective measure to reduce the output of harmful greenhouse gases. Experts confirm that the tax returns from capital investments and job creation would by far outweigh the granted subsidies. In the long term there are bigger risks in not using the technology, because of the many applications and the positive environmental effects, than there are possible risks with its use.

4.1. Necessary frame conditions

In the beginning of the nineties the new upward trend started in Germany and Denmark. This was caused by the possibility of obtaining a minimum price for electricity from biogas, the availability of state subsidies after a bigger awareness through the Rio Conference and the possibility of co digesting other organic waste from agro-industry. In some projects the improvement of the slurry as an odour reduced, hygienic and plant compatible fertiliser was the main incentive. On farms with no connection to the public sewage system biogas were built for household waste water treatment.

Now the German Biogas industry is in the stage of its biggest upswing with over 150 companies offering systems and services around the technology. The first companies offering large scale biogas systems are already registered in the new market at the stock exchange. The reason for that is the recently passed Renewable Energy Law, where a fixed minimum price of 0,102 EUR for electricity from farm biogas plants up to 500 kW is available. Electricity from biogas plants over 500 kW to 5 MW is fetching 0.092 EUR and from 5 MW to 20 MW capacity 0.087 EUR. Landfill gas and sewer gas has a guaranteed minimum price of 0.076 EUR up to 500 kW and 0.066 EUR over that limit. This remuneration is guaranteed for a duration of 20 years. Only the few countries in central Europe, which have similar minimum price systems, have a considerable increase in the use of the technology.

Biogas technology is gaining additional upwind through new subsidy programmes for "Market Incentive and Development of Renewable Energies", wherein biogas plants are receiving an up to 30 % grant in interest reduced loans and debt reduction. In Germany until the year 2003 30 Mio. DM are granted each year, which would mean 600 average size agricultural biogas plants could be built each year and by that time the number of biogas installations would be almost 4 times as high as in 1999. Also regional governments in Germany and European neighbouring countries have additional subsidy programmes for biogas plants.

4.2. Technology developments

In the starting phase technical conditions for biogas plants have improved and reduced the initial costs:

- Simple module construction with serial parts from industry and the possibility of do it yourself building
- Collective construction of farm scale biogas plants after the snow ball principle
- Low cost turn key installations enables the farmer with no technical skill to produce biogas
- Simple CHP-plants equipped with used and new engines from car industry
- Low tech desulphurisation of biogas is possible through a biological process of air injection

Through better frame conditions new technology developments can take place in the fields of:

- specialized digester and installation technology
- dry fermentation,
- automation in energy production from biomass from the field
- quality improvement and control,
- gas upgrading for fuel cells,
- biogas in agricultural vehicles,
- integrated gas and heat distribution systems,
- biogas in organic agriculture.

4.3.. Market outlook

Countries like Germany with a minimum price system are and will be taking a leading role in the implementation and the development of biogas technology in Europe and world wide. European neighbouring countries are orientating themselves on the progress and the successes in Germany. Traditionally there is an intensive cooperation taking place with the German speaking neighbouring countries in the field of biogas technology, as some countries have similar frame conditions, but increasingly other countries are seeking technology exchange. A big potential for biogas utilisation is available in the Benelux, France, Spain, Italy and Turkey. Worldwide the most interesting markets for export and technology exchange are to be seen in China, Japan, India and the United States.

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