Ontario Large Herd Operators
European Anaerobic Digestion Tour Report

Germany, Denmark and the Netherlands
August 21 – 29, 2006

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EXECUTIVE SUMMARY

Ontario Large Herd Operators European Anaerobic Digestion Tour Report

Destinations:
The Netherlands, Germany and Denmark touring agricultural anaerobic digesters for biogas production, August 21 – 29, 2006.

Objectives:
The objective of this trip was hands-on learning, focussing on the following topic areas:

- The production of biogas at a variety of agricultural locations;
- Different inputs: manure, corn silage and other energy crops, food processing byproducts and other organic inputs.
- On-farm and community digesters: ownership, partnerships, manure transport;
- Standardized design, and companies with proven track-records;
- Maintenance experience and down time; and
- The use or sharing of excess heat.

Background to Anaerobic Digestion:
Anaerobic digestion (AD) systems produce biogas by digesting manure, energy crops and other organic inputs, including food-based residuals. The biogas (made up mostly of methane) is combusted to produce renewable electricity and heat. Biogas systems can be installed on farms, or in centralized locations receiving inputs from a number of farms and industries. In Ontario, the cost of producing power from biogas systems is almost competitive with large wind developments, but offers significantly more co-benefits in terms of on-going spending and employment in rural areas, and environmental benefits like waste diversion and odour and pathogen reduction in manure. This tour investigated biogas opportunities in Europe.

Attendees:
Thirty two attendees participated in the tour, including 20 farmers, representatives from the Ontario Power Authority, Hydro One, the banking community, researchers, technology vendors, the waste management sector, and the public sector.

Budget Considerations:
The cost of the tour was $2800 per participant.

Thank you to Sponsors and Supporters:
The Ontario Large Herd Operators would like to thank the following sponsors and supporters:

- Ontario Ministry of Agriculture, Food and Rural Affairs
- Agricultural Adaptation Council and the CanAdvance Program
- GE Jenbacher
- Dairy Farmers of Ontario
- Canadian Embassy, Berlin Germany, and particularly Steffen Preusser

Tour Sponsors: Ontario GE Jenbacher Agricultural Adaptation Council

1. INTRODUCTION

Ontario Large Herd Operators European Anaerobic Digester Tour Trip Overview and Lessoned Learned


Figure 1. LHO European Tour Group

On Monday August 21st a group organized by the Ontario Large Herd Operators left from Toronto Airport bound for Amsterdam. The next seven days would be spent travelling by bus through the Netherlands, Germany, and Denmark to study anaerobic digestion technology. The 32 participants were quite a diverse group, made up of dairy, beef, swine, vegetable and cash crop producers, research and extension people, waste haulers, industry people, plus a banker, a representative from Hydro One, and the Ontario Power Authority (Figure 1). Although a diverse group, they all had a common goal of seeing and learning as much as they could in seven short days. Or perhaps the group would say seven long days, as the tour days started early every morning, and ended late every night.

Many hours where spent riding the bus, but each stop managed to give the group something new to talk about between Amsterdam in the Netherlands, to Ribe, Denmark in the North, and then back again. In all, the group visited 16 anaerobic digester installations, or biogas plants as they are more commonly referred to in Europe. Each stop had been carefully chosen because it was unique in some way either by the company that had installed the facility, or because of the goals that the owners were trying to achieve.

There are other things in Europe to see besides biogas plants, so the first day did start with a stop at the Aalsmeer Flower Auction. Aalsmeer is a co-operative where 3000 grower members market their floriculture products through a central marketplace using the Dutch Clock auction system. The group saw a lot more colour than the usual black and white many were used to. But after that, the rest of the European scenery and history was mostly enjoyed from the bus window, or from the interesting towns the group stayed in each night.

The first biogas plant visited was in the Netherlands at the Eissen Dairy. Here the group was introduced to the basics of how biogas is produced from manure. Manure from the dairy was pumped into an insulated above ground concrete manure tank. Hot water heating tubes wrapped around the tank kept the contents at about 40^{o}C. At this temperature anaerobic bacteria in the manure are quite active converting the organic matter in the manure into methane gas (CH_4), more commonly referred to as biogas. The biogas was collected off the top of the digester and used to fuel two Jenbacher diesel engines running a pair of 625 kW electrical generators. Heat from the engines was collected and used to heat the hot water to keep the digester warm (Figure 2).

Before the biogas could be used in the engines, the hydrogen sulphide and moisture must be removed. A small amount of oxygen was added in the head space of the digester to combine with the hydrogen sulphide to produce a precipitate, thus removing most of the hydrogen sulphide from the biogas. The biogas was then transferred to the engines underground, so most of the moisture would condense out of the gas.

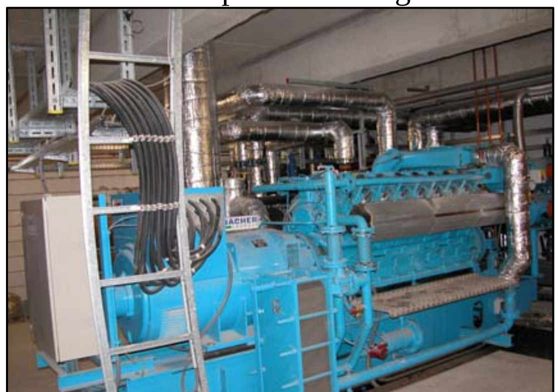

Figure 2. Heat Recovery from Genset

The majority of gas was removed in the anaerobic digester, and the effluent was then transferred to a long-term storage were the bacteria continued to work, as the manure cooled off. This tank was also covered so the biogas could be collected and pumped to the engine.

The effluent in the long term storage was eventually applied on adjacent fields. Anaerobic digestion preserves the nutrient content of the manure, so that it can continue to be land applied as a fertilizer. Anaerobic digestion also greatly reduces the pathogen content of the manure, and greatly reduces the odour. This was most evident when the group visited the Futterkamp Research Station. While the group stood and viewed the digester, 50 ft away, the long-term storage tank was being agitated and manure was being hauled to the fields. There was no smell, other than what was coming from the cows in the barn!

The group quickly learned that a variety of other ingredients were added to the digesters to increase the output of biogas. The most notable ingredient was corn silage (Figure 3). Many digesters used a modified TMR mixer to meter corn silage into the mix to increase the gas production. At one stop, a German engineer remarked that you had to “Love her like a cow”, when referring to the digester. This helped the group to understand that you have to “feed” the digester very similar to how you would feed a cow. You need to concentrate on providing lots of energy

Figure 3. Feeding Corn Silage to the Digester

feedstocks, and to make changes gradually when you introduce new feeds. The group also saw installations that were further processing the energy crops added to the digester to make the energy more available to the bacteria, in order to increase gas production. One company also added grain to the long term storage to try to keep the digestion process going after the effluent had left the main digester.

The biogas reactors which the group saw were basically of two types. The most common was the vertical totally mixed digester (Figure 4), while the group also saw several horizontal digesters (Figure 5). The horizontal digesters were usually used for feedstocks with higher dry matter content, like poultry litter. There did not seem to be a clear right or wrong, in terms of digester designs. The biogas companies would design the digester to meet the individual needs of the producer. The design would be based on feedstocks available, intended use for the biogas, alternate uses for heat, etc.


Figure 4. Vertical Digester


Figure 5. Horizontal Digester

The group saw several creative uses for the additional heat captured from the engine-generator sets (or genset). Most biogas plants were using excess heat to heat hot water for the barn or house, but three of the biogas plants were actually selling the heat for use by others. One plant in particular was using the excess heat to provide hot water heating to a nearby airport, and two others were supplying a portion of home heating requirements in adjacent villages, such as Jühnde.


Figure 6. Jühnde Bio-Energy Village

Jühnde is a small German village where all the energy to the village is supplied by the adjacent biogas plant (Figure 6). The plant supplies the electricity from diesel engines operated on biogas, running generators, and then excess heat from these gensets is used to heat hot water which is supplied to the villagers for water and heating needs. In the winter when excess heat from the gensets is not enough to provide the homes with heat, extra boilers are fired with wood chips. Plans are currently under way to dry the wood chips with extra heat that is available in the warm summer months.

Another unique stop was to a gas station that offered its customers the option of filling up with biogas (Figure 7). The biogas supplied to the gas station was produced at a nearby biogas plant similar to the others visited, but it had an extensive refining process to concentrate the gas to a level that could be used in natural gas powered vehicles.

Figure 7. Biogas Station

Most of the biogas plants visited with the tour had multiple partners. Having multiple partners allowed different feedstocks to be brought together for processing. For instance the group saw several plants were the manure from cattle and hogs was mixed into the same digester. As well different food by-products were also added at several sites. Co-operatives ranged in size from two to three farmers up to one large plant that managed the manure from 300 farms in a 50 km radius from the plant. 20 tanker trucks were used to pick up the manure at the farms and transport it for processing at the centralized biogas plant. After processing, the treated manure would be stored in tanks in the area for land application, or spread directly onto fields depending on availability.

Although the group visited primarily larger newer plants, many of which had price tags nearing €1 million, not all biogas plants are of such a large scale. If the group had travelled south to Switzerland, Austria, and southern Germany, biogas plants that were individually owned and operated would have been more evident.

The group also had several opportunities to visit with technology suppliers, and leaders in the biogas industry. One leader from the German Biogas Association noted that, in Germany, direct benefits from the biogas sector include: 650 MW of installed electrical capacity, a reduction of 4 million tonnes/yr of CO_2 emissions, $960 million spent in construction in 2005, and revenues of $500 million to farmers from electricity sales each year. He also noted that the anaerobic digestion/biogas sector in NW Europe is a mature industrial sector with over 400 businesses (8000 employees) offering services to farm-based, cooperative, and industrial biogas facilities. The vast majority of biogas facilities are farm-based systems.

The European farms visited were similar in many ways to what the producers had at home. So why don't we have a proliferation of biogas plants here in Ontario? There are two main factors that have made biogas generation in Europe wide-spread:

1. The government there has made a commitment to have electricity prices that reflect the cost of producing renewable power from different technology systems (biogas, wind, etc), and specifically for biogas systems using different inputs (manure, energy crops, food-based inputs), and with different scales (higher prices for smaller systems).
2. Guaranteed access to the electricity grid with few restrictions or fees.

At present electrical prices in Ontario offered to farmers producing electricity from biogas are not sufficient in most cases to make it economically feasible. The Standard Offer Program (SOP) program announced in November 2006 (www.powerauthority.on.ca) offers $0.11 to $0.1452 per kWh. German farmers receive the equivalent of up to $0.22/kWh. While it is anticipated that construction costs for digesters will be slightly lower in Ontario, practical applications in Ontario will likely be limited to facilities that can find just the right balance of economies of scale, while maintaining a farm-based management cost structure. Without additional funding (through grants or higher electricity pricing) there are some particular scenarios that may still drive farm-based biogas in Ontario. Some of these special cases will likely involve the use food by-products that have a tipping fee associated with them. In other cases the pressing need to address manure odours or reduce pathogen risks may over-ride the lack of profit potential. Lastly, locations that can make use of excess heat in a marketable manner will likely move forward.

The technology used by the biogas plants that the group visited in Europe would apply in Ontario as well, and based on our observations there are several highly experienced companies that have solved many of the technical problems faced by this industry in the past. Many of these companies are looking to partner with companies in Ontario, so if the electricity price paid for biogas improves, the technology is ready to go.

Biogas production in the future could provide Ontario farmers with an additional source of income, economic opportunity for rural business, while providing society with an alternative use for food by-products, and reduced odours and pathogens from manure, and climate change emissions reductions. The potential exists for a "win-win" situation.

2. SUMMARY OBSERVATIONS AND RECOMMENDATIONS

Six Observations and Recommendations Regarding Anaerobic Digesters and Biogas Production for Electrical Generation

1. Few technical barriers stand in the way of widespread adoption of anaerobic digesters in Ontario for producing electricity from biogas. Electricity pricing and grid access are the key factors both in Europe and Ontario.

2. In Germany, direct benefits from the sector include 650 megawatts (MW) installed electricity capacity, 4 million tonnes/yr CO_2 emissions reductions, $960 million in construction in 2005, and revenue of $500 million to farmers from electricity sales each year. The on-going growth of these benefits were initially triggered only 5 years ago with suitable electricity policies. Such benefits can be readily captured in Ontario with a slight price increase to the Standard Offer Program to value "non-electricity benefits".

3. The similarities between the European and Ontario context mean that European experience in technology, environmental and safety standards, training, and partnerships can be readily adopted in Ontario. OMAFRA should engage in knowledge transfer from Europe, as well as seeking Ontario-specific knowledge.

4. Government can play a key role in laying the groundwork for a biogas sector, including electrical and environmental standards and policies, demonstration projects, and knowledge sharing. Once the sector is established, a biogas industry association, technology companies, and local knowledge sharing can be relied on to drive biogas development.

5. Anaerobic digesters are not the solution for new income on every farm. Systems require significant capital expense (ranging from $200,000 to over $1 million) and require significant knowledge and commitment to operate effectively.

6. While "non-electricity" benefits such as pathogen control, odour reduction, and rural economic development were key motivators for development of the sector, they were not the primary motivation for most system operators. Since these benefits are of interest to OMAFRA (and to other Ontario Public Service partners), it falls to OMAFRA to place emphasis on them in discussions with other government and non-government stakeholders instead of relying on voluntary uptake by farmers who adopt these systems.

Technology Implementation On-Farm

1. Both farm-based and centralized biogas facilities appear to be economically viable under the established energy pricing regimes in Europe.

2. Significant knowledge and commitment from the operator are required to operate these systems effectively. Only through optimized operation and very low "down times" are these systems economical.

3. Even with significant technical support, the operation of a digester is a complex challenge. Often, rules of thumb and trial and error are the means of determining operational standards. There are no clear guidelines for successful "recipes", best mixing practices or day-to-day activities.

4. System implementation and innovation was spurred on by electricity pricing. The result is a proven contribution to the energy sector providing predictable consistent distributed power to the grid, and providing economic returns to farmers.

5. The local Ministries of Agriculture had not played significant roles in assisting in technology adoption for the sites visited on this tour.

Electricity Issues

1. In Germany the price paid for generated electricity is linked to the type of input material used in the digester. For instance, systems using only energy crops receive a higher electricity price because the inputs have a higher cost than simply managing manure. Systems using food-based inputs collect a tipping fee (paid by the waste generator to dispose of the material) and thus are provided with a lower electricity price. Most systems were operated for maximum continuous power production.

2. Farmers were guaranteed access to the electrical grid. Typically, farmers were responsible for paying for wiring and transformers to get electrical power to the grid. This was typically in the range of 5-10% of the project cost. The farmer was not responsible for doing grid capacity assessments, nor for paying the utility for the right to access the grid. In some cases the farmers did have to pay for significant construction of electrical distribution wiring.

3. While there is a bonus in the electricity price for systems using the excess heat generated during electricity generation, few systems are able to find an effective heat sink. Heat use examples include greenhouses, municipal hot-water heating systems, systems to dry out the digestate, and other industrial heat sharing such as with an airport or hotel.

Observations Regarding the Biogas Industry Sector

1. The anaerobic digestion/biogas sector in Northwest Europe is a mature industrial sector with over 400 businesses (8000 employees) offering services to farm-based, cooperative, and industrial biogas facilities. The vast majority of biogas facilities are farm-based systems.

2. The marketplace offers farmers significant flexibility in determining what type of digester design they would like to implement. There are generalized approaches to tank design, mixing systems, and electrical generation systems which have prevailed among the over 4000 digesters constructed. There are different construction quality approaches for farm-based versus industrial digesters. There is no need to re-invent the wheel when the systems undergo wide-spread implementation in Canada.

3. The German Biogas Association is a strong organization that provides lobbying, training, technical recommendations, and operational guidelines. A consistent unified public voice for owners, operators, and vendors was identified as being critically important for the sector. The main challenge of renewable energy associations was to secure suitable energy pricing and maintain a positive position in light of other conventional power sources.

Government Policies Influencing Anaerobic Digester Implementation

1. There are two key factors which enabled wide-spread adoption of biogas in Europe:
   a. Electricity prices that reflect the cost of producing renewable power from different technology systems (biogas, wind, etc), and specifically for biogas systems using different inputs (manure, energy crops, food-based inputs), and with different scales (higher prices for smaller systems).
   b. Guaranteed access to the electricity grid with few restrictions or fees.

2. Government policies have a very clear and direct impact on biogas implementation. German rules and regulations have led to an expansive biogas industry. The Danish regulations which had encouraged digestion were changed in the early 2000's, meaning few new digesters have been built in recent years. Holland's renewable energy price bonus was cancelled for new projects in August of 2006 as a result of commitments by large energy companies to implement large wind farms. Thus, the available benefits to farmers and the rural business sector are directly linked to stable government policy. System owners and designers can and do respond to the economic and regulatory systems that governments establish, since the economic returns of biogas systems are fairly clearly understood.

3. There was little focus on the implications of land-application of the end product (called digestate) at the sites we visited. Digestate was treated as an agricultural material, even when food-based inputs were blended in.

4. Each country and state has its own rules around management of the digester. These rules have to be generally compatible with European Union directives. In some cases, the local municipal regulatory and health agencies have specific control of siting, type of input materials, pasteurization of inputs, and digestate management.

Conclusion:

In conclusion, there are few obvious differences in agricultural management between Ontario and Germany, meaning that technically, anaerobic digestion as implemented in Germany could be implemented in a similar manner in Ontario.

3. DETAILED INFORMATION FROM SITE VISITS

The following chapter is a summary of notes taken at the various sites during the tour.

German Biogas Association

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Biogas Association Structure
The German Biogas Association (GBA) or *Fachverband Biogas e.V.* represents the entire spectrum of the German Biogas industry: developers, owners, operators and service providers. The GBA has a Board of Directors, with 7 members, office staff, a variety of committees, representation from 18 regional groups, and representation from other organizations and associations. There are over 2500 members. Our speaker, Markus Ott is a senior staff person representing the companies (developers, engineers, installers) at the head office.

Having one association is key to be able to lobby against traditional energy. No multiple agencies. Fight internally, but present a consistent external message.

There are various technical working groups with voluntary member participation. These include the Legal Advisory Group, Gas Injection Working Group, Biowaste & Fertilizer Legislation Working Group, Public Relations Working Group, Security Working Group, and the Authorizations Working Group.

Status of Biogas Sector
Figure 8 shows that currently there are over 3500 digesters in Germany and the market still growing. 1000 digesters were built in the last year and there will be an additional 600 MW of new installed capacity by end of 2006.

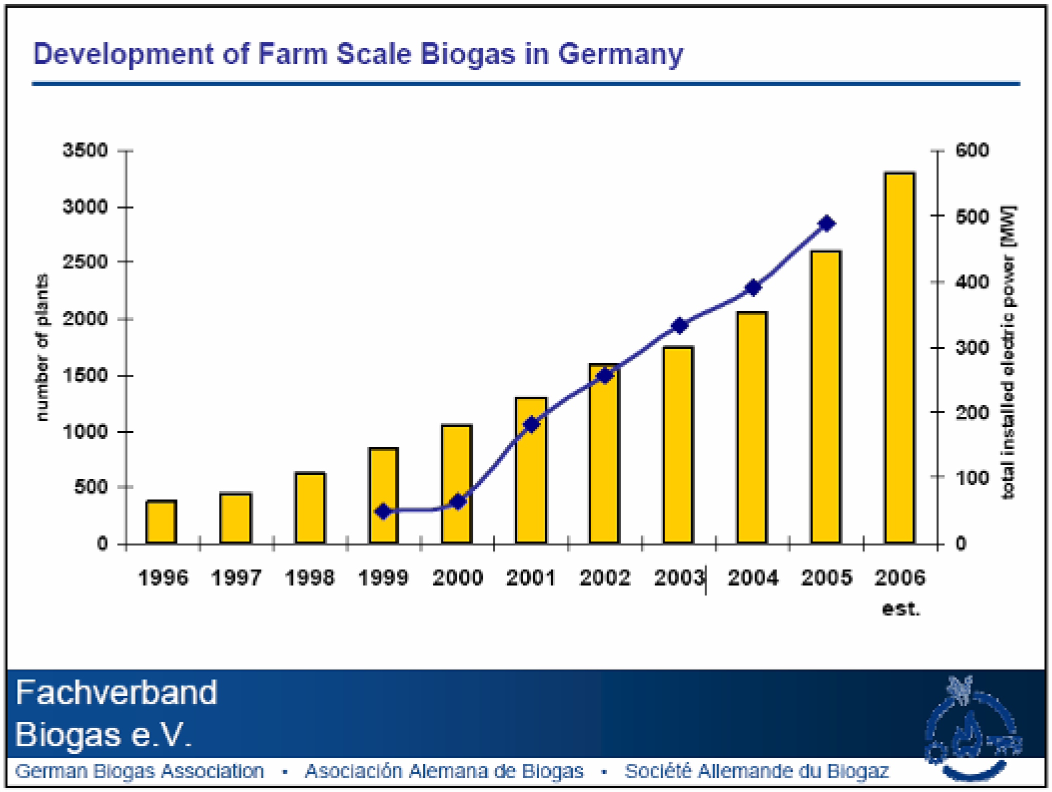


Figure 8 Development of Farm Scale Biogas in Germany – Markus Ott, German Biogas Association

Figure 9 below shows that digesters provide 3.2 billion kWh/year (i.e. 3.2TWh/yr) providing roughly 1% of German demand. In contrast, wind provides 6-7% of German electrical demand.

	2005	**2020 (projected based on available feedstocks)**
Generated Electricity from Biogas (1 TWh = 1 billion kWh)	3.2 TWh/yr	76 TWh/yr
Total Installed Electrical Power	650 MW	10,000 MW
Spending on New Digester Construction	€650,000	€7,600,000
Jobs Directly Linked to Biogas Industry	5,000	85,000
Export Rate (Biogas Business Outside of Germany)	8%	30%
Tonnes CO2e Emission Reduction	4 million	103 million

Figure 9 Status and Projection for Biogas Industry – Markus Ott, German Biogas Association

Almost all biogas is going into combined heat and power units (CHP), with future potential for fuel cells or cleaning for addition to natural gas system.

In 2006, there were 410 companies active in the biogas sector (engineering, construction, servicing gensets etc). These are not servicing only agricultural installations – for instance Kompogas builds digesters for source separated organics for municipalities.

There is a lot of job potential: the wind industry has 80,000 jobs. Biogas is next, and German companies are poised to get into international market.

No opinion is offered by the association on which technology is best, rather, they set the approach for safety, quality, warranties, etc.

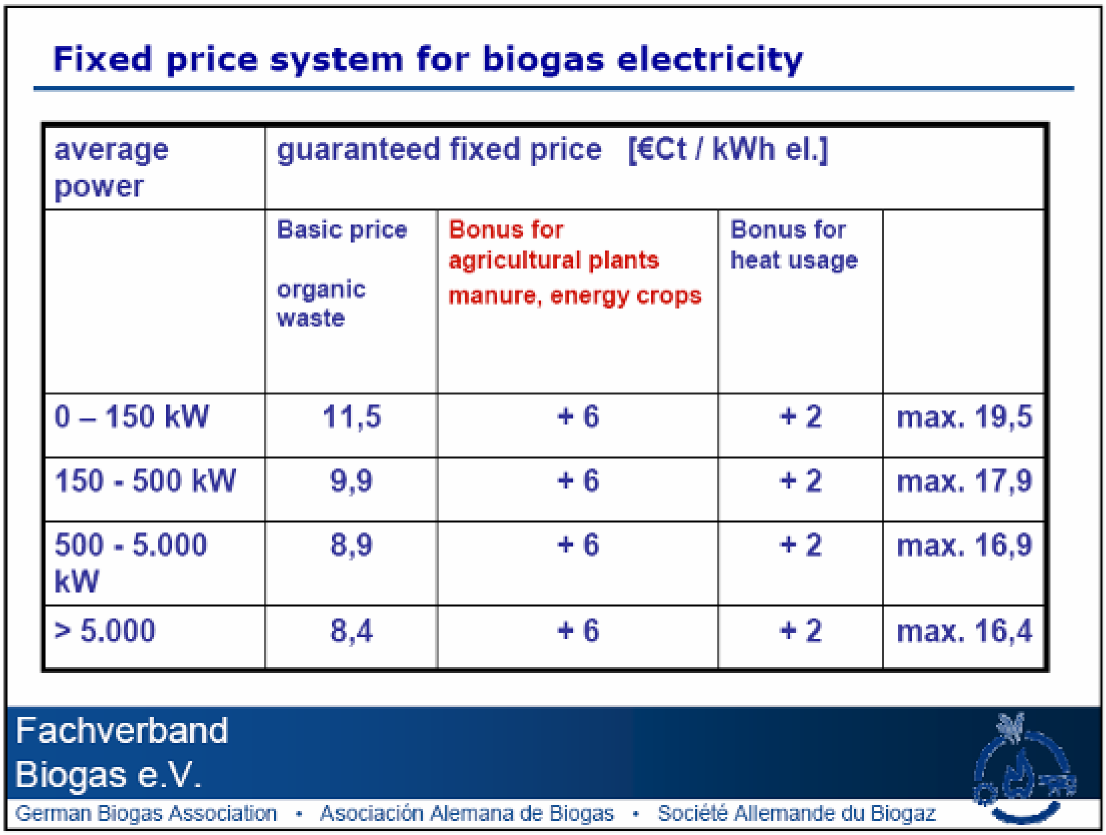
Drivers for Biogas Sector Growth

Following the introduction of the 3rd Renewable Energy Source law a couple of years ago, 90% of farm-based digesters now operate using energy crops because the price is more attractive than “waste”-based digesters. In addition to the price, working in the waste sector is sometimes more challenging, and presents “different” challenges than farming.

The reason behind higher prices for energy crops was that a lot more biomass potential exists in crops, so it is worth pursuing to meet society’s needs. Based on feedstock available, biogas could satisfy 17% of Germany’s energy demand, whereas waste-based digesters will top out at 1-2%. A key component enabling the sector to develop is the principle of providing an electrical price that reflects the cost of production. For instance, in Germany photovoltaics (solar) gets 54 ¢/kWh, and wind gets 8-9 ¢/kWh. The wind price is dropping because experience, cost cutting and so on. The wind experience demonstrates that as society invests in renewable energy sources, the long term cost decreases as technology advances.

Figure 10 shows that different sized systems are provided with different electrical prices to reflect the different costs of production. Thus smaller systems are provided a higher rate per kWh of power produced.

Figure 10 also shows a bonus for using heat from the digester for some beneficial use. 10% of all digesters use all the heat produced during combustion, 80% use some of the heat. Heat uses (beyond self-sustaining heat to keep the digester operational) include the heating of barns, homes, swimming pools, neighbouring residences, greenhouses, industrial and commercial buildings, and use in value-added agricultural processing on-site.


Fixed price system for biogas electricity

average power	guaranteed fixed price [€Ct / kWh el.]			
	Basic price organic waste	Bonus for agricultural plants manure, energy crops	Bonus for heat usage	
0 – 150 kW	11,5	+ 6	+ 2	max. 19,5
150 - 500 kW	9,9	+ 6	+ 2	max. 17,9
500 - 5.000 kW	8,9	+ 6	+ 2	max. 16,9
> 5.000	8,4	+ 6	+ 2	max. 16,4

Fachverband Biogas e.V.
German Biogas Association • Asociación Alemana de Biogas • Société Allemande du Biogaz

Figure 10 Fixed Price System for Biogas Electricity – Markus Ott, German Biogas Association

Value of Biogas as a Power Source
While biofuels have a higher profile in the public and political realms, eventually biogas should rise up because biogas is much more efficient. For instance:

- 1 ha committed to biogas = 70,000 km diesel equivalent
- 1 ha committed to biodiesel = 15-20,000 km diesel equivalent

Figure 11 shows the electrical yield potential from different sources of biogas inputs

	Yield (tonne/ha)	Electrical Power (kW)
1 ha corn silage	50	2.0 – 2.5
1 ha grain corn	12	1.5 – 1.8
1 ha grass	25	0.8 – 1.2
1 cow	--	0.2

Figure 11 Electrical potential from different biomass inputs in biogas systems – Markus Ott, German Biogas Association

Cost to the Electrical Ratepayer

The marginal additional cost to electrical rate payers because of this higher renewable power price for biogas alone is roughly 0.01 to 0.02 ¢/kWh (yes, those decimals are correct), or less than 1%. This is in part because biogas makes up less than 1% of total electrical production. The supplemental cost for renewable energy sources (including water power) in the German energy portfolio is roughly 0.5 to 0.7 ¢/kWh over other sources.

Discussion on Appropriate Funding Mechanisms

Grants versus Guaranteed Electrical Price: Germany had a national demonstration program that funded capital costs for biogas systems. Such grant programs do not cause good development. The program paid €2000/m^3 of digester capacity, which prompted the development of large tanks. Often projects ran out of money before full installation and operation was achieved. The alternative is to provide an attractive electricity price for producer which provides incentive to keep the system operating. This is the recommended approach.

General Discussion Points

Flares – the challenge with flares is that you need fancy flares with high end compressors and so on, not just standard materials. This is an obstacle. Many biogas installations do not have flares in Germany.

Plug flow digesters versus fully mixed digesters - lower process cost for plug flow systems must be balanced with higher capital costs.

Fewer than 0.5% of German biogas plants do reverse osmosis or produce high quality fertilizer.

There is little interest amongst German companies in going to Canada to do pilot or demonstration projects. They would prefer a stable pricing structure in which they can fully participate in a marketplace.

Operational efficiency is key to good economics - German biogas systems shifted from 27% operating efficiency in 2000 to an average 96% efficiency today. One of the keys to stable operation is microbiological support, meaning the monitoring of biological parameters. For instance, an operator achieving 85% versus 63% efficiency with and without lab support captures an additional €150,000/yr in revenue.

Safety - the German Biogas Association took the initiative and developed the standards for safety so no one else could do it in an overly regulatory manner. The concern was that overly-regulatory standards would be developed along the lines of natural gas systems which would be totally out of proportion for farm-based biogas systems.

Future of the Biogas Industry in Germany

The long term goal in Germany is to eliminate Russian oil and expensive German coal, as well as to eliminate nuclear power by 2030. Most Germans agree on these principles, so it easy to get general buy-in. Traditional energy companies can also build biogas plants and so are not "enemies" of biogas.

Currently plant size is going up, and there is a shift to cooperative systems. But Markus Ott sees the future as going back down to farm scale.

The price for new projects is dropping by 1.5 ¢/kWh over time. Ongoing projects get the price they got at initiation (guaranteed for 20 years), so there is incentive to get up and running today, even if shortly, in order to lock in a higher price.

When trying to sell biogas to the public, do not talk about energy – everyone knows this is a win-win. Instead, talk about economics and job development. Don't talk about subsidies for farmers.

Research areas for the future:

- Multi-crop systems - no monocultures – aim for rotation.
- Automization
- Biogas cleaning
- Optimizing biogas use for peak power
- Microturbines
- Fuel cells
- Biogas as a vehicle fuel

Van der Louw-Verbeek Dairy Farm

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Background information:
History:

1980	Construction of a new farm in Zeist (province of Utrecht)
1991	Take over of the farm from parents
1998	Construction of the new farming operation in Zeewolde (province of Flevoland) with 530,000 kg quota added to 120,000 kg owned by parents
2002	Take over of parent's quota, plus quota purchase to a total of 850,000 kg
2003	Take over of another farm in the neighborhood; total quota 1.2 million kg
2006	Take over of another farm in the neighborhood next to the farm which was bought in 2003; total quota of 1.6 million kg.

Today, all the milking cows are at the original farmstead. The raising of the young stock takes place on one of the other farms.

Present Operation:

Covering 170 ha:	30 ha grass, 24 ha corn. The rest in beets, potatoes, wheat, onions.
Soil:	Recovered sea clay
Employment	Mr. and Mrs. Van der Louw, plus one full time employee

Dairy Herd and Production:

Milk quota	1.6 million kg
Milking cows	150
Young stock	150
Year average	9300 kg milk, 4.16 % fat, 3.36 % protein

Operational Goals for the Farm:
- to maintain a good running operation
- owner milks each day at least once
- optimum time management between work and family
- by achieving the above three goals the result is a stable operation

Dairy Barn:

- growing from 120 producing cows to 160
- the raising of young stock is on one of the other farms in Lelystad , the young cattle are cared for by the person living in the house.
- 2 x 10 Fullwood rapid exit milking system
- insulated dairy barn
- heated drinking water system
- calves: automated milk drinking system
- loose housing for calf raising
- summer feeding
- stress on the importance of light and space

Diet for Milking Cows
Mixed ration of grass silage, corn silage, dried alfalfa and beet pulp.
Supplemented with concentrate fed by computer feeder.

Diet for Dry Cows
Mixed ratio of grass silage, corn silage and straw.

Breeding:
The use of good bulls from Alta and other semen companies.
Current bulls used: Joshua, Fortune, Paramount, Wildman, Zesty

Technical Specifications of the Wind Turbines:
One wind turbine in owned by the farm. Brand: Vestas Type: V52- 850 kW. Four other wind turbines on the other farms are rented.

Vestas V52-850kW
<u>Rotor:</u>

Diameter:	52 m
Swept area:	2,124 m^2
Speed revolution:	26 rpm
Operational interval:	14.0-31.4 rpm
Number of blades:	3
Power regulation:	Pitch/Optispeed
Air brake:	Full blade pitch
Hub height:	70 m
Cut-in wind speed:	4 m/s
Nominal wind speed:	16 m/s
Stop wind speed:	25 m/s
Generator type:	Asynchronous with OptiSpeed
Nominal output:	850 kW
Operational data:	50/60 Hz, 690 V
Gearbox:	1 planet step/2-step parallel axle gears

DETAILS FROM SITE VISIT AUGUST 2006

Farmstead and General Information

The family was farming near Utrecht but a highway and environmental reserve was proposed locally, so the government paid to move them. Had 57 ha. 155 milking cows. Since they were squeezed out due to the land reserve they were eligible for land on polder. Now they have 170 ha.
No pasturing, new polder, too much damage to pasture.
Land costs: €50,000/ha ~ $30,000/ac
New polder first cropped in 1984.
Extra hot this summer (35ºC), but normally summer is 25 ºC max. Winter once in a while drops to -10 ºC to -25 ºC but often just around freezing – wet snow doesn't stick.
Crops – last year 35% of farmstead income was in onions. The year before there was a glut of onions, 0 profit. Highly variable.
In the last 6 months they've had 7 government inspections – environment, health, etc.

Wind Turbine Details

25% of farm income comes from the wind turbines.
The farmer owns 1 windmill at the home farm, and there are 4 on neighbouring farm that he purchased. Of those, one yields $20,000/yr, other 3 at $1000/yr based on previously negotiated contracts. The 20 year contracts are extendable.
Turbines are 850 kW Vestas unit. 70 m tall.
Most wind turbines are farmer-owned.
Investors are also involved in some.
Cost: €800,000. Financed 100% by the bank – 10 years. Constructed December 2002.
Grid connection was roughly €100,000 - same for one turbine or 5. This is included in the €800,000 cost.

Few repairs. Wind damage is the most common problem. Not the gearbox though.
Vestas – good sales, not best follow-up. 5-6 weeks for parts sometimes. Internet connected tracking of production. Central command for monitoring.

The electrical grid is underground. The transformer is at the foot of the turbine in box.
Maintenance contracts guarantee 95% operation time (17-18 days down over 5 years).

No effect on crops from wind turbines.
6.4 m/s at this site. This is a typical speed.
Anywhere with >6 m/s wind is okay for wind.

Price goes up every year.   3.3 ¢/kWh last year, now 4.4 ¢/kWh electricity. Plus 7.8 ¢/kWh from government (accounts for environmental benefits, transmission fees etc – elimination of government fees).
All electrical power goes to grid – buy cheap grid power is used to operate the farm (i.e. they are not net-metering).
Voltage to grid – 700 V, 22 kVa

Collecting Information Before Making a Decision:
A group of 28 farmers got 2 or 3 of them to research and present recommendations to everyone else. There was no government support to choose a direction. There were no subsidies on the construction, just the price of power.

Cellphone transmission antennas set up on the tower for extra revenue.

Biogas versus wind – at the time wind was the better economics and there was no infrastructure for biogas. Even now the biogas subsidy just got eliminated because Holland has met its requirement for renewable power.
Most Dutch recognize that wind turbines are not beautiful, they are ugly and ruin the view.

Most farms in the polder areas have a turbine because it is very windy.

Dairy Barn Details

Barn built in 1996. 1 barn originally. Now they have a separate barn with milkers and dry cows in one, and heifers in another.
2x10 rapid exit parallel parlour with single return exits – can release one cow at a time – allows sorting.
130 cows milking takes 2 hours – too long, but doing it because cell count got too high – therefore new routine, new equipment – currently 250,000 count.
Penalty over 400,000 count for extended period.
Was milking 90 cows/hour – prepping all 10 at once.
Now dry prep 2 cows, attaching 2 units, etc.
Increased time.
Like Canadians, the farmer gets too attached to cows, old cows are a "challenge" instead of getting rid of them.
Has started teat dipping.
Barn has closed sides, was the style when built. Now they build them with open walls.
Fear was wind and driving rain and blown bedding. Solution: raise the curtain when it gets windy.
Alley scrapers with milking cows (none for young cattle).
Drier floor means cleaner animals.
Footbaths only once per 2 weeks.

Feed: Corn silage: not much grain – energy in the plant. Grass silage, beet pulp and soy meal as well.
28€¢/L milk – Canadian farmers want 40 ¢/L
3.7% interest available from banks.

Calves:
Sloped floor manure pack. Builds up over the time. Mini high-hoe to clean it out. 3 hours to clean out. Slatted floor at feeding area at top of sloped floor. No hutches in Holland. 50% of manure is on the little slatted area at the front because they make space while they're eating. Self-propelled, self loading TMR – "RMH 630 CS". 118 m^3, 7 tonnes capacity – €110,000.
Robotic calf feeder for last year – collar, milk replacer.

Eissen Dairy Biogas Plant

Gasselterboerveenschemond 18
NL 9515 PN Gasselterboerveenschemond
BK
Ph. +31 (0) 59 96 58 211

Background
PLANT AND OPERATIONAL PARAMETERS

Biogas plant built by:	PlanET Biogastechnik GmbH Up de Hacke 26 48691 Vreden, Germany Tel: + 49 (0) 25 64 / 39 50 - 0 Fax: + 49 (0) 25 64 / 39 50 - 50 www.planet-biogas.com e-mail: info@planet-biogas.com
Feedstock:	manure & corn silage
Reactor dimensions:	3 X 500 m^3 Two primary digesters, one secondary.
Feed rate:	40 tonne silage, 50 tonne manure - 50% hog (hauled in), 50% dairy from on-site
Biogas production:	About 20,000 m^3/day
Cost of plant:	€2,500,000
Energy output:	1250 kW
End products:	Digestate for land application

DETAILS FROM SITE VISIT AUGUST 2006

Announcement regarding Plan ET Canada partnership with CEM Engineering. Martin Lensink P.Eng., CEM Engineering, http://www.cemeng.ca/, St. Catharines announces that they are officially PlanET Canada.

Digester Basics
Fully mixed 3 X 500 m^3 digesters
Paddle and vertical mixers
2 X 625 kW Jenbacher co-gen units
7800 hr/yr
40% efficiency use of gas
54% methane
No heat recovery right now, other than 10% energy to sustain digester

Wooden roof, ambient oxygen for H_2S removal
€2,500,000 invested
9.7 €¢/kWh + 5 €¢/kWh bonus
Farmer is operator, and ownership is with investors. Farmer would run it differently, but the investors want to try it out and do testing.

Gas Management and Electrical Production
2 layers of dome for biogas storage – one protection for wind. One wasn't fully pressurized when we were there – needed bigger compressor – purpose is weather protection.
All gas flows from primary digester to secondary digester – then long condensation pipe underground, then to the engines.
20,000 kWh/day currently running. Capable of up to 30,000 kWh/day. Currently doing testing to optimize production.

Feedstocks and Digestate Management

Total input: 40 tonne silage, 50 tonne manure - 50% hog (hauled in), 50% dairy from on-site. Feed manure and silage every 2 hours. Hog manure brought by truck 12 km. 28% dry matter inputs.
Slow start-up process – 4 months to full production.
3-4 hr/day labour.
€70,000 to connect to grid.
Odd rules with regards to using own manure – they have to load each manure load onto a truck, GPS and sample the load, then send to digester. A blend of 50% own manure is required in Netherlands.

Farmer had the approach of "not understanding" additional rules around nutrient management. Perhaps a reaction to seemingly unreasonable rules. Nutrient management was done by other farmers – don't worry about specific rules. Manure hauled into to central dump tank – mixed to ensure consistent blend. Weekly bacteria sampling.

1 corn silage hopper per primary digester (2 primaries).

FAN screw press separator for digestate. Separator – 50% of liquid recycled in digester.

Operating system convenient in office – easy touch screen.

Farmer's focus appeared to be on digester operation and less on dairy operation.

Bio-Energie Hasetal GmbH

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Background :
The Manure Exchange (Gülle Börse) takes in surplus manure from local farmers and uses it partly in its biogas plant and partly distributes it to surrounding farms which lack manure. Due to German regulations, the exchange receives money from manure-delivering farmers. The biogas plant annually generates about 7 million kWh, 50% of the produced heat is used for internal heating, the rest goes to nearby 30-40 households.

PLANT AND OPERATIONAL PARAMETERS

Biogas plant built by:	Schmack Biogas AG Bayernwerk 8 D-92421 Schwandorf Contact: Ludwig Dinkloh, Head of International Business Tel.: +49 (0) 9431/751-260 Fax: +49 (0) 9431/751-5260 Cell: +49 (0) 151 161 53351 Email: ludwig.dinkloh@schmack-biogas.com Internet: www.schmack-biogas.com
Type of plant:	EUCO® Titan
Feedstock:	40,000 m³ manure & 12,000 tons corn silage
Reactor dimensions:	2 x EUCO® 400 m³ 5 x COCCUS® 1800 m³
Feed rate:	100 m³ manure / 20 tons silage
Operating temp.:	38 – 42 °
Dry matter:	In digesters 5 – 8 %
Agitation:	3 rotors sliding up and down on inner walls
Biogas production:	About 10,000 m³/day
Methane content:	52 – 55 %
Sulfur (as H_2S):	< 200 ppm

Cost of plant:	€2,500,000
Energy output:	10 x 80 kW
End products:	Digestate for land application
Comments:	Built in 2001

DETAILS FROM SITE VISIT AUGUST 2006
Wilfred Forster.
Centralized manure depot
Agricultural region. 40% of population in region living off of agriculture
200 farming enterprises, average size 34 ha. Hog finishing, chickens, turkey. High density of livestock, so need to manage manure in centralized manner to ensure properly distributed. 15 years of business as manure broker.
In 1991, the business had 2 people. Now has 28 people.

Digester Basics
In 2001 began doing biogas
800 kW production
7 million kWh total/year
Equivalent power for 1700 homes.
1100 ha of land leased for application of digestate (and cropping).
3000 ha managed for others for digestate application.
All digestate is land-applied.
38ºC operating temperature.

2 horizontal and 5 vertical reactors. One of the horizontal reactors was not operational when we visited.
10,000 m^3 biogas per day. The operator sets production to maximize electrical generation, rather than on how much manure he gets – uses energy crops to tweak recipe to max out gas production.

Digester - €2,500,000 capital cost, €100,000 electrical connection costs.
Internal heat use for tanks. Sells all green electricity, uses cheap conventional electricity for on-site use. 5% internal power use.
High electrical price and 20 years guarantee is good enough for the bank – no government grant or subsidy to build the facility.
Comparison of centralized facility with many co-gen units to a single farm digester: 1 digester, 1 motor, if it goes down then zero production. However, at a centralized location you cannot afford down time because manure flows in from many farms.

If there are emergencies, the fire crew has been trained to come with confined space gear. In Germany 5 people have died in biogas accidents.

Vertical tanks: concrete cast for vertical tanks, insulation, cladding. Rubber bubble, single dome, net for wind. Special concrete blend for sulphur.

Horizontal tanks: The horizontal reactors are also concrete, not steel drums. Paddles on a shaft move material through the horizontal reactors.
It takes 12 hours to move inputs through the horizontal tanks. Heat is applied in the core of the paddle system shaft. Thermophylic, 72ºC (note: this seems odd – thermophylic is 50-55ºC, this seems to be a pasturization temperature, but typically you only pasteurize when off-farm food inputs are used, and then only for 1 hour).

Sump system inside horizontal reactors: simply box area on side of channel – sand scoops up with the horizontal shaft, then falls in the box. Auger system removes sand.

Advantage of horizontal system – corn floats, so this gets it good and wetted before going into vertical tank. Only 10% of gas production comes out of horizontal digester (although this is high considering only a 12 hour retention time). Another advantage of plug flow horizontal – can push through high solids, where-as in verticals can't move thick material. Non-digestable material gets pushed through horizontal reactors. Only 4 kW motor to move horizontal material, versus vertical digests – 3 agitators using 11 kW. Horizontal is very efficient.

Vertical agitation – rail system on wall to move agitators up and down. Would not use this system again.

Gas Management and Electrical Production
Variable price electrical production:

- 500 kW at 16 €¢/kWh
- 300 kW at 14 €¢/kWh blended prices is 15.25 €c/kWh

20 year contract is key. Operator says it's a form of new socialism.
Diesel – co-fired 80% biogas, 20% diesel.
Government is okay with that until 2007, at which point they have to convert to biodiesel.
Currently operating at 50/50 blend diesel/biodiesel.
Biodiesel = 65 ¢/L, diesel = 96 ¢/L – Steffen Preusser (Canadian Embassy in Germany) has report on taxes on biodiesel - *Drivers and Strategies Influencing the German (European) Biofuels Market* – May 2006
800 kW (10 X 80 kW), 8200 operating hours – down time only for maintenance
Cost of connection to grid varies depending on size of facility.
Gas storage dome is at 200-800 mbar. Pressure feeds diesel generators.
10 X 80 kW Perkins diesel engines. Hans-Juergen Schnell modified design - from Southern Germany, which seems like the other end of the world.

Overhaul at 40,000 hours, but they often only run generators at half-power.
Having multiple smaller generators allow maintenance, optimum operation of generator.
Service contract for these is €80,000/yr.
Oil change every 600 hrs.
Gas analysis: 53.5% methane in biogas
H_2S – 0 ppm. Ambient air added at 0.3%

Feedstocks and Digestate Management
40,000 m^3 (tonne) manure per year
10,000 tonne corn silage. Only works because state guarantees 15.25 €¢/kWh. Silage comes in from 15 km radius.

No food waste – less money. Waste management is a base rate, but the farmer-targeted crop price is more desirable.
Also cereals, rye, wheat, etc. – all are economical, more money from biogas than feeding crops to livestock. Leads to ethical question: feed the poor versus feeding digester.

- 1 tonne rye for food = €100
- 1 tonne rye to biogas = €180

Have pre-storage delivery tank for incoming manure. 20 trucks/tractors doing the rounds.
Contracts – facility is paid 7€/ m^3 by the farmer to pick up manure, but have to return digestate and spread it. The farmers want the NPK – also non livestock farmers get some of the digestate.
50 km radius for pickups, 300 farms participating
Liquid manure useful to keep the blend wet
1 m^3 manure – 20 m^3 biogas
1 m^3 silage – 200 m^3 biogas
1 tonne wheat – 600 m^3 biogas
Logistical challenges on hauling manure – has to be in the right place at the right time – winter spreading, sufficient storage.
1 November to 1 February - no spreading
Rented 20,000 m^3 storage from farmers
No issues with digester upsets – such a large quantity of manure means that one load that has high antibiotics or something has little effect – big homogenization tank. However it should be noted that they have slightly low quality biogas (53% methane content).
Big hoppers for mixing in energy crops. Mixed with manure to get a pumpable blend.
Highest dry matter of blend will be 12%.

Werlte Biogas Plant

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www.bga-werlte.de

Background:
PLANT AND OPERATIONAL PARAMETERS

Unique properties	Industrial plant for manure and slaughter waste
Built by	Krieg & Fischer Ingenieure GmbH Hannah-Hannah-Vogt-Strasse 1 D-37085 Goettingen Germany Tel.: +49 (0)551 - 90 03 63 - 0 Fax: +49 (0)551 - 90 03 63 - 29 Fischer@KriegFischer.de www.kriegfischer.de
Business plan:	Co-op of 130 farmers use the plant to process manure and slaughter waste. The plant was recently sold to EWE, a local energy supplier.
Type of plant:	Large scale single stage digestion plant (vertical digesters)
Feedstock:	- 110,000 tonnes per year - 60% manure, 40% slaughter waste (food waste)
Reactor dimensions:	- Manure is stored in a 2,500 m^3 tank, slaughter waste in a 500 m^3 tank - Inputs are mixed and pasteurised at 70ºC for 1 hour in two 80 m^3 tanks (Nachgärer) - Primary reactors: 2 x 3,200 m^3 - Secondary reactors: 2 x 2,400 m^3 (+ 2 x 1,700 m^3 gas head room) - Final storage: 2 x 5,000 ^{m3}
Feed rate:	continuous feed totalling 300 tonnes per day
Operating temp.:	39ºC (mesophylic)
Dry matter:	13% (input); 5.5-6% (in reactor); 5.2% (output)
Retention time:	- Primary digester 21 days - Secondary digester 16 days

Agitation:	- Primary reactors: vertical shaft with 2 propellers - located at the top and the bottom - Secondary reactors: 2 horizontal propeller agitators to circulate liquid
Biogas production:	1,000 - 1,100 m^3 / hour
Methane content:	60-65 %
Sulfur (as H_2S):	Uses an iron II chloride desulfurisation step, planning on adding an active charcoal filter as well.
Cost of plant:	approx. €6 million
Energy output:	- 2 x 1.25 MW Deutz diesel co-fired generators (total 2.5 MW) - Heat used to heat tanks and run pasteurisation process.
End products:	Liquid fertilizer
Comments:	- Requires two full time staff to handle deliveries and check operation of plant - Sand is not a problem (no poultry manure or slaughter waste) - Plant was built in 2002 and required about 1 year to run properly

DETAILS FROM SITE VISIT AUGUST 2006

Torsten Fischer, General Manager Krieg and Fischer – engineering firm. Clients are large farm corporations

Lots of manure in this region. Farmer cooperative to distribute manure according to NPK needs. 100,000's of tonnes. Since the manure was being trucked anyways, may as well collect it, capture biogas and make money. Co-fermentation with fats, oils and grease, and other materials.
For this site, the project proponents worked with a general contractor: Hael GmBH. Didn't have experience in biogas, so Krieg and Fischer did the layout, design of measurement devices, etc.

Digester Basics
2002 start up. German system has a declining $/kWh every year, so the goal is to get the system running, generate a few kWh, then really get it going. Actual operation was in 2003. Need lots of time to get it running effectively.

2.5 MW production. Design for 2 MW, with 25% reserve. Of course, now running full capacity.
Have done some redesign: was originally 1 primary digester and 2 secondary. Now 2 primary digesters, 2 secondary digesters.

Vertical tanks with top-mounted mixer are most efficient. All of tank volume gets used most efficiently when mixing – no dead spots.
Higher organic loading (better) than horizontal tank.
Because this is a big facility, the system is expensive and efficient. For farm-scale systems it's okay to build them cheaper and slightly less efficient.

In Germany companies are getting lazy: "here's our one-size fits all system – take it or leave it."
At this site, including permitting etc the total engineering cost was €100,000 on a €6M project (although those were early days and he'd charge more now). For small scale projects Krieg and Fischer also does engineering. For an average 400 kW system, depending on input substrates, typically 5-6% of the cost is on engineering.

Glass coated steel tanks are used. For the 70ºC pasteurization of materials steel is easier to work with. Diameter to height ratio of 1:1 is cheaper in glass coated steel than in concrete.
Mixer on top is a 20 kW mixer with inverter to control RPMs. Allows energy savings. Hangs on the roof. Shaft is 13-14 m long. Mixer at the top, big propeller at the bottom, spins at 16-19 RPM. Different mixing speed for each system. One shaft with 2 propellers at this location. Some larger systems will even have 3 propellers on one shaft.

Problem at this site: engineer and contractor were two different people. Contractor had to use lower quality pumps because of agreement with another company. Lots of problems. At this site they spent around €50,000 on pumps in a €6M project, but these pumps are the biggest problem. Spend wisely!

Operators need to talk more together.

Gas Management and Electrical Production
Production in 2005 was 16,000,000 kWh (as predicted).
How many generators should a plant have?
1 engine: 85-90% availability assumed – sometimes a challenge with down-times.

2 engines: 92.5 to 95% availability – depends on gas holding volume – use bubble as reserve for oil changes etc. You learn in the 1st year to get it right.
Internal electrical usage: in Germany all the power goes directly to the grid, and you buy what you need from the utility with cheaper "dirty" power (i.e. coal, nuclear, natural gas). Gas engine on its own does use self-generated power (6% for compressors, etc).
This plant has a total self-use of 10%, which is relatively high, but it's a large facility with pasteurization, etc. Top mixers in the digesters are most efficient.

Connection to the grid: €200,000 including the transformer
Typically different scales of cost:

- 500 kW unit = €50-60,000 connection cost
- 1 MW unit = €75-80,000 connection cost

Engine: straight biogas, no bi-fuel blending at this site.
Biggest diesel bi-fuels are 300 kW, above this typically run pure biogas.

Krieg & Fischer is in Canada, with project in Saskatchewan (ClearGreen at Cudworth Pork) and a new project in Prince Edward Island. K&F is not a general contractor, only engineering. This is good for international projects. 90% of their projects are farm-based digesters.

Gas fired flare. Two regulatory permission documents: small plants have local government regulations Large plants have a higher level approvals, and then have standards for flares. German Safety Regulations for biogas (the Bible) requires that for systems with potential for a >20 m^3/hr blow-off require an "other solution". That solution is typically a flare. Flare: €40,000 – dead money, rarely used.

Gas storage: low pressure. Gas engines need pressure, so a compressor is required. Diesels can suck the biogas. Big gas engine needs big pressure: 80 mbar. 30-40 mbar for smaller engines. Want to reduce condensate for engine.

Desulfurization using simple air system, no column used.
But if alfalfa feed, lots of protein, lots of sulphur. But with lots of food-based inputs you have low sulphur. Fewer than 1% of digesters have anything other than the simple air pump system for desulfurization.

Feedstocks and Digestate Management
Receiving area for inputs: 2 trucks at a time.
1 insulated tank for fats to keep them warm – if cold, they cannot be pumped.
1 non-insulated tank for manure.
Full stream pasturization of all inputs including manure. 70ºC, 1 hour, then cooled. Big job to cool the material: requires 5-6 pumps. Heat recovery occurs between

pasturization tanks. The pasturization approach was required by the local veterinarian, which the designers feel is over-the-top. The requirements were put in place because design occurred in 2001 when BSE was a big issue, thus things were overly cautious.

No farmer trucks arrive at the site. Instead, only non-farm vehicles are used. There were even fears about dirty shoes at the time of design. The only benefit of the pasteurization was income to the engineering company. The result is lots of piping, challenges for operators, pumps, etc Lots of work. Although the fact is that most big plants have these issues when working with multiple farms.

Challenge: if you feed 70º C material into the digester you get significantly too much heat. Need to remove heat.

Pasteurization: EU Standard 1774, 2002 . 25 countries, each with their own interpretation. Each of the 16 states in Germany has their own interpretation. Plus the local veterinarian has some say. This is an inconsistent approach.

Odour from trucks bringing inputs: need for some sort of odour control system during pump-out. Designers wanted to develop it based on actual measured odour. Government insisted on using theory only. Result was a theoretical-designed bark biofilter, which subsequently did not work. New odour control system is a bioscrubber, then a biofilter. 3-5 air exchanges per hour (not sure exchanges of which space – the trucking dump booth?)

Hauling material: First they fully empty the farm storage tanks, then clean trucks (inside & out). Results in empty truck doing return trips. Cannot haul back and forth according to local rules. Very inefficient.

System uses 80,000 m^3 manure and 30,000 m^3 fats. Result is more output material volume than original manure. Farmers take it all back because they are happy to get the additional NPK.

The income from the tipping fees for fats pays for the manure transportation costs. Fats do not digest on their own – need to be blended. There is no good recipe for fats alone. Need volatile solids and total solids of both fats and manure. 1:1 ratio VS gives good recipe. Above that is a bonus.

This site takes no corn silage because of 2001 (old) laws. This is a "waste" biogas plant. Lower $/kWh paid because they are getting the tipping fees from wastes, and there is no cost to produce the inputs. Getting €10/tonne tipping fee. Fats, waste from slaughter facilities, paunch manure.

Laws (EU Standard 1774, 2002) have 3 categories of material:
"worst" is brains from Specified Risk Material – not allowed in digesters. Paunch manure is lowest risk.
Dissolved Air Flotation (DAF) waste – just a bit is taken.
Kitchen waste, expired food (e.g. yogurt) also accepted.

Piping in receiving area: 3 way valves
Had foaming problems with fats. Had overflow. so paved yard for easier clean up.
Pasteurization tanks – require 1 cm particle size.

Inorganic solids build up: Krieg and Fischer will not touch a project with sand in it. Too expensive. This location has operated for 3-4 years and no one knows how much sand build-up has occurred inside. At another project they had two 3600 m^3 digesters, built in 1995. After 7 years they went in, had 2 m sand build up. Top mounted mixers will likely deal with reasonable levels of sand, but not 15% sand, or chicken litter. Best solution for sand: cone design. Source-separated organic waste (household) often has dirt. Up to 20% sand in spring and fall. Fischer has seen a digester half-full with sand. Even in a cone-design somehow the sand did not know it was supposed to fall down the cone. They had a 45º angle, and it didn't fall. A 60º angle worked, but the cone is more expensive than the whole rest of the tank. Avoid sand. Avoid woodchips (which float). Straw is also a problem: doesn't digest well, increases retention time, perhaps from 20 to 50 days.

Pasteurization is a waste of time for the manure, and it was a foolish government policy. If they did have to deal with foot and mouth and the potential for transferring that in the digestate then they would require pasteurization of the manure.
Contact in Manitoba: George Kowalski – 205 434 9345. Worked at Wertlte Plant.

Beesten Biogas Plant

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Background:

PLANT AND OPERATIONAL PARAMETERS

Unique properties	- Very low maintenance plant. Single reactor concept. Built in 2005
Built by	Lipp GmbH Industriestrasse D-73497 Tannhausen Germany Tel: +49-(0)7964-9003-0 Fax: +49-(0)7964-9003-27 info@lipp-system.de www.lipp-system.de
Business plan:	Coop of 4 farmers. Goal is generate electricity and take advantage of the 20 year guaranteed feed in rate.
Type of plant:	Vertical reactor
Feedstock:	- 12,000 tonne per year silage (50% dry weight) - 1 tonne per year corn kernels - 12,000 tonnes per year. manure - 75% hog (2000 hog) and 25% cattle (100 bulls)
Reactor dimensions:	- Pre-reactor (Konservierung): 1200 m^3 (1:1 silage : water mixture and then allowed to hydrolyse) - Reactor: 1300 m^3 and 400 m^3 gas head room (largest possible is 1500 m^3 with 500 m^3 gas head room) built using a patented LIPP technology - Final tank: 2400 m^3
Feed rate:	68 tonnes /day
Operating temp.:	40ºC (mesophylic)
Dry matter:	29% input, 7-8% output
Retention time:	20 days (?)
Agitation:	2 shaft agitators (a pump pushes the material out of the bottom of a cylinder that pulls material in from the top of the tank)
Biogas production:	10,000 kWh per day (minimum) (or 70 m^3 / hour)

Methane content:	52%
Sulfur (as H_2S):	- less than 200 ppm (uses iron II chloride) - will add a second desulfurisation step as levels can rise to 350ppm
Cost of plant:	€1,250,000
Energy output:	190 kW and 250 kW MAN gas generators (total 440 kW)
End products:	Liquid fertilizer (7-8% dry matter)
Comments:	- Plant uses a very low 4% of the generated electricity to operate the plant - No sand problems - Like most plants, repairs are carried out by owner - Generator maintenance is the annual oil change - Rebuilt motors: check 2-G in Gronau-Heek (www.2G.de) - Pork manure digests well with corn cobs and wheat (Monovergärung) - Cattle manure digests well with total plant material (Ganzpflanze-Vergärung)

DETAILS FROM SITE VISIT AUGUST 2006

Hosted by Roland Lipp - LIPP GmbH, and Mr. Schaafma (farm owner)

Digester Basics
Digester with dome above for gas storage.
Storage tank for digestate.
Everything is automated. LIPP prefers full automation to decrease the workload to around 1 hour per day.
This facility was 1 year old.
Typically after 5 years they clean out the tanks. Engine maintenance every 500 hours. A local company is used for service, including valve rebuilds. The farmer changes the oil.
The turbochargers have to be replaced every 2 years. 6-7 years for the cylinders in the motor.
The full project cost €1,200,000.

Uses fancy LIPP assembly process using continuous rolls of steel and rotating assembly system. Double fold system. Stainless steel preferable over concrete.
At this site they have 2 gas engines, 190 kW and 250 kW. Gas is preferred over diesel because of a longer life span.
Desulphurization is done in the standard way.
LIPP also sells an external system that does the

biological process with micro-organism, special temperature and atmosphere. Chicken manure and fatty wastes have high sulphur contents.

LIPP has a digester at a layer farm in Val D'Or Quebec, 2 X 700 m^3. This system has a desulfurization setup.

This system relies on one pump into the digester. Relies on gravity overflow at the outlet. This digester is 1300 m^3, with a 400 m^3gas storage.
No heating pipes inside digester. Instead, you heat the wall surfaces from the outside.
Best heat transfer. 5 pipes per "layer" of steel (2 foot band).
Profile inside-out: steel wall, plastic infloor heating tubes, mineral wool insulation, aluminium siding.

Spreading digestate: no spreading for 5-6 months per year.   Typical rate of 170 kg per 10,000 m^2. No nitrate limit with winter application. No cover crop requirement.

LIPP focuses on quality construction, long life. It's worth investing in quality materials. Process is secure, as LIPP has been operating since the 1970's. Their systems will operate for a minimum 20 years. 5 year guarantee by law.

Farmer at this site was happy:
1. manure availability
2. corn fields close by
3. grid connection close by

Farmers are the only investors in this site. 4 of them.
10-15 investors normally. 30% of cost by investors, 70% from bank.
€1,250,000 at this site. 190 kW and 250 kW generators.
No flare, but setup in place if they had to.
Heat used for farm house, cattle, pool.
Considering sharing heat into town with a hot water pipe.
Secondary storage for digestate currently not covered. Assuming 96-97% biogas recovery in their 20-30 day retention time.
Prefer tall and narrow tank design. Experience with sludge treatment shows higher costs and lower output with a lower wider tank.
Don't need wood post and ceiling for desulfurization.
Lipp takes 2 weeks to provide a quote and 4 weeks for delivery in Germany.

Visit to LIPP Construction Site at Salzbergen
Concrete foundation. Assembly machine.
Roof constructed. Assembly of gas balloon inside. Ropes suspend the balloon from the ceiling. The balloon is a flexible plastic material (orange plastic). There is an air gap between the balloon and the ceiling.






The tank has a painted coating above the manure liquid level.
The assembly machine is called a "profiling" machine. The metal is kinked at an angle, providing a tight seal. System was run while we watched. It operates at 5 m/minute.

The actual roll of metal is a sandwich of metal: stainless steel on the outsides, and something else on the inside. The roof is made of galvanized steel. The bottom of the tank is made of heavier gauge metal than the top for structural purposes.

Gas Management and Electrical Production
Gas storage: costly but useful as a buffer. Germans are big on efficiency, so only ¼ to ½ day of storage capacity. 400 m^3 of capacity above digester, which allows for some maintenance. Thus virtually no downtime at the facility.
Connection to the grid: 600 m to the transformer. €50-100,000 to connect to the grid, depending on the distance.

Feedstocks and Digestate Management
Crop input tank. Ground grain corn - 2200 tonne
Corn input: finely ground and wet. Good inputs = good outputs.
Special LIPP system for the corn input: slightly fermented and almost syrupy. Pressure pump used to avoid air in the system. Material has high energy density. Feeds directly in homogenization pit in transfer area.
Corn storage system – filled annually at harvest. 3.5 pH – very sour.
Digester has 6.6 pH.

4000 m^3 manure – 2000 hogs, and bulls. Underground pipes. All manure is fresh
Centrifugal pumps used. 10-12% dry matter manure going in.
Transfer area where liquid manure mixed with crop inputs.
No preheating tank.
Dosing every 2 hours.
Some digestate recirculation (small percentage)
Started full of water and cattle manure

Used 304 stainless steel for crop storage and 316 stainless for digester because of sulphur. No additional liner was required.
The digestate storage uses lower quality steel.
The digester is not the place to do mixing. Mixing should be finished before material goes into the digester. Should be high efficiency conversion process, relying on only slight mixing in the tank.

Sand is difficulty. Could go with horizontal digester, although those have size limitations.

“Spargelhof Querdel” Biogas Plant

Elve 27
D-48336 Sassenberg
Füchtorf
Ph. 05426 / 2327

Background:
PLANT AND OPERATIONAL PARAMETERS

Unique properties	Very low maintenance plant. Single reactor concept. Built in 2005
Built by	Bio Energy Biogas GmbH Loher Busch 52 32545 Bad Oyenhausen, Germany Tel: +49-(0)5731-794-244 Fax: +49-(0)5731-794-215 Contact: Mr Klaus Peter Hankel Kape.hankel@bioenergy.de www.bionenergy.de
Business plan:	To expand family business
Type of plant:	Main reactor is a plug flow horizontal digester.
Feedstock:	Turkey manure, corn silage mixtures. Turkey manure ranges from 20 to 50%. Approx. 4,500 tonnes per year.
Reactor dimensions:	- Horizontal reactor is made from concrete slabs that are held together by cables under tension along the length and width of the reactor - Heating cables and insulation are sandwiched between concrete slabs - Reactor: 5.8m high, 6.3m width and between 19.8m and 27m long (700 m^3) - Digestate storage is in a vertical reactor (appr. 1,500 m^3)
Feed rate:	48 doses a day (@ 260 kg) for a total of 12-13 tonnes a day
Operating temp.:	39 ºC (mesophylic)
Dry matter:	- 30-35% (greater than 30% defined as a dry fermentation) - Output has D.M of 8%
Retention time:	- 80 days (can be reduced to 50 days with balance of digestion occurring in a secondary digester)
Agitation:	- Slow horizontal paddle agitation that reaches to base of reactor and above level of material to break up floating layers. - Keeps sand in suspension so that no accumulation possible
Biogas production:	Stored in headroom of reactors under two flexible plastic sheets: 530 m^3 - top sheet serving as protection for the weather.
Methane content:	52%

Sulfur (as H_2S):	200 ppm; removed by the addition of air (wooden beams above reactor)
Cost of plant:	€ 1.1 million
Energy output:	120 kW Scania and 190 kW MAN Heat used in turkey coops
End products:	Currently used as liquid fertilizer (plans to dry to pellets)
Comments:	- Construction of reactor took only 3 days - Low maintenance (1 hour a day to fill feeder hopper) - Current plant can be expanded to 1 MW (work will start in the fall) - Also does slaughter waste

DETAILS FROM SITE VISIT AUGUST 2006

Mr. Schlüter from BioEnergy
15,000 turkeys. Turkey barn recently cleaned out.
21 kg birds – meat turkeys - 3 crops per year.

Digester Basics
Dry fermentation, no liquid addition .
Started in February 2006.
Rectangular construction with mixer shaft along centreline. Sediment builds up in rounded corners. Even 1" rocks stay in suspension and work their way out.

Standard heating along walls. Concrete walls.
700 m^3 tank, 500 m^3 headspace. Concrete structure – 20 cm concrete, 7 cm insulation, 7 cm non-supportive exterior.
Paddles inside – 1 m long, 60 cm wide, offset around shaft.
Cuts into digester contents.

Turkey barn required €20,000 last year for heating – now using hot water pipes in the barn.

Tire-based pump – bellows system. Small air pump for air addition for H_2S. 1.5-2% ambient air mixed for H_2S removal. Can see the yellow crust built up inside. Pneumatic valve for inlet valve so that when outflow pump isn't running no new digestate can be added. Blow-off valve for safety if pressure builds up. 7-8 mbars.

Outlet pipes for digestate – 2 of them for safety, insulated against frost.

Secondary storage is not a reactor. This is a regret for farmer, but he didn't have the money at the time. Vendor and Biogas Association guy both said that if material is well-digested then capturing biogas off the secondary storage isn't worth the effort.

Gas Management and Electrical Production
Inner membrane goes up and down, but outer membrane stays inflated.
4 hours of gas storage.

3 phase line right on property. 400 V generated transformed to 15,000V.
Connection cost – €7500 for cable to the line . This was a low-end cost, since the wires were close by. €30,000 for transformer.   Sells all electricity to grid, process electricity is purchased from non-green power. Designed for 250 kW but bought a 120 kW and a 190 kW motor (Scania and MAN).

Condensation of moisture from biogas pipes using standard approach of long underground pipe.

Feedstocks and Digestate Management
Corn silage 8 tonne/day, turkey manure 2.5-3 tonne/day, and small amount of cereal as needed or available.

Corn silage harvested at different time for digester than for feed for cattle.

Feeder hopper for inputs. 2 mixers at bottom. Mixing well before addition – no water so need good blend immediately. Electronic tonnage meter. 48 doses per day. Auger up into digester. Added below the digestate level, so air tight. 30-40% dry matter input. No liquid added, but possibility of substrate recirculation if too dry.
Even though 30% dry matter, this means 70% liquid, so wet enough.   Can tell if need to recirculate digestate in order to wet the system down - mixer motor demand goes up.
13-15% DM coming out.   Digestate sampling sent to labs.

BioEnergy worked with the customer to develop the right recipe.
35-40 days retention time (or subsequent discussion, could be up to 70 days…).

Bioenergie Ahden GmbH & Co. KG Biogas Plant

Hofstelle Ebers
Schokamp 2
33142 Büren-Ahden
Germany

Background:
PLANT AND OPERATIONAL PARAMETERS

Unique properties	- Plant utilises a co-fermentation process that uses hog manure (2,000 head operation) and food waste. Shares heat with local airport and hotel. Start-up Nov. 2005.
Built by:	BIOGAS NORD GmbH Werningshof 4 33719 Bielefeld, Germany Tel.: +49 (0)521 557 507 34 Fax: +49 (0)521 557 507 33 Contact: Mr. Reinhold Poier poier@biogas-nord.de www.biogas-nord.de
Business plan:	Co-op of 3 farmers invested in a biogas plant to process hog manure and waste food. Heat to be sold to a nearby airport.
Type of plant:	Two-stage digestion plant using vertical reactors.
Feedstock:	- 4,000 tonnes / year hog manure - 10,000 tonnes / year waste food
Reactor dimensions:	Primary digesters: 2 vertical reactors each 18m diameter, height 6 m made of reinforced concrete tanks with floor and wall heating. Each contains 1,527 m^3 liquid and 406 m^3 gas storage. Secondary digesters: 2 vertical reactors each 22m diameter, height 7.5 m made of reinforced concrete tanks with floor and wall heating. Each contains 2,661 m^3 liquid and 741 m^3 gas storage. Final storage: reinforce concrete tank with 22m diameter, height 7.5 m. Contains 2,661 m^3 liquid and 741 m^3 gas storage.
Feed rate:	38 m^3 per day divided into 20 doses
Operating temp.:	38-40 ºC (mesophylic)
Dry matter:	15%
Retention time:	Primary digester: less than 48 days Secondary digester: less than 46 days
Agitation:	One diagonal propeller stirrer and a mounted horizontal propeller stirrer

	(can be raised and lowered). 2-4 cm floating layer is constantly present (causes no interference).
Biogas production:	Stored in headroom of the reactors under two flexible plastic domes. Top dome protects lower sheet from sun and the elements.
Methane content:	65-70%
Sulfur (as H_2S):	300 ppm (removed by naturally present bacteria through the addition of air over wooden beams)
Cost of plant:	Estimated at €2,500 to €3,300 per installed kW for complete new plant. Hence this plant would have cost €2.1 million.
Energy output:	750 kW electrical from a rebuilt Jenbacher; co-gen heat is used for biogas plant, hog operation and to heat nearby airport (1 km).
End products:	Used as liquid fertilizer
Comments:	- Has mixed in glycerine from biodiesel plant and clay used to bleach vegetable oils. - Sand build-up in the reactors requires that they are shut down and cleaned. (downtime: one day)

DETAILS FROM SITE VISIT AUGUST 2006

Mr. Soenke Neumann, Biogas Nord salesman
Mr. Ibers – Manager of Engineering and Equipment
Andrew Meyer – Biogas Nord

Biogas Nord is a 10 year old company
More than 130 biogas plants in Germany and internationally, including a very large facility in Wisconsin: 2 plants producing 8 MW – messy set-up and site.

This site provides heat to the local airport, and will provide heat to a hotel (which is under construction). 10 cm hot water pipe. 1.2 km. Plastic pipe. Cost €120-130/meter. Sales of hot water provide an additional €0.02/kWh. This cost is 30% less than using natural gas at the hotel.

Digester Basics

Digesters are heated inside the walls and floors. Double roof. PE, PVC. 35 mbar pressure. Outer dome for weather. Wood construction inside, slats below dome. No insulation below dome. Concrete centre post – acid-safe.

Uses high quality Flucht mixers. Have both vertical and horizontal mixers. Propeller mixers. Big diagonal mixer. 2 mixers 1 m off the wall. Crank-based system to raise and lower mixers from outside.

Glass viewing windows.
Pipes for inputs running in the ground.
Heating system installed on current "storage" tanks – ready for further digestion.
Gas measurement column to see how full storage is.

Biogas Nord does two types of plants: agricultural standards (lower investment cost) and industrial standards. Difference is in quality of materials, wood, steel, PVC ducts.

When we were there spreading was going on, so one tank was empty.

Things to change for next time:

- Have more than one mixer in the pre-dump tank.
- Don't have too many contractors on the project –
- Manure directly to the digester, not to the pre-dump tank.
- Do lots and lots of research first, speaking to operators to get experience from complete systems, then sit down with the design and get the plant that you want. Your interest, versus the company selling you a standard plant.
- Standard versus individual: this is more about layout and configuration versus equipment used – want to be able to call your neighbour about the equipment.
- Piping system – do it yourself for the design, and do lots of planning.
- Make your pre-dump tank as big as possible.
- Need as big a loader as possible, not just your farm yard manure tractor.

Gas Management and Electrical Productions
This site has a 750 kW Jenbacher engine.
2 smaller generators is better than on big one.
Also, if producing less than 100% calculated gas production then can run one unit at 100%, and the other at 100% for only 12 hours or whatever.

Transformer for electrical was €40,000, connections at the engine another €25,000. Total electrical minus transformer was €40,000. Connection to the grid cost depends on distance. Did not have to pay utility to connect to the grid.
System is 400V, 50 Hz, transformed up to 10,000 or 20,000 V.

Safety valve: water based.   If blow-out condition, could connect to flare. A flare costs €50,000. Biogas Nord operates a mobile flare service for €50/month. They will deliver it in 6 hours, or at most 24 hours within 400 km radius. They rarely use it.

Use 1% O_2 for H_2S.

Heat for winter for hotel. Hotel has no heating system as back-up, so had to provide 100% guarantee to hotel. Thus have natural gas back-up system.   Backup is 500 kW system. Cost €1.6M for entire setup, Biogas Nord digester component is €1.2M.

Get 2€¢/kWh bonus for using the heat. Actually comes to 1.5 to 1.7¢/kWh average for heat used (not able to do it all the time).

Feedstocks and Digestate Management

Digester has 250 m^3 pre-dump tank for mixing before the digester. Using glycerine, glycerine/water mix, and waste from a marmalade and jam plant. This is mixed to homogeneity. 15 to 55 m^3/day of homogenized material mixed with manure. The limiting factor in their blend is the relationship between ammonium-N and carbon.   No storage space for large volumes of material, so only take what they need, and from local delivery distances.

Manure is brought from under-barn storages from the on-site finishing hog barns, and pumped into the pre-dump tank when convenient. Blended with food waste. Want to avoid stirring the system all the time. They only pump 150 m^3 at once.

Underground pipes. Central pumping station connected to each digester. Valves to allow different flow to different locations, allows fewer pumps. Digestate moves from one tank to another, with 1 tank as back-up. Would use valve system when more than 3 digesters. Have different system for 2-3 tanks. Typically use electrical controllers on the valves, but in this case it was a manual system.

Regrets: Flucht submerged mixers – Biogas Nord installed 500-600 of them, and get phone calls once per week about them. Probably more than 10% of plants have problems with them.   However, would continue using submersible mixers. Don't like external mixers. Submersible pumps: takes less than 1 hour to replace versus angled units, for which you would have to empty the tank. For submersible pumps simply open the roof, slide up the slider using the steel rope and pull it out.

Rotor chopper pump at pumping station – good for mixed inputs. Normal plants with silage and manure don't bother with chopper pump. Vogelsang chopper pump. Very happy. Eccentric screw pump.

Sand bedding: have installed screw separator for sand in Wisconsin and it works for sand. For sand should install doorway, drop in a bobcat and do cleanout.

Jühnde Bio-Energy Village

Visitor Centre
Koppelweg 1
D-37127 Jühnde, Germany
www.bioenergiedorf.de

Background:
The Jühnde bioenergy village in northern Germany switched its power supply to renewable energy completely. The project was given scientific support by the universities of Göttingen and Kassel and has meanwhile become famous not only throughout Germany, but all over the world. The Jühnde bioenergy village attracts many visitors who experience on-site that a hundred per cent energy supply from renewable energy sources is utopia no longer but a serious alternative with ecological, economical and regional advantages over conventional energy supply systems.

Energy Concept of the Bioenergy Plant in Jühnde

The energy plant is composed of the following three main elements:

1. Haase biogas plant, 700 kW electrical and 740 kW thermal energy on the basis of renewable raw materials and liquid manure.
2. Biomass heating station with a 550 kW boiler with automatic feed from the company Schmid Holzfeuerungen.
3. District heating network for connecting the approx. 140 houses

The functional principal is as follows:

Only renewable raw materials (e.g. rye, wheat, sunflowers, maize) and liquid manure are fermented in the biogas plant. The methane resulting from this is converted into electricity and heat in the combined heat and power generator. The electricity is fed into the public grid and the heat is transported to consumers as hot water at around 80ºC via the newly installed district heating network. The biogas plant consists of a liquid manure mixing pit, a fermenter and interim storage containers. The plant is only operated with biomass such as liquid manure from cattle and swine and whole plant silage. These substances are permitted by the Renewable Energy Sources Act. The energy released from this is converted into electrical energy (feeding into the public grid of the energy provision company) and heat. The heat generated during the burning process is transported via the district heating network to the households in Jühnde in order to heat homes and to generate warm water. The heat base load demand is covered by this. The fermentation residue which results is used on agricultural crop land in accordance with regulations. The biogas production successfully began at the end of January 2006, and the biogas in the fermentation residue storages, is also connected. Currently, the power station is running at 60% capacity and has generated more than 800 MWh of electricity. Output shall increase further in the coming year.

A wood chip heating plant is used to ensure that the households' heating needs are met all year round. This is fired with non-processed wood only and it is no problem for it to burn wood up to a maximum moisture content of 60% atro with G50 piece sizes. Wood chips from nearby woods are used. The village of Jühnde had good experiences with the biomass heat generator in the first winter (2005/2006). This heat is also fed into the district heating network**.** The households get their water and home heating needs from this environmentally-friendly energy. By doing so, the people of Jühnde are not only saving on their heating costs but also preventing around 3,300 tonnes of carbon dioxide from being released every year into the atmosphere, which would otherwise have been the case if conventional heating methods were used.

An important step in the planning and implementation of the technical concept was finding a project manager with suitable experience. In his function as project manager, Hans Erich Tannhäuser, graduate engineer, faithfully implemented all matters to do with the implementation of the Jühnde Bioenergy Village project. Together with the operating company and selected specialists, the project came in within budget and was implemented to the highest quality standards.

PLANT AND OPERATIONAL PARAMETERS

Biogas plant built by:	Haase Anlagenbau AG Gadelander Straße 172 24539 Neumünster Germany
Type of plant:	Wet, total stirred reactor, reactor and storage tank with gas storage roof
Feedstock:	Dairy manure 30 tonne/day, silage (grass, and corn) 25 tonne/day, ground corn 4 tonne/day
Reactor dimensions:	3000 m³ primary, 5000 m³ secondary
Feed rate:	Once per hour, 55 – 60 tonne/day
Operating temp.:	38°C
Dry matter:	Input: manure 6-8 %, silage 28-32% In reactor 9%
Retention time:	66 days in reactor
Agitation:	Submersible mixer
Biogas production:	300-350 m³/h

Methane content:	50%
Sulfur (as H_2S):	100-200 ppm
Cost of plant:	€1,650,000
Energy output:	680 kW electrical
End products:	Liquid fermentation residues

DETAILS FROM SITE VISIT AUGUST 2006

Gerht Pfeffenhors – 20 year resident of village
Nina Pingel – Haase Biogas
www.haase-energitechnik.de

Haase Biogas:
200 employees
40 plants built this year.

History
University of Göttingen – idea of village to produce its own energy. Did technical and economic projects. In the year 2000 they were happy with their projections and sought a village to participate. Four points for village eligibility:

1. Right ratio of farms and citizens: 5 big farms and 4 small farmers per 750 citizens was thought to be a good ratio.
2. Enough land to spread digestate – 1200 ha in this case. They need 300 ha of this for corn, triticale and grass production for the power station – i.e. ¼ of land from spreading is used to power digester.
3. Forest resources nearby to provide wood for supplemental heat in winter: biogas provides enough heat for the hot water use of the village, but not enough to heat the houses in winter – use supplemental heat from wood, and even have an oil system for peak times when it hits -15 to -20ºC. Not worth it to design renewable system for the last percentile of the heat use curve. Last 5% with oil.
4. Willingness amongst villagers. Villagers have done lots of work: biogas plant, network of heating pipes. Villagers participated in the process of sourcing wood, selecting the biomass combustion system, selecting the digester system.

Ran out of money. Government stepped in with grants.
Village participants paid in upfront – €400 per house for warm-water customers. Had 50% participation at first, now up to 70%. Original corporation was shut down in 2004 when government stepped in with grants. Now participation requires €1500 (3 X €500 shares) to participate. 1 vote per member, not per share. Control remains within village. November 2004 they turned sod. First delivery of warm water was September 2005.

€1.5M government grant. €500,000 from the co-op. Bank covered the rest.
€800,000/year turnover. Getting 17¢/kWh guaranteed 20 years.
¾ of revenue from electricity, ¼ from hot water.
Network of pipes cost €5.3M.

Heating System Basics

Biogas production from corn, triticale and manure. 700 kW electrical, 700 kW thermal – hot water. Provides 60% of village hot water needs.   Most houses had hot water oil systems with radiators.
The oil-based backup system is security for town – can provide 100% back-up. Went with oil as back-up because you're sure when you turn it on that it will work.   1.5 MW oil furnace as backup.

Thermal load in village:
10% kitchen and bath – on hot days too much heat energy and so actually blow off some of the heat with radiators at the digester. New heating system being developed to dry the woodchips – under development. Can also dry produce or grains.

Woodchip burner: Swiss design – much knowledge and experience. 55% humidity wood. Will dry the chips in the future.

Woodchips: tractor loads into big hopper. Moving floor system, then scraper to oven. Better than screw for maintenance. Woodchiping is done elsewhere because of noise concern, and infrequent use – why keep a chipper on hand year-round?

Heat to village – 68 to 70ºC at furthest point.
PVC pipe into house. 1 cm pipe, 5 cm insulation. 20 cm mainline.
Steel inner pipe. 2 wires to monitor for humidity in insulation – 10 mm gaps on wire allows you to determine where your leak is.

Pipe into houses
1. direct to radiators. Radio control battery operated motor for thermostats.
2. water to boiler for bath/kitchen with heat exchanger.

Each house is metered for use. At the speaker's house he pays 4.9 ¢/kWh electrical, plus €500/yr fixed for his hot water.
He's used €1100 since November 2005, plus his €500 fixed price for a total of €1600. But it would have cost him €1800 for the same heat and electricity (3000 L oil at 60¢/L). Plus he saved €150 for not

having to clean his chimney, no maintenance, no oil storage, no water pump to the radiators – probably €700 savings overall, plus he's saving the world!

Hot water from digester at 80ºC, arrives at house at 72º. Warm water goes directly to his radiators. Pressure controller at each house. 3 bar pressure at plant. Separate tube in boilers for hot water. Furthest home is 1.5 to 2 km away. Network total is 5.5 km of pipes. Return water comes at 40ºC. Insulated return tube.

Digester Basics

Pre-cast concrete tanks – sure of quality.
8 m high. Submersible agitator pumps. 17 kW mixer on slider – can raise and rotate. 4 mixers in primary digester, 2 in secondary.

Normally 3000 running hours before problems.
Operates at 39ºC, 60 days retention time in primary digester.
€2,000,000 for biogas system
System comes ready-built in factory, already tested with biogas.

Nutrient management: N and P application limits because this is a water conservation area. Apply at 10 m^3/ha. University is doing nutrient analysis constantly. 4 km radius for 1200 ha.

Gas Management and Electrical Production

9000 m^3 digester
360 m^3/hr gas production at 50-52% methane. 100-200 ppm H_2S
All electricity goes to the grid.
Transformer cost €50,000 (included in €2M cost). All other electrical cost €60,000
Combined Heat and Power (CHP) unit - €400,000
Deutz unit. 1 generator – why not more? Don't need more heat. More money to buy another. Generator has good muffler.

Flare at this location. €16,000. Integrated into container design (no foundation). Only 800ºC (low temperature)
No odour problems with neighbours.

Dome – 2 membranes. 5 mbar pressure to hold outer membrane up. Biogas pressure changes.

Feedstocks and Digestate Management

Biogas plant is like a cow. You must love her for her to perform well. Don't mix substrates before adding to digester – avoids early biogas production.
Weight system on dry mixer. Automatic loading of 500 kg/feeding (every 2 hours)

30 m^3 manure, 28 tonne silage, 2 tonne grains. Not important to mix every hour. 33% DM silage. 80% DM grain corn. 12-13% DM manure. Digestate comes out at 8% from primary tank, 6% from secondary tank. 10% volume reduction in primary digester.

Corn silage is purchased at €72/dry tonne. Triticale at €65/tonne. Triticale slightly lower biogas production than corn. Corn silage is the best cost/yield, but triticale allows crop rotation – harvest in July. 1 harvest, versus 3X for grasses. Winter triticale being planted now – same yield, earlier in the year. A dry late summer could result in bad silage. Here they have had the same biogas yield between corn silage and triticale, but many think it should be 10% difference. Yields: Triticale 12-13 tonne/ha D.M. Corn 8-9 tonne/ha D.M.

Need the manure even though it's high volume, low yield – it provides the methanogenic bacteria. But it's not worth driving a long way for manure.

Visit to Local Dairy Barn:
Once/week manure pick up for community digesters.
140 milkers, 100 heifers. 10,000 L milk versus 8500 in Canada
Dry cows in pasture. 3.9% fat. 3.6% protein
3 sided herring bone parlour built in 1992. 1 hour, 100 cows. Smaller groups.
Farm right up in village. No odour issues. Digestate brought back to farm – little bit of odour – still sulfur compounds the provide odour.

Hohne Biogas Plant, Kuhls Family

Wiesenstr. 2
29362 Hohne-Spechtshorn, Germany
Tel: +49-(0)5083-700

Background

PLANT AND OPERATIONAL PARAMETERS

Biogas plant built by:	Archea Technology Hoher Kamp 7, Klein Heßlingen 31840 Hessisch Oldendorf, Germany Tel +49 (0) 5152 / 52 71 62 Fax +49 (0) 5152 / 52 71 61 heidi.dubois@archea.de www.archea.de
Type of plant:	Dry, horizontal primary digesters, with wet totall stirred vertical secondary reactors. Gas storage roof over secondary digesters.
Feedstock:	12-13 tonne/day of material added: 8-9 tonne/day silage, plus grass silage, green rye silage
Reactor dimensions:	2 X 325 m³ primary, unknown m³ secondary
Feeding rate:	45 times per day, 300 kg/load
Operating temp.:	55°C
Retention time:	66 days in reactor
Agitation:	Submersible mixer
Cost of plant :	€1,500,000
Energy output:	500 kW electrical
End products:	Liquid fermentation residues

DETAILS FROM SITE VISIT AUGUST 2006

Archea Technology www.archea.de
30-40 digesters across Germany
Standard size is 200 kW.
This site is 500 kW
Archea has 20 employees and specializes in planning and servicing digesters.
Horizontal digester tanks – Eisenmann builds the tank. "Eisenmann" means steel man.

Digester Basics
This site has 2 horizontal reactors. Black steel inside (black steel contains a black oxidization which is then coated with a protective oil). Heating coils around tanks. Insulation. Outside sheet is zinc. Uniform heating with coils.

Paddlewheel agitation along the length of the digester. Paddlewheel goes within 2 cm of the wall, so well mixed. 2-3 rpm.

Sand removal units unique to this design. 20-30 cm holes along bottom of tank. Found along the first 1/3 of the digester. Valves to open collection sumps, drain into auger along bottom. For corn-silage systems only requires clean out once every 2 months. For sand clean-out could run auger more often, daily, 2-3 times per day, no problem. Big advantage over vertical system where emptying out is a necessity to get to the sand build-up.

Tanks are 325 m^3. Thermophylic primary digester. 12-13 tonne/day of material added: 8-9 tonne/day silage, 7 m^3 manure for start up. Also grass silage, green rye silage.

Bauer screw press separator to be used at outlet when construction finished. Plan to use heat for additional drying along with screen separator and then will recirculate liquid component back into the digesters. Recirculating 4% by volume of the digestate.

This digester will get a “technology bonus” price on electricity because it will operate only on crops and not use manure at all. Dry fermentation bonus for >30% dry matter input. Would be no problem to add for instance potatoes, but then they would not get the biomass bonus because the potatoes would be considered a “waste”.

If the digester input is too liquid then it’s no longer a plug flow. Advantage of plug flow is that the substrate stays together with little horizontal mixing – zones of specific biological activity develop: bacteria generate their own heat, hydrolysis occurs, etc.

This digester has a 15 day retention time. 10-12% dry matter out of primary digester. The mixing motor is perhaps 10 kW. 2 separate shafts on the mixers on this system, one at each end. Centre shaft bearing. Free floating, not attached, digestate is lubrication.

These systems are a standard dimension. For more input they would add more digesters in parallel. Have been building these systems since 1998/99. Chief maintenance is with the co-gen unit. Never had to disassemble or go into a digester tank.

3-6 months until fully operational.
Cost of one reactor alone: €150,000. Whole project at this site: €1,500,000, which includes the cost of a digestate drying system.
Oxygen-poor (reducing) environment, so steel will not rust. Additionally, black steel is rust resistant. Organic acids are a bigger issue, although black steel is also resistant to them. Spray coating, not just type of steel.

Group observation was that there were many many pumps.

Gas Management and Electrical Production
500 kW Pro2 cogen unit. www.pro-2.net Uses Deutz motor.
Cogen unit: €500,000.
Gas versus diesel: higher wear in diesel because higher compression ratio. Also with diesel co-firing you have to purchase diesel fuel (increased costs).

Farmer can do own oil change. Company suggests that any other maintenance is best left to a servicing company: downtime = lost income and the company will be more skilled at solving problems than the farmer. The company also knows the weak spots, having visited many co-gen sets.

Transformer and electrical connection costs: €70,000. 400 V to 20,000 V. Connected to grid via underground cable at the road. The farmer pays the connection to get to the grid.

Double membrane dome. Wooden ceiling roof system. Use special membrane on the wood for desulfurization. Need to replace membrane after 5 years.

Feedstocks and Digestate Management
Loading the digester: each charge is 300 kg, 45 (?) charges per day
Tanks are 90% full, with head space for gas. Tank is not level, rear is a little higher – gas climbs to the rear of the tank.

Feeding wheat into secondary digester as well. Hungry bacteria – tests show you can still get good gas production in the secondary tank. Maintaining thermophylic temperature in secondary tank. Getting lots of boost. Has to be wheat or other grains, but not corn. The conversion process goes after starch first. Boost is from 480 kW up to 537 kW from this extra addition.

Drying digestate solids later in the process. Material is quite wet and need heat to dry. After drying, will be 80-90% D.M. Will sell to horticultural farmers, or pelletize for biomass combustion.

No further storage built. Will dry material coming out of secondary digesters and recycle water. Land application of some of the liquid component.

Innoculating digester when starting: 50% manure, 50% digestate from another digester.

RWG Jameln Biogas Gas Station

Jameln biogas plant & Germany's first biogas gas station

Hans-Volker Marklewitz, Manager
Bahnhofstr. 37
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Tel: +49-(0)5864-988012
http://www.wendland-elbetal.de/index.php?id=57,91,0,0,1,0

Background:
PLANT AND OPERATIONAL PARAMETERS

Built by:	BIOGAS NORD GmbH Werningshof 4 33719 Bielefeld, Germany Tel.: +49 (0)521 557 507 34 Fax: +49 (0)521 557 507 33 Contact: Mr. Reinhold Poier poier@biogas-nord.de www.biogas-nord.de
Business plan:	95% biogas for electricity, 5% for sale at local gas station as purified biogas
Type of plant:	Two-stage digestion plant using vertical reactors.
Feedstock:	Crop inputs
Reactor dimensions:	2000 m^3 X 3
Feed rate:	10 tonne dry matter per day
Operating temp.:	38-40 ºC (mesophylic)
Biogas production:	7000 m^3/day
Methane content:	65-70%
Energy output:	600 kW total (250 kW and 350 kW units)

DETAILS FROM SITE VISIT AUGUST 2006

Biogas Nord digester and Haase gas cleaning system
Hans-Volker Marklewitz and Dr. Ernst Schoettle ernst.schoettle@t-online.de
(gave tour in English – advisor to project)

Digester Basics

Corn silage is main input. Corn grain too.
2000 m^3 tanks X 3. 1 primary, 1 secondary, 1 storage
Took only 14 days to get the digester up and going.

Measuring pH, organic acids – strong focus at this site on management of digester contents to optimize production. Biogas Nord offers a service, but doesn't meet the needs of these guys, so they choose to do their own basic analytical work onsite. Train the farmer for monitoring/ controlling amount of gas production. Monitoring methane % is important. Gas production and methane quality are key indicators to monitor for hints that things are working well.

A healthy digester is a stable digester. Organic acids should not exceed the buffer – pH at 7 is best, or a little higher. Don't drop to pH 5 or 6. Measure free acids and buffer. A ratio lower than 1 is best. "Phostac" acid – buffer capacity. Buffer is ammonia bicarbonate – comes from liquid manure urea N which then splits into ammonium bicarb. If concentration of buffer is high enough then pH won't drop.

Raw gas is at 53% methane, 46% CO2 and other impurities (primarily concerned with H_2S). Methanogenic organisms have a range of acceptable free acid concentration. If concentration exceeds this level there is no additional biogas production. If phostac ratio is low (e.g. 0.3) then you don't have maximum production. Need to change pH or feed to get levels back up if they drop too low.

Steps if pH drops:

1. Stop feeding – something is wrong. When you stop, concentration of free organic acid drops. You don't know what happened to your populations, so may need to regenerate bugs.
2. Pump back material from secondary tank or someone else's tank back into primary digester – e.g. 50 m^3 to re-establish. Marklewitz recently gave 200 m^3 to another farmer to regenerate his primary digester. If you only have your own materials to regenerate with, it may take lots of time.

Gas Management (Including Gas Cleaning) and Electrical Production
7000 m^3/day of biogas.
Primary income still from electricity generation. Only a small % of biogas is purified. This is because German Law still benefits electrical generation, not auto fuel production. RWG Jameln is an early innovator in Germany – first biogas gas station. 5% of their biogas to the gas station, 95% to electricity. 60 cars per day at full capacity. Limited by the size of the purification unit. Non-used purified gas is returned to the electricity biogas stream if need be.

Generators are locally implemented (Drie and Costa or something) – 250 kW and 350 kW systems.

Biogas cleaning is a Haase unit.
1. Charcoal cleaner
2. Raw biogas compressed to 7 bar
3. Absorption column. Biogas moves up the column. Washed with an organic solvent (counter-current). CO_2 and impurities absorbed by solvent. Leads to >96% methane biogas. Absorption occurs at 12 ºC. Solvent is organic ether.
4. Gas compressed and sent to gas station (only few km away)
5. Saturated organic liquid heated in heat exchanger from 12 to 60 ºC.
6. Desorption column – counter-current with air (going up). Because of the heat, the CO_2 evaporates and releases to the air stream. At the bottom of the desorption column is clean solvent for re-use. H_2S is one of the gases blown out.
7. Release through charcoal filter (polishes some H_2S, etc) and then exhausted to air.

Perhaps in future could clean CO_2 and sell. This process produces a cleaner CO_2 than combustion gas CO_2. Probably only works at larger-scale plant.

Adding gas to natural gas system would be nice, but still not allowed (is allowed in Switzerland and Sweden). The speaker mentioned that Switzerland is no longer allowed to add electricity to the grid – need to confirm this).

If it were only a biogas to fuel system the bank would likely have not funded it, but since it's got the electrical component, funding was secured. Grant from government for innovation. 50% of cost.

There are many other systems that could have been used for cleaning the gas such as a charcoal (TSA) system. Another system well-developed in Austria relies on pressure changes, result in cleaning with absorption and desorption.

Water based gas cleaning systems are much bigger. Gas cleaning system cost €500,000. Economies of scale mean that doing a systems 10 times larger would be a marginal cost increase, not a 10 X increase. This systems is a 100 m^3 system.

This system has very low methane loss (5%) – better than typical 10%. They figure this system could get as low as 1% once they optimize it. Only operating since June 22nd, but working very well. Operated after 2 days. No regulatory problems.

No problem to run gas pipeline through neighbours' properties. Many minor difficulties in getting the digester system fully operational. Nice hot summer, had problems with cooling system. Good public reception. Car companies are all sold out of biogas-capable cars. They contain a small gas tank as back up since the availability of natural gas/biogas may be limited in some areas, so "just in case".

€80,000 to connect to the grid, including the transformer.

This is biogas offered up as a gas. Biogas to liquid (BTL) on the other hand is a waste of time for such a limited biomass resource.

Feedstocks and Digestate Management

Tanks: 1 primary, 1 secondary, 1 storage.
This is desirable because if something goes wrong in the primary digester then have digestate in the secondary digester that you can use it to regenerate if the primary goes bad. Grain and silage fed into first digester.

This material is sticky, so stirring is important. If pockets or islands develop, then acidification takes places – messes up the bugs. Feeding 10 tonne dry matter per day.

Agrarenergie Kaarßen GmbH & Co. KG Biogas Plant

Laaver Straße 2
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Background:
PLANT AND OPERATIONAL PARAMETERS

Unique properties	- A very large biogas plant situated next to a very large dairy operation. The excess heat is used to prepare a concentrated liquid fertilizer.
Built by:	BioConstruct GmbH Henrik Borgmeyer Wellingstraße 54 D-49328 Melle Tel: +49 (0) 52 26 / 59 32-0 Fax : +49 (0) 52 26 / 59 32-11 Cell: +49 (0) 162 / 2 45 44 80 www.bioconstruct.de , Email: h.borgmeyer@bioconstruct.de
Business plan:	10 investors started up an energy plant based on locally available resources (basically manure).
Type of plant:	Two stage reactor design. Before digestate is put into the final tank, the solids are removed by a centrifuge and the liquid fraction is concentrated 2.5 times using the excess heat of the generators.
Feedstock:	100,000 tonnes of dairy cow manure (the biogas plant is obligated to use all the manure created by the neighbouring dairy operation) 30,000 tonnes of corn silage (delivered daily)
Reactor dimensions:	Primary reactors: 2 x 5,500 m^3 (no gas headroom) 18m diameter, height 20 m (made of enamel coated steel plates screwed together, lower plates 10 mm, upper plates 5 mm) Secondary reactors: 1 x 2,500 m^3 (800 m^3 gas headroom) & 1 x 5,200 m^3 (2,500 m^3 gas headroom) Storage tanks: 1 x 5,200 m^3 & 1 x 7,500 m^3
Feed rate:	Continuous parallel feed to both primary reactors: 350 m^3 of manure (whatever is produced) & 80 - 100 tonnes of corn silage
Operating temp.:	40ºC (mesophylic)
Dry matter:	9-10% (in the primary reactor)

Retention time:	Primary reactor: 22 days Secondary reactor: 8 days
Agitation:	Primary reactor: vertical shaft with 2 propellers near the top and the bottom (generates currents of 5 m/s) Secondary reactor: height adjustable submersible propeller agitators (2 per reactor)
Biogas production:	1,200 m^3 / hour
Methane content:	51-52%
Sulfur (as H_2S):	2000 ppm (have a 15m column to remove sulfur through biological means), after treatment under 150 ppm
Cost of plant:	€10 million (this includes €1.5 million to build solid separator and digestate concentrator) Took 9 months to build, and started operation December 2005
Energy output:	2 x 1,416 kW Jenbacher gas motors (total output 2.8 MW) Heat is completely used internally to heat tanks and in the concentration of the digestate
End products:	- After the secondary reactor the digestate is run through a centrifuge to remove any solids. This tends to be undigested wood chips used for litter in the dairy operation, and sand. This is returned to the dairy farm and used as bedding. - Next the liquid fraction is run through three low pressure evaporators and condensers. The liquid is heated to facilitate the evaporation of the water. The evaporated/condensed water is sent to the local water treatment plant. The concentrated liquid fraction (2.5 times concentration) is stored and sold as concentrated liquid fertilizer. As the neighbouring farmland is poor in nutrients the fertilizer has a ready market.
Comments:	- Sand is expected to remain in suspension and removed in the centrifuge. - Operates 8,000 hours per year - Economics depends on a) heat usage and b) cost of feedstock (silage). Silage currently sells for €20-25/ tonne (higher price than for wheat). - Typical Bioconstruct plant is 500 kW (one sixth this size). They will build 10 of these this year.

DETAILS FROM SITE VISIT AUGUST 2006

Dairy Operation (Kaarssen - next to biogas plant)
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This farm currently has 1,700 head of dairy cattle. There are also calves. The plant is currently undergoing expansion. When finished there will be about 5,000 head.

The farm also has a carrousel milking machine. This permits 80 cows to be milked at any given time. The process is semi-automated. The operation was originally an East German co-op that was bought by a Dutch investor after reunification.

Digester Basics

Built 1.5 years ago. Goal to minimize volume of manure having to be spread because of limited space for storage and land application.

Tall narrow design. Only problem is that the corn silage floats. Most important thing is to keep stirred. Have not had any problems.

All heat from co-gen unit is used to reduce volume – steam distillation to boil it away.
Result is 3 fractions of manure:

1. solid - produced from digestate with separator

   Liquid split into 2 streams with steam evaporation:
2. condensed stream that is discharged to local wastewater treatment plant (60% of total liquid
3. thickened liquid with 30% of liquid volume and 4X the nutrients of the original manure stream.

N, P, K: 20, 10, 13 kg/m^3 – 4 X normal manure

Barns: old barns have 2000 head, existing new barn is 1000 cows, and new barn under construction another 1000 cows. Old East German farm – purchased and modernizing. Conversion from cooperative to private as part of big East German privatization scheme.

Manure sump, mixer, level sensor, rotary cutter pump. Old barns have their own sumps. Farmer doesn't like all the levels and pumps and mixing – hassle for keeping levels just right – too much fine tuning.

Governor and Agricultural Ministry were very supportive. Environmental Ministry was a big hurdle. Heavy requirements. The farm site is in an EU nature reserve. Required to have a 30 m stack for the generator emissions.   Overall, 2 years to get all the approvals.

Gas Management and Electrical Production

Gas storage only 2500 m^3, producing 1400 m^3/hr biogas. Gas storage on secondary digester tanks. 2800 m^3 secondary tanks. Rotary paddle turners. Always have combination of big rotary turner and smaller one. The big one runs often and the small one when needed.

Biological desulfurization column. Tiny plastic balls, biogas flows up. Same biological process as occurs in other designs under the dome. In this case a biofilm develops on the plastic balls and there is significant surface-air contact. Works pretty well. Problems: this summer, too hot (>30ºC) – bad for the bacteria who want a specific temp range. Cheap process compared to chemicals. 2000 ppm H_2S in, target is 200 ppm out. So much gas out of this plant, this is the most effective approach.

2 X 1400 kW Jenbacher gas engines. €1,000,000 to connect to the grid. – had to run 17 km cables. Main line which they had to run to is 20 kV. Generators 480V.   Load 3 MW onto distribution system.

Financing – €10 million. Includes €1 million for condenser and €1 million for electrical lines.

5 km to wastewater treatment plant. 1 km to pipeline. Farm had to pay to lay pipe. Farmer did the work to design the lines – had to run 17 km to get to 20 kVa.

Feedstocks and Digestate Management

7 other farms bring silage. Farmer is paid €2/tonne for the manure. The biogas plant is required to take it daily. Basically covers the nutrient value of the manure (could be up to €2.5/tonne) Local farmers pay €11/tonne for the digestate (because 4X the nutrients of normal manure. Area has low nutrient levels in the field.

Dump tank – 1 day capacity only. 350 m^3. Have cover for it, wasn't installed while were there there, but visible clamps. Part of contract is that farmer can do scraped waste feed from the barn, etc. Problem is that wood chunks and other foreign material mess up the pumps, and if they got into the augers for the silage could be big problem.

Silage feeding system – 15 ft deep sump. Have double redundancy in feeding system – last minute decision to double everything up, and has been very helpful (as a note, the large digester in Alberta has had serious downtime due to broken components in the feeder system for their pack manure – no redundancy in system).

Currently dumping onto the apron in front of the plant – plan is for dumping directly into the hopper. Needs to be silage – if grain corn, then gas quality drops from 55% to 48 % methane because of lack of acidity – needs to be ensiled for hydrolysis.

Screw separator to get rid of stones and big pieces of corn leaf before pumps (not to be confused with the system at the evaporator later in the process). Not screw press, rather two screws running against the flow kicking material out. Redundancy in the entire input system.

Manure mixed with silage right after stone separator. Tried two different pumps and found the eccentric one was superior over the rotating cylinder type. Lots of stainless used . Didn't use stainless in the feeder system pipes because assumed they'd be damaged or have to be replaced anyways from time to time. Feed system into the primary tanks at the bottom. 2 X 5500 m^3 tanks. 20 m high

Only 12 Bioconstruct plants in Germany. This one is 2.8 MW but most of the rest are ~500 MW.

Dewatering process: Pump out secondary digester up to top of platform to centrifugal decanter. 3000 rpm. 15 m^3/hr, which his exactly their production of digestate. Augered out at bottom Alfa Laval product. Problem with long leaves of silage (in digestate) ended up plugging the heat exchangers and the decanter. Alfa Laval did two trials: screw press and chopper. Didn't like chopper, so screw press is focus. First test run very promising. Resulted in much cleaner decanting. This is critical because heat exchanger has 1 mm gaps.

Heat exchanger uses heat from the genset – exchanged to digestate. Small vacuum applied (10 atmospheres) – leads to 60ºC boiling point. Using 90ºC heat off the generators. Steam from first vacuum is exposed to a re-heating process 2 times (steam is condensed in cooler towers, then re-evaporated to get higher concentration in the sludge) The better the heat, the better the quality of distillation. Condensate (steam at the end of the third evaporator/condensing tower) is sent to a tank, then to the waste water treatment plant. They get a rebate from the wastewater treatment plant of 50€¢/m^3 because the condensate is warm – helps their biological processes at the municipal treatment system (sewer system). Condensate has biochemical oxygen demand (BOD) of 150 mg/L.

The physics of this system is very straight forward. The challenge is the quality of the liquid, specifically chunks of plant material.
Closed system for cooling liquid. Heat off engine – heat exchanger – second loop to distillation process. Worked at 40ºC outside.

Condenser design was not a package – worked with one Finnish designer to do the design. Whole system cost around €1 million. Saves them on transportation cost. 50,000 m^3/year = €125,000/year savings Plus use all the heat – €300,000 more (assume from 2 ¢/kWh bonus?). High electrical cost – a number of 35 kW of pumps in the system. 190 kW demand, 8000 hour/year. ~10% of electrical production just at condenser.

N in condensate – want it in the sludge instead, so used sulphuric acid after the decanter to push the pH to 3ish. Anti-foam agent also used in vacuum cascade process. Rinse out the heat exchangers to avoid baking on material. CIP system to clean exchanger.

Condenser – 7 weeks old, very new – not fully experienced, but appears to be viable.

Overhead feed tank for hauling trucks. 50 second loading, 30 m^3. This system was one of the demands of the farmer, who does the hauling. 3 trucks. 1000 ha. Different tanker sizes, so remote control - type in your tanker number and it fills the correct volume.

All storage is at this site – no remote field storage. Digestate moved only for land application. 45 day retention time.

Futterkamp Research Station

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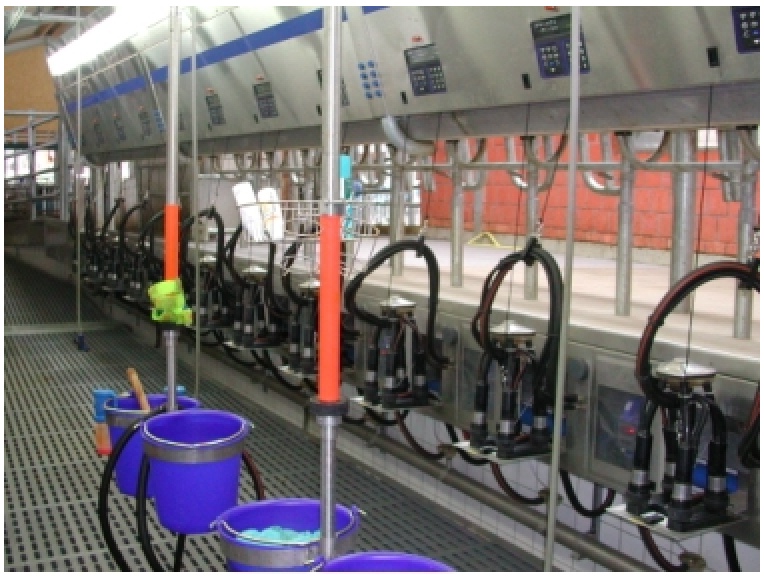

DETAILS FROM SITE VISIT AUGUST 2006

The Futterkamp research and demonstration centre is a facility operated by the local agricultural land chamber. The mission of the facility is education: preparing young farmers, and further education of current farmers.

Sources of funding for agricultural land chamber groups include:

1. Government grant – €3.5 million/yr
2. Percentage from farm property taxes - €8 million/yr
3. Funds from the operation of the facility:
    a. €2.3 million/yr from milk and hog sales
    b. Nominal fees from courses, renting of space in demonstration sales area

Futterkamp gets €4 million/yr from this state-wide budget for agricultural land chambers. The board of the centre is made up only of farmers.

Dairy Barn and Other Facilities
Dairy cows are for dairy training, but production is also important. The facility was built in 2003. 180 head. Built according to current recommendations for stall size, layout, etc.

Side by side parallel parlour. Open design. Single lane sort gate with individual weighing. Has a slight downhill slope – likely reason for why cows were not moving out of the parlour area while we were present. Milking 2X per day. Fresh feed to entice return. Bred with American bulls. 9000-9500 kg/year. Somatic cell count of 150,000 4% fat, 3.53 % protein. Good efficient parlour. Tapered shape is good for observation. Perhaps narrower than Canada is used to. Good light, perhaps too little ventilation in parlour. Floor heat in parlour, and radiant heat overhead. Double twelve with 2 staff. In Canada could be done with 1 staff. 120 cows/hr with 2 staff.

The facility has 3 groups of cows, 2 groups doing experimental feed, the third group is a control group. They are using feed intake monitors. 3rd group has conventional feed, with unmonitored intake.

No problem with wind in wide open uncurtained barn. No bedding blowing problems.

Manufacturers have the opportunity to install, test and demonstrate different stall designs etc. The facility is also for apprentices so they can train on and observe different equipment. Hutches are increasing in popularity in Europe.

More work with straw versus mats. Short straw on mattresses, and very little of it. Rubber floor – 3 years old. Appeared to be folding and lifting a little, but in good shape. Milk prices are low in EU – 25¢/kg – bottom of anybody's scale, so farmers are looking for opportunities to save. Dairy farmers are shutting down. Quota – 56 ¢/kg – 10,000 kg production ~ €5600/cow. Can depreciate it.

Swine barns – farrow to finish. 250 sows – increasing 320 to 350ish. New barns. Loose housing is the way of the future in Europe. 1 feeding/day

Manufacturer's Monthly Trade Show Area
Demonstration area for manufacturer. First Thursday of the month. 200-250 visitors per day. Lower in summer, higher in winter. Up to 800-1000 per day. Most salesmen show up. Manufacturers rent space. Operating since 1991. Good concept. This was the biggest one in Germany. Would be very interesting to consider such a facility in Ontario!

PLANT AND OPERATIONAL PARAMETERS

Biogas plant built by:	EnviTec Biogas GmbH Boschstr.2 48369 Saerbeck Industriering 10a 49393 Lohne, Germany Tel. + 49 (0) 25 74 – 88 88 0 Fax + 49 (0) 25 74 – 88 88 800 http://en.envitecbiogas.de nadine.loose@envitec-biogas.de
Type of plant:	Envitec Single Stage Digester
Feedstock:	5000 m^3 corn silage, 10,000 m^3 dairy manure.
Operating temp.:	38 – 42 °
Dry matter:	Corn silage in at 35% dry matter
Energy output:	330 kW el.
End products:	Digestate for land application
Comments	Built in 2005

Digester Basics
"Envitec" digester. 1700 m^3 single stage, mesophylic. 330 kW, 400 kW heat. Belongs to City Works of Kiel. 20 year partnership.

5000 m^3 corn silage, 10,000 m^3 manure. Hot water for heat in stalls and offices. Guaranteed price made digester attractive. 18 ¢/kWh. By comparison 10 ¢/kWh is industrial power price. Futterkamp buys the heat from the plant – 4 ¢/kWh.

Some digestate recirculated.
Iron II chloride used to desulfurize. Added directly to digester. Just a little bit.

Not enough desulfurization in conventional air approach, so need something additional. Had >1000 ppm H_2S levels, so needed extra boost.
Have 43-44 days retention time. Have only had 50% full time operation in 2005 – problems with bricks in pumps, etc.

Feedstocks and Digestate Management
5000 m^3 corn silage, 10,000 m^3 manure. Buy corn silage for 20-25 €/tonne fresh weight. 30-35% dry matter.
Frozen manure has never been a problem, since never had frozen manure. Direct fresh manure added. Fresh manure does provide better gas production – significant manure portion in this digester.

Digester belongs to city works. Lots of stones and bricks end up in the tank – shows necessity of ownership or buy-in for good operation.
98-99% operation in the last 4-5 months.

While on-site, digestate storage was being agitated and pumped. There was virtually no odour at the site during the agitation and pumping. Loading up a large (4000-5000 gallon) tanker took only a few minutes. The operator had an automated system operated from within the tractor cab for pump out.

Presentation by Draeger at Dinner
Fewer than 1/3 of digesters have gas measurement equipment, 2/3 don't. Biogas quality (percent methane) has big implications for electrical production. Concentration of contaminants has implications for engine life. For a $1million project, a few thousand dollars in monitoring is worth it. Typically Draeger offers a service and calibration contract.

A measurement unit with 4 measuring heads costs €7000. Calibration differs for electrochemical versus infrared systems (the latter can go longer without calibration).
Draeger recommends calibration every half year – €1600/yr cost.
Also need dryers and coolers for the gas to run the system properly.
Total costs appears to be €12,000-13,000/yr although vendors would not give exact quote.

Ribe Centralised Biogas Plant

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Cell: +45-2166-2511

Background:
Ribe Biogas Plant was built in 1989-90 and started operating in 1990. The plant is owned by Ribe Biogas Ltd. The owners are the manure-supplying farmers, a food processing company that supplies organic waste to the plant, the regional power company and two investment companies. The aim of Ribe Biogas Ltd. is to establish and operate a biogas plant and to develop and promote biogas production technologies. The biogas plant contributes to solving environmental and agricultural concerns in the area related to handling, storage and redistribution of animal manure, as well as to bring some economic advantages for the farmers.

The plant receives cattle, pig, poultry and mink manure from 50-60 livestock farms. The slurry is mixed and co-digested with intestinal content from abattoirs, digestible fatty organic wastes from food and fish processing industries and from medicinal industry, and with wastewater sludge from a poultry abattoir. The digestion temperature is 53°C (thermophilic). A minimum guaranteed retention time of 4 hours at 53°C ensures efficient sanitation of digested biomass. The actual retention time is much longer (16-18 days).

The digestate is returned to the manure suppliers as a pathogen free, nutrient-declared, liquid fertilizer. In addition to digestate returned to the farmer who produced manure, surplus digestate is sold to about 72 crop farmers in the area. There are 25 decentralised storage tanks for digestate, with a total capacity of 50,000 m^3. The storage tanks are placed close to the fields where the digestate is to be applied. This has significantly reduced the cost and time for transport and has enlarged the application area for digestate. The tanks were constructed with 40 % investment grant from the Ministry of Agriculture.

The biogas is piped via a low pressure transmission pipeline to a combined heat and power (CHP) plant at the city of Ribe. The plant supplies the city of Ribe with electricity and heat, and was established in 1996/97 to replace three earlier coal-fired CHP units. The gas engine is fuelled with a mixture of biogas and natural gas (dual-fuel). The biogas fuel has first priority for use.

Background:
PLANT AND OPERATIONAL PARAMETERS

Built by:	Krüger Ltd.
Business plan:	Digest manure and food wastes. Pipeline biogas to combined heat and power (CHP) plant on edge of town
Type of plant:	Vertical digesters. Pre-sanitation of food inputs.
Reactor dimensions:	3 × 1745 m^3 = 5235 m^3
Feed rate:	Animal manure: 352 tons /day Other biomass: 68 tons/ day
Operating temp.:	53ºC
Agitation:	Vertical shaft propeller mixers
Biogas production:	4.8 million m^3/year
Gas storage:	1000 m^3
Cost of plant:	45.3 million DKK (5 DKK = CAD $1)
Energy output:	CHP-plant/gas boiler
End products:	Transported back to farms. Land-applied as liquid nutrient
Comments:	Pre-sanitation - MGRT 4 hours at 53°C 3 × vacuum tankers: 2 × 20 m^3 + 1 × 30 m^3 Average transport distance to haul inputs - 11 km Operating since 1990

DETAILS FROM SITE VISIT AUGUST 2006

Jens Bo Holm Nielsen
University of Southern Denmark

History
1980's - manure management and water focus. Environment, energy and farming problems. Denmark has an integrated way of thinking. 1987-90 planning began on the digester, construction started in 1989-90. 20 centralized plants built in Denmark. Government supported. Ministry of Agriculture and Ministry of Environment were both key in developing it. Ribe plant was biggest in the world. There is one new centralized digester under development right now in Denmark. New one will be 1000 to 1200 tonne/day. Ribe is 400-450 tonne/day.

Primary focus was environment and nutrient distribution. Integrated logistics make it work. Crop farmers are buying the digestate. The Danish way is cooperate. Technology is one part, but logistics and planning and time is key. This digester is a limited company, but others are cooperatives. Ribe started as 4-5 shareholders. Raised 1 million Danish Kroner (DKK). The system was so successful that farmers bought out some of the other investors (the electricity company and the "environmental" investor group). Participants now have to provide 1000 DKK/cow to participate in new projects.

20 plants operating in Denmark, 10 planned.
Biogas plant does the treatment, hauling and storage. Farmer handles application (often by contract). 150 to 250 ha average acreage in this area. >100 cows now average. Lots of big pig barns. At the big hog barns the plan is to separate out the liquid with N, send thicker material to biogas plants.

5% of Danish manure is treated, but they have run out of food wastes to add to digesters Will need to move to other crop/grass inputs. Need to find a balance between Danish and German approach. Farm scale has never really made sense in Denmark with economic balance. But farm scale is also about environmental issues. Payback includes value of nutrients.

Centralized vs. farm scale – 15 years of history . Details can be found on the Southern Denmark University website . Farm-scale system numbers not as accessible. Having professional staff is very helpful, but farmers can also be good. Question is "where is your heart?" Animals? Biogas?

9 months of manure storage required for dairy in Denmark. 12 months manure storage for pigs. March to June is best application time for biogas. Winter canola has good uptake, but winter wheat is not as good. October 1 – no spreading – water quality (Danish drink groundwater). Same rules for biogas, manure, food wastes.

Economics of using energy crops– needs increased financial incentive to make it work. Denmark has half the electricity prices of the Germans – 0.6 DKK/kWh (roughly 8.5€c/kWh). Also <u>need</u> to sell heat as income: Need heat, electricity, tipping fees. Tipping fees are 20% of revenue. Remaining 80% is 2/3 electricity, 1/3 heat.

Digester Basics
Was 80 farmers in the cooperative, now 50-60 participating (farms getting large). Waiting list for new participants.

Single stage digesters. 12 days thermophylic. Heat exchange with raw manure.
2 post-treatment tanks (2 days capacity) – no gas collection off these old tanks. New one typically have covers, providing additional 20% gas yield.

Smell on-site. Never had complaints. A little bit of smell on-site. Very clean location. Break disease cycle in loading/unloading process. But not as strict as the example we saw at Werlte in Germany: Unload truck, sample for TS, VS and other stuff.

Internal spray system in the truck tank with sodium hydroxide. Cleaned out, load up digestate, haul to field storage. Never run empty. 1/3 of cost was in hauling at the beginning. Now 20% of cost – through optimization. Bigger trucks, quick loading. Important to set up the system right at the beginning. Lots of cooperation at this site with veterinarians – integrated approach. The future is trucks and pipelines. Perhaps trucks to a centre pipeline collection point, then pipe in to the plant. This approach decreases traffic at the plant.

Worldwide it has been shown that putting the plant in the wrong spot with regards to wind for odour is always a challenge. 2 or 3 Danish plants in the wrong place.

When spreading digestate, there are a few hours of ammonium smell, but none of the mercaptan smell from typical manure. Half the original biomass is eaten up in the "black liquor" (digestate). 3-4% dry matter coming out. Digestate infiltrates quickly into the soil, and runs off plant leaves.

1 manager, 2 technicians, 4 truckers.

Water lock controls head space at top of digester. Optimum for thermophylic is 18 days while they have 16 days, so not long enough.
Had tank collapse. It was nearly clean inside. Lots of sand in the pre-storage tanks (2 day retention – sand drops out).

Life cycle balance including diesel of trucks etc has been done – good total benefit. Including all costs, still 3:1. Good for society, better than ethanol or biodiesel. Getting great methane yield – 62.9% at our visit.

Gas Management and Electrical Production

Biogas drained and cooled, piped 3 km to combined heat and power (CHP) unit to provide heat and power for the city. 2 engines (1 MW each) and 3.5 MW heat. Heat for 1100 houses, schools, etc. Full heat load in summer. In winter require natural gas as well. Biogas cleaning – draining out of condensed gas. Gas drying is needed, even with pipes out to the CHP unit 3 km away.

Electric load and heat of the facility (versus total biogas potential) – 14% of total in winter, 7% in summer. But they don't use biogas at the site. Instead, they use fuel oil to heat: biogas is sent to CHP plant 3 km away. Use low cost input (fuel oil - "dirty" electricity) as inputs to system to optimize economics.

The co-gen units are Jenbachers. Jenbacher will guarantee performance based on your gas production.

H_2S is a big focus for the engine. Using iron chloride to reduce the sulphur levels. In addition, some pet food wastes have iron chloride in them.
Using vertical column approach like Kaarsen. Standardized approach. Knocks H_2S down to <100 ppm. Treatment system is "Scan Air Clean", a Danish company. Biological treatment: plastic material inside, digestate flows down, biogas flows up – digestate provide organic slime for biofilm.

Feedstocks and Digestate Management

Ribe receives 400-450 tonne/day. 75-80% of inputs are from the local Ribe area. 20% is food waste, pet food, and poultry slaughter waste. Have tough pre-sterilization standards.

3 trucks pick up raw manure – every week or two. 2 pre-storage tanks onsite. 2 days of capacity, continuously stirred. Macerator chopper pumps. Feeding 3-4 times per day. 3 thermophylic digesters. No secondary tanks. 1800 m^3 each, 75% dairy manure, the rest pigs, poultry and mink.

Manure moves 11-13 km. 15-20 km too much hauling. 40 km hauling for food waste from slaughter house near German border – "Danish Crown" – farmer-owned slaughter company – slaughters 20 million pigs/year. Partnership between biogas plants and food industry is key for both. 300,000 m^3 co-digested in 20 installations Cannot do it only with manure, need food waste.

Lower quality inputs: paunch manure – gets €10-15/tonne
Higher quality inputs – fatty organic. High gas yield = lower price tipping fee.

Biodiesel glycerine – paying €40/tonne – produces very high gas yield.
Meat and bone meal – have done trials – high protein is a challenge because of the nitrogen. N inhibition from high ammonium. Need to add high carbon material like glycerine to balance C:N ratio, as well as manure, corn silage, etc

Currently 8% DM going in. To do 12% DM in they may need new mixer. Continuous 13 kW mixer motor running right now. Many years in operation, low maintenance. Vertical mixer located at top of tank.

Nitrogen in digestate is tracked to ensure no inhibition is occurring in the digester. Plants with manure and waste are all running on the edge to maximize production. But ammonium bicarbonate is part of the buffering effect. 4% of ammonium in output is acceptable level.

Counter-current heat exchangers between incoming and outgoing material – takes manure from 17ºC to 42ºC. Use hot water heating to get tanks up to 53ºC.

Best pump is a mono-pump (rota pump). Can move 10-15% total solids. Need to maintain pumps well. 1.5 cm particle size going into digester.

Every truck load is analysed for total solids.
Quality of manure: pigs – if <5% dry matter, then farmer has to pay a fee. Above 5% get a bonus. 8% for dairy. Never had foaming at any plant. Only occurs when overloading with organic matter. Good buffer capacity in cattle manure, so never big problem.

Danish company "Camea" has 30 separator units implemented.
Dries to 30%. Recently became legal to burn the separated fibres and use the P material in ash for application.

Decentralized storages: installed by farmers – big hog producer paying 1.5 to 2 €/m^3 for treatment, farmer paying 50% of value of nutrients.

Hegndal Biogas Plant

Kent Skanning, farm owner
Tinghojvej 13
DK-6893 Hemmet, Denmark
Tel: +45-97-375216
http://hegndal.dk/

PLANT AND OPERATIONAL PARAMETERS

Feedstock:	Hog manure pipelined from 6 km away
Feed rate:	50 tonne/day
Cost of plant:	€2,000,000
Energy output:	300 kW el.
End products:	Digestate for land application

DETAILS FROM SITE VISIT AUGUST 2006

Kent Skaaning has 50,000 pigs. 25,000 finishers and 25,000 weaners. 8 employees. Farm workers work 37 hours/week. Swimming pool on-site heated by digester. Workers take a swim after work.

Getting 29.8 piglets/sow. Denmark average is >30. Weans at 24 days. Danish Duroc pig, but not recognizable as Duroc.

Crops: grass seed production, spring barley, winter wheat, potatoes, rape. Winter wheat, spring application of digestate, as late as possible, give full application at once.

Organic-N is a problem because of its slow release over summer – impact on groundwater in winter.

Denmark has the same problem Ontario has, that the biogas industry is too small and does not have enough lobby power.

Digesters have double the benefit of wind because you get energy and improved manure characteristics.

Insurance keeps going up. €10,000 per year, which includes engine breakdown insurance (electrical sales coverage).

Digester Basics
50 tonne/day input
16 day retention time
Thermophylic
Secondary digester – 30% of gas production. 3 months capacity.
Remote storage facilities.
Pipeline manure to digester from barns. Never use trucks.
Fish industry waste in smaller tank. Dosed once/hour into digester.
Gas storage bladder in the building.

Prefers incorporating digestate instead of application to growing crop.
In standing wheat he gets 85-90% utilization, where-as with incorporation he gets 95% utilization.

Uses pipeline to send digestate back to the barns, which are a few km away.
Drag hosing the manure is too expensive. Instead, uses nurse tank, 100 m^3, with radio-control pump. As security he's monitoring pressure and flow at both ends.

Facility cost €2,000,000 but today the whole thing would be cheaper.
Probably making a profit today. 7 year payback on the system.

Gas Management and Electrical Production
Expanded at this site from one engine to two. Sometimes takes up to a week for more difficult repairs to get done. Every 30,000 hours need to do the cylinders. Roughly 1 ¢/kWh cost on maintenance of the engine.

300 kW being generated, 20 kW of that is actually diesel because this is a dual-fuel system. Dual fuel has higher efficiency of kWh/m^3 biogas, but higher operational cost.

Cost him €100,000 to connect to the grid. The utility is regulated by law to allow him to connect. He is paid 9€¢/kWh.

H_2S – standard ambient system in the gas storage.

Accidental explosion occurred at his site when worker was using a drill beside the secondary storage.

Farmer pays connection to the transformer near the grid. Ratepayer pays for connection to the grid. Government policy to encourage windmills and get participation, so society pays for connection from transformer to line.

Feedstocks and Digestate Management

This site uses only hog manure, no other manures. Hog manure can have inhibitory effects, and it would be better to occasionally mix in some cow manure.

6 km of pipelines. Longest stretch is 4 km long. In 5 years he's had no problems. Pumps 120 m^3/hr 160 mm pipe is just sufficient.   Bigger would result in sand settling in the bottom.

Evaporator and Decanter Systems

Decanter centrifuge to remove solids: 80% of P in solids. 78% of organic-N in solids. Organic N is the most challenging form of N for the environment. This system deals with 80% of the environmental challenges of the digestate. Costs \$1/m^3 to decant. Savings on manure handling is >\$1/m^3 so it pays for itself.

Manure application: typically 140 tonne/ha, but can go up to 160-170 tonne/ha with this digestate. In Denmark farmers are always hopping to satisfy politicians and "stupid people" so have to respond with overly expensive equipment.

April to September the digester has excess heat, which currently has no use. Why not use to evaporate the liquids? In today's market, with sufficient landbase for spreading, the economics of evaporation do not make sense. Also, you need a good technician to make such a system work. Biogas is the same as a cow – feed it right to get it to work. Too hot and it's not happy, etc. If you operate a digester you have to know how to fix it yourself.

Flow from digester to decanter: 3 m^3/hr. Remove 10% volume in the solids. Pushes it to 50% D.M.   Capturing 80% of the organic N and the P. 80% of the liquid then goes into the evaporator. 80ºC heat with a vacuum, then a second stage at 50ºC and then another at 40ºC, then cool it back to water.

An acid is added before the evaporator, causing the ammonium to follow the liquid, not the steam. The N is in commercial N fertilizer form.

The complete treatment system costs €2,000,000 and costs €7/tonne to operate. €1/tonne for the decanting process, which is good business.

Screw press yields 20% of the P. The centrifuge yields 80% of the P, but costs $100-200,000.

No value today in a dry nutrient material because the chicken farmers own the market on dry nutrient material.

Skovbaekgaard Farm Biogas Plant

Hans Ole Jørgensen, farm owner
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Tel: +45-7539-2720
www.skovbaekgaard.com

PLANT AND OPERATIONAL PARAMETERS

Type of plant:	Vertical primary digester with secondary fully mixed digester
Feedstocks:	Own manure, plus 1000 m^3 glycerine from biodiesel
Reactor dimensions:	Primary is 9 m high, 13 m diameter (1200 m^3)
Operating temp.:	51 °C secondary, 33 °C secondary
Methane content:	52 – 55 %
Cost of plant:	€2,500,000
Energy output:	626 kW el. Deutz , plus 800 kW heat
End products:	Digestate for land application
Comments	No food waste because organic farm

DETAILS FROM SITE VISIT AUGUST 2006
450 organic dairy cows. Meeting Danish "organic" requirements because farmer was paid 500 DKK/ha to go organic. The water well for the local community of Esberg (100,000 people) is located nearby.

Good price for organic production, but higher input costs. Cows have to go out on pasture. 200 cows in the morning 7:00 – 2:00. 250 out in afternoon 2:00 – 8:00. Milking at 4:30 am, 12:30, and 8:30 pm. 3.5 hours to milk.

Barn and biogas system were built in 2002. Barn costs 11,000,000 DKK and the biogas system cost 10,000,000 DKK.

Organic milk: farmer gets 40 DKK¢/L more for it.
4.2 fat, 3.4 protein
2.10 DKK/L + 40 ¢/L bonus = 2.50 DKK/L = 18% premium.
Also get the 40 ¢/L if 3.5% fat.
4,400,000 L in quota. Organic cows don't yield as much (9000 L/yr, where conventional Danish cows yield 10,000L/yr)
3.5 DKK/kg quota. (50¢/L Cdn) or around 3500 DKK/cow
Grows his own grain, silage, clover and barley. Sells lots for seed.

Biogas and weed control? Hasn't seen a difference at his site. Improvement in crop uptake compared to manure: 1 week versus 1 month before he notices crop uptake.

6 workers, 5 from Eastern Europe.
40 place rotary parlour. 160 cows/hour.
Only place in Denmark with large bright rotary parlour.

Dirty cows, rainy outside, but have to send them outside for 6 hours/day because organic requirement. Had 3 good dry months just prior to our arrival.

Organic: took 5 years to get into it.
Was able to get more quota by going organic.
Only 2 dairy farmers that are organic and have biogas.

Somatic cell count of 300,000. Too high in his opinion. If mastitis with organic, can only use antibiotics if the vet says it's okay.

Raised calf wagons. 4 weeks of use, 1 week of wash and sit to clean: no disinfection allowed. Bull calves are gone after 14 days (Danish rules) Lots of control and visibility in this setup. No antibiotics for calves. 20% increase in cows going as cull cows because he's organic. Used to put 4 week old calves inside, but the calves prefer to be outside, so changed to current set up. Would prefer to have his dry cows inside, but paid a 3000 DKK fine last year.

Current set up with groups of 200 and 250 has challenges: when calving and moving cows inside the social structure gets disrupted.

Mats are bolted down. Likes it with this setup.

He only sorts cows in the milking area. He doesn't look at or touch the cows in the resting areas.

Cropping:
200 ha owned.
800 ha rented.
Feed for own and 500 other organic cows.
8 people doing cropping.

Barn: full pit under the aisles. 1.2 m deep. Mixes and pumps to digester once per week in summer and twice per week in winter. Prefers to agitate and pump when it's cool, otherwise you're blowing off lots of gas. Doesn't see a difference in manure volume winter or summer. Perhaps only 10% difference, even with the animals on pasture 6 hours per day. 15-18% of their food is from the pasture.

Windmill Basics

Much more money to be made in wind than biogas.

Built windmills in 1997. 600 kW units. Needs 14.5 m/s winds to engage. 1,200,000 kWh/yr from wind at his site.

Also invested in windmill in Germany. 2 MW. Cost €3,400,000. In spot with 6.8 m/s wind. Yields 5,500,000 kWh/yr at 43 DKK¢/kWh.

In 1999 Denmark stopped inland wind turbine construction. Farmer likes the looks of the turbines. Money is a byproduct. Electrical distribution is underground. Transformer is adjacent to power. Government does all the work on the connections.

The farmer paid 200,000 DKK for the electrical lines to the windmills. Transformers cost 270,000 DKK for each, but farmer doesn't own them, just rents them for the lifetime.

Digester Basics

Digester is 9 m in diameter, 13 m high.

Primary is 51ºC, 18 days capacity, secondary is 33ºC, 3 months capacity.

30% of gas off secondary storage.

Digester is same design as Kent Skaaning. South African/Ghanian designer.

Economics are not good.

Gets 60 DKK¢/kWh but needs 80-90 to make it work. Perhaps a 12 year payback, but goal was 8 year. 20 year price guarantee.

Works alright, but not as much gas as predicted.

Early on was only getting 5000 kWh/day, currently hitting 8000 kWh/day.

Took lots of time to learn. Sometimes something that works somewhere else doesn't work here. Costs money, takes time.

He would build it again, and would do it the same way. Prefers this to the German technique which has too many pumps and mixers.

On weekends the digester takes care of itself. He walks up, looks okay.
Likes digestate for crops – works faster than conventional manure.

No flare. Furnace takes fuel oil, and biogas as back-up. Or, use fuel oil to heat up digester only as back-up. Not clear.

Gas Management and Electrical Production

625 kW Deutz engine. Works well. People say the Jenbacher is even better.
400 V to 10,000 V. The transformer cost 400,000 DKK.
When digester was built, had peak power price, but now one daily price.
US$50,000 for the storage bubble (bubble in a building). Building cost extra.

1000 m^3 capacity gas storage, 5-6 hours storage.
No storage capacity on the secondary digester.
H_2S scrubbing in the scrubber tower.
Biogas from the primary digester at 300-400 mmH_2O, and 30 mmH_2O from the second.

Feedstocks and Digestate Management

Only local manure, too expensive to haul manure. Mixing vegetable fats, but no animal fats because the system is organic. Paying 480 DKK/m^3 for vegetable fats from Germany. 2/3 is transport cost.

Also adding glycerine from biodiesel. It costs money to get, but he needs it to get sufficient biogas production. Adding 1000 m^3/yr.   Glycerine is key – no profit without it. Producing 3000 to 3500 m^3 gas/day without it, versus 10,000 m^3/day with glycerine.

Glycerine. Heated to 70ºC and added to digester every 20 minutes. 20 minute dosing of manure too. Glycerine at 70ºC because it's easier to handle that way.

Doesn't add straw bedding to the digester.

With manure, the challenge is that thick material yields more biogas, but harder to pump 15% material.

Cannot afford adding energy crops with low power price in Denmark.
To add corn would need to add it straight into the hot digester, not in a pre-tank.

Oat straw is good, as it has a fat content, but the result is sand in your pumps. He adds 100 tonne/yr only.

Adding glycerine is easy. Adding straw is hard. Oat straw is added manually with a 1 inch chopper. Make it as short as possible.

Had an overflow last week. Doesn't know why. Used a silicone additive product to prevent foaming for 2 years. Now adds straight diesel (not biodiesel).

7.5 kW stirrer.
10 minutes of mixing/hour.

Grocery store in Tarm (small rural village)
Milk is sold in 1 liter cartons only with 0.1, 0.5 and 1.5% fat, selling for 7.75 DKK/L.
3.5% fat sells for 8.75 DKK/L
Butter 12.96 DKK/250 gram
Cheese 79.95 DKK/750 gram

Stichting Natuur Energie, Oostellingwerf (SNO) Energy and Gorter Dairy Farm

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Background:

Dairy Farm Information:
A family operation owned by Kees Gorter,
A 3 row (1 plus 2) barn built in 1970 and updated with new stabling in 1990, 120 freestalls here plus 80 in the heifer barn. Farm employs Kees (part time due to digester commitments), a full time herdsman, and approx 0.5 units part time help with cropping etc. 120 cows total with 104 milking now. Production per cow is 9200 kg milk with 4.4% fat and 3.5% protein. 1,150,000 kg (yearly production) quota. (50,000 kg butterfat) Somatic Cell Count is 150,000 to 200,000.

Stalls are deep bedded with sawdust which is added 3 times per week. Uses 50 m^3 (1765 cu.ft) per month for cows and heifers combined. Stalls are scraped off at milking. Manure pit under slatted floor barn is 20 m x 55 m (66 ft x 180 ft), depth 1.5 meters in Uniform daily manure removal to feed the digester means that the level goes down during pasture season and goes up in the winter.
The parlor is a 2 x 8 Blue Diamond rapid exit parallel, DeLaval claws, ID and detachers. Milking takes roughly one and three quarter hours plus 15 minutes clean up. 85 hectares of owned land is used to feed the cows. Crops are 65 acres grass, 15 acres corn and 5 acres wheat.

Silage for cows is stored in bunkers, one 1.8 x 11 x 30 m, and two 1.5 x 10 x 24 m. 65 hectares is rented to provide "feed" for the digester. Crops are 6 hectares barley, 13 hectares special energy corn, 16 hectares grain corn and 30 hectares silage corn. These feeds are stored in 3 bunkers, 2 x 12 x 24, 2 x 10 x 35 and 2 x 15 x 35

PLANT AND OPERATIONAL PARAMETERS

Biogas plant built by:	PlanET Biogastechnik GmbH Up de Hacke 26 48691 Vreden, Germany Tel: + 49 (0) 25 64 / 39 50 - 0 Fax: + 49 (0) 25 64 / 39 50 - 50 www.planet-biogas.com e-mail: info@planet-biogas.com

Feedstock:	10-15 m^3/day manure (dairy and hog), 10-15 tonne corn silage, straw, and sunflower material , totaling roughly 25 m^3/day
Reactor dimensions:	2 X 6 m high by 15 m wide.
Feed rate:	1 m^3 manure every 2 hours
Operating temp.:	38 – 42 °C
Dry matter:	8 % DM
Agitation:	3 rotors sliding up and down on inner walls
Biogas production:	156 m^3/day
Energy output:	200 kW el. MAN co-gen units
End products:	Digestate for land application

DETAILS FROM SITE VISIT AUGUST 2006

Kees Gorter
Kees is one of 3 partners

Stichting Natuur Energie, Oostellingwerf (S.N.O.) means "working together on biomass locally". Wanted new farm income, not farming maintaining windrows and ditches
400 farmers, 25,000 people in the region. Enough manure and biomass to support the 25,000 people's energy requirements. Too big for farmers to do big project, but possible to do things cooperative instead. There's a Dutch expression: "It's easier to cycle when you don't have too many people telling you where to go".

Biogas requires work 365 days/year.
Big investment, can't back out.

Kees Gorter
120 milking cows.
1,100,000 L shipped.

Cees Peters
100 cows
70 ha
10-12 ha for corn for digester
Was on board for local federation of agriculture and became interested in biogas.

Biggest effort was plant design and approvals. Local and provincial governments were main players. The federal government only regulated the $/kWh and the co-substrate inputs (i.e. insuring the correct inputs are used).

Partnership. Everyone has a computer control screen at home. But someone has to "get the call". In this case, it's Kees Gorter. Nice to be able to talk about decisions. Different pay scale for on-site farmer.

Took 6 months from dig to grid. It was a bad political game that unfolded the week before our tour when the government pulled the plug on pricing (existing systems will maintain their funding).

Insurance: only 10% higher than conventional farm. No labour and safety worries.

Digester Basics
Plan-ET standardized design
Digester tanks: 6 m high, 15 m wide.
Concrete tank, spray-on tar above waterline.
10-20 years from now this may be a problem.
Paddlewheel mixer. 1 bushing inside. Very slow rotation. Very safe, well-proven in manure.
Wood under bubble – no oxygen. Won't deteriorate.
Primary digester has heat in floor as well as walls.

No automated monitoring currently for biogas, but will do it on new system. Looks like overkill, but handy to have the measurements.

Some government subsidies were available for non-digester related components: laptops, scales, etc. Results in very expensive non-capital equipment. Very few subsidies available because this is nothing new – it's all been done in Germany already. The bank is okay putting up the farm for a digester normally. But in this case it's a limited company. 1/3 subsidy, 1/3 farm dollars, 1/3 bank. It took a couple of years for the bank to be convinced. Can't match with subsidies – needs to be private equity. In this case, it was 3 good bank customers and lots of education. Many plants are financed in a sale-lease back configuration. You get paid for your labour, then after 10 years you buy it back.

It's bad news when a waste hauler owns the digester. Bringing in waste all the time – need control of the system.

Gorter wanted to finance it himself.
Needed €1,000,000. He got 3 year 5.3% money.
10% principal, 10 year money.

Gas Management and Electrical Production
Currently generating 200 kW, will be 500 kW. 600,000 m^3 biogas
1 m^3 = 2 kW electricity
1.2 MW = 400 households

Miliewuwaliteit Elektriciteit Productie (M.E.P) was the name of the government subsidy. Was getting 15 €¢/kWh, which included the MEP subsidy of 9.7 €¢/kWh. Now only the 5.3 €¢/kWh portion is left. Old price had 10 year guarantee. Today, S.N.O. can work with 6 €c/kWh for the upcoming new components they are building, because they will get a blended price with the old price for the existing components.

New projects will not be able to move ahead with the current price. Open market for electricity, but there is only a 0.5 ¢/kWh green credit over the consumer price (available through a Rotterdam company that sells green power). Every consumer pays €40-50 /yr for environmentally sustainable energy – the government collects it and pays out. Interestingly, government didn't eliminate the "take", just the payout.
There is a nation-wide target of 9% renewable power by 2010. Big energy utilities have said "we've got big projects we can do" so the government cut funding to the small projects. Big utilities don't want to bother with farmers, and big utilities remain in control.

Heat use idea: heating salt: can hold heat, put it in container, move it to other location. A fantasy that just might work.

In the Netherlands there are 20 operating digesters, 20-40 in construction. But government just cut the subsidy for all projects, even those under construction. Existing projects will continue to get the subsidy under existing contracts, but no new projects will get a subsidy price.

The current 5 ¢/kWh has an inflation factor and does go up: "corrections" and indexed increases.

Corn costs 25 €/t
Maintenance ~ 1¢/kWh
Electricity demand of the plant ~1 ¢/kWh produced

Today the system is just profitable. Have to do daily work, plus maintain and operate the digester. Thus you need partners: "you go to that meeting and I'll go to this one". Lots of paper, time, and family-sized aspirin.

Connection to grid: €45,000 to utility. €45,000 for wires at the farm end. Also monthly fee of €400-500 to access the grid. Also a distribution fee. A standard fee, and a unit price. The result is a very confusing bill.

Gas pipe from both primary and secondary digester – blend gas from first digester with gas into the second, then pull the gas from the second digester to the co-gen unit. Have 50 m of underground pipe for condensation of liquid.

Using 0.7 to 0.9% ambient air for H_2S. Use 2 second air bursts.

PlanET – good company, good service. This site is only 2 hours from Germany. Engines – did not work with PlanET – simple to did it themselves. Oil, plugs, filters maintained by farmer. Engine manufacturer comes every 2 months to fine tune. The manufacturer charges an hourly fee. Using MAN engines.

Feedstocks and Digestate Management

2 dairy farmers, one hog farmer.
Every 2 hours 1 m^3 of manure added.

Today: 4000 m^3, 8% D.M, 156 m^3 biogas/day
60 ha corn, 45 tonne/ha yield, 32% D.M = 544,000 m^3 biogas/yr
All details available on S.N.O's website www.SNO-vergisting.nl
918 m^3 digester volume 50 days retention time. Digestate out at 7% DM.
Secondary digester: can't see any bubbling going on.

Best manure configuration is concrete floor scraped every 2 hours, added to digester all the time.

Government list of products to add to digesters: sugar beet pulp, potato peelings, vegetable oil etc. It's called the "positive list" – Google "positieve lijst" to find out the allowable inputs.

Slaughter waste is currently not allowed, and is buried because of feed issues. Slaughter material is handled at one big plant in the Netherlands. Deadstock pickup costs €50/cow and €10-20/calf for pick up, and the government is still paying half on top of that.

Looking at bedding from the digestate, but concerned about closed loop for phosphorous. Digestate as fertilizer: when it was dry the grass looked perhaps a bit more yellow, but now it looks better than the neighbours' grass. You see faster uptake of the nutrients compared to conventional manure: 2-3 days for grass, just like commercial fertilizer.

Needed to build 4 extra bunkers for inputs, and an input pit.
Currently 10-15 m^3/day manure, 10-15 tonne corn silage, straw, and sunflower material , totaling roughly 25 m^3/day. Next spring will step up to 35 tonne/day – will include wheat seeds. 15 tonne dry matter per hectare wheat or 30 tonne/ha corn both yield about the same energy. However the wheat is less volume to handle.

The Netherlands is small, they need regulations. Germany picked up digestion in the 80's and kept going, whereas in the Netherlands something didn't work and it stalled. The motivation had been political – "too much manure". Only recently have the regulations shifted correctly to make sense. Dutch regulation requires 50% manure from your own farm. Gorter thinks the 50% own manure regulation is a good regulation – avoids industrial activity in the countryside. In addition, the cost of moving manure around the countryside doesn't make sense.

To get good regulation farmers had to lobby: as individuals, and as a farmers union. Changes in 2002-03 resulted in rapid uptake of technology. The Netherlands is part of "North Sea Bioenergy" group with Scotland, Germany and Belgium – sharing info, regulation, knowledge: labour, energy crops, etc.

Energy crop plant size: Is big best? Driving around large volumes of water, have to store it. Too much H_2O is also an issue.

Would not use PlanET dry matter hopper again – can't mix other inputs in it easily. Want consistent blend of material. Instead would go to a mixing pit. Manure, grains, potato peels all mixed together, then direct into the 2 digesters. Want to mix co-substrates into manure before addition to the digester, and not 2 days of mixing, just 4 hours. Corn silage will stay out of mixing pit in separate mixer. Mix before adding to digester. Every day the same ingredients. TMR mixer versus mixing pit: TMRs not common for manure, so pit is better. They put everything but corn into the premix. They can pump up to 25-28% D.M manure from the barn.

Pump out manure every 2 hours. Not more than 1-2 ft building up of manure. People were concerned about odour, but it hasn't been problem.

Getting a tipping fee for taking potato peels, but they pay for hauling. It must be the same tonnage every week. Their recipe was developed on their own; you can't simply rely on German information.

No trouble with insurance, perhaps because the insurance people don't know what they're in for. But with a low-pressure system there's not a lot of risk if the thing does blow.

Use air burst system in exit pipe to keep material moving. Every 30 seconds when pumping. Pipe is vertical pipe in primary digester, with elbow to exit at top and flow to secondary. Air burst from a pump at the entry of the pipe, down near the bottom.

Changes if they could do it again:
Would have better mixing system. Currently have to always move corn from the bunk to the mixer.
With higher energy-density crops could have shorter retention time (from 50 down to 35 days), and could put in 3rd engine.

Nij Bosma Zathe Applied Research Station

Boksumerdijk 11, 9084 AA Goutom
Phone 058-216-7592
Livestock Manager is Gelein Biewinga, Gelein.biewinga@wur.nl
Crops Manager is Durk Durksz, Durk.durksz@wur.nl
www.asg.wur.nl/NL/onderzoek/Faciliteiten/Praktijkcentra/Nij+Bosma+Zathe

Background:
This 200 hectare applied research station is located just south of Leeuwarden in the province of Friesland. The six row free stall barn features 2 older Galaxy robotic milking boxes placed in tandem. Robotic milking research at the station has focused on combining this method of milking with grazing. The station has about 120 cows and milks half of them in a parlor and half with the robotic system. Plans for a new dairy barn will incorporate a bedding pack concept with either organic bedding or sand and some method of automated cleaning.

The second area of research at this station is biogas production from co-digestion processes. This work was originally done with a small on-site Krieg and Fischer plant, and they are now cooperating with the SNO facility to work on co-digestion on a larger scale. The digester at the station was constructed in 2000 and consists of two 80 cubic meter steel tanks and a 30 kW dual fuel co-generator.

DETAILS FROM SITE VISIT AUGUST 2006

Practical Research Station – Part of University of Wageningen Network

M.E.P subsidy – was 9.7 €c/kWh with a 10 year guarantee. At that price for a farm with >150 cows it seemed achievable to implement a digester economically. Recent cutoff of the subsidy: you had to have your building permit in place.

Burning manure: in Zuid Holland where there is a high manure concentration farmers are paying €15-20/m^3 to get rid of manure.

Can get yields of 65-75% methane with high energy-density crops.
Hog manure – 6% DM – 25 m^3/tonne
Dairy manure – 10% DM – 20 m^3/tonne
Broiler manure – 60% DM – 246 m^3/tonne

Broiler manure: sulfur problems and nitrogen inhibition
1.7 to 2.0 kWh/m^3 biogas

Saves 0.2 to 0.4 m^3 natural gas with the heat available

35% electrical efficiency with 60% CH_4 biogas gives 2.0 kWh/m^3 but 30% efficiency with 50% CH_4 gives 1.48 kWh/m^3 biogas. Big difference.

Grass silage: needs to be chopped short to avoid mixer and pump problems.

Not allowed to put in molasses, bread, fats/grease, bakery material. Dutch researchers did life-cycle assessment of food waste through digesters. One challenge is that restaurant waste varies over time. Destination of this material is currently landfill or combustion. Note, these materials are not land-applied as a biosolid either.

Dairy – 60% organic N and 40% mineral N
Digestate: 60% mineral N and 40% organic N

M.E.P. Miliewuwaliteit Elektriciteit Productie.
Gone now: 9.7 €¢/kWh plus 5.5 ¢/kWh base.
Economics (with the former MEP): 120 cows, no cosubstrate: €228,000, 27 year payback. Need cosubstrates!

If you have tipping fees, and use silage (which you pay for), then you could achieve 6 year payback.
You can use 30% less commercial fertilizer, a savings of $2-3000/year – little benefit.
Still no GHG credit available in Europe.

No subsidy in place for non-electricity benefits such as gas usage.
Diesel motor – cheaper, higher efficiency conversion, but high NOx emissions – The Netherlands views this as not green enough. Only purely gas systems are considered green.

For feeding into the gas pipeline network there is a law is already in place to do this, but the gas must be clean: 70-80% methane. But, since there is no subsidy in place, this is not economical today

Key observation: set the gen-set in the community, and pipe the gas to it. Use conventional gas to heat the digester.

Digesters Basics:
5 year old digester. Built as research unit. 80 m^3. Plug flow, 2.5 m^3/day. 28 days retention time. Probably more quasi-plug flow because of lack of thickness of the inputs.
Insulated steel tank. 37-40ºC. Gas pipeline on angle to allow condensation.
37 kW production. Runs when milker is running to offset power use. 8-9 hours/day.
Central shaft stirrer with heating on the shaft.
No problem with sawdust in the digester – it just goes through.

Energy Crops Research:
Energy crops for local farmers with existing digesters is aim of research.
Sorghum: looks like corn. Sudan grass: looks like grass.
Input at <20% by volume: gives good C:N ratio for recipe.

Different issues:
Taller: more tonnage/ha
Silage: higher sugar and high digestibility.
Lots of energy in stems, versus big cobs.
Standability leads to woodiness which has a lower digestibility.
Only 20 farm digesters in North Holland because they have bigger farms with lots of land, thus few manure management issues.

4. DEBRIEFING MEETING BY TOUR ATTENDEES
Groningen, Netherlands – August 27, 2006

A debriefing session was held on the second last day of the tour with the 32 participants. Discussion was split into Take Home Messages, and Different or Unexpected Things You Saw, Things That Stand Out.

Take Home Messages

- Technical convergence is occurring – quality principals coming together even among different plants – becoming standardized. Let's not reinvent the wheel – 10 years of technical development already done. Invest in learning what's working.
- Variety at German plants. Many ways to skin a cat. Great depth in engineering. Know your objective, then pick plant. Generally same prices – pick plant to match your feedstock.
- Biogas can be a successful sector, but need funding structure to make it fly.
- Plants are more complex than expected. Steep learning curve. Can't afford to hire someone because economics will be tight.
- Lack of commonality among systems – lots of people making things work. Making the concept work. No standardization in systems yet. Lots of variety, no standardization. Consolidation is yet to come.
- Regulatory rules in Germany, Holland, Denmark result in lower generation connection cost to farmers (lower than Canada). Not paying utility to connect. Integration into grid seems to be working fine. Clear. Cost to farmer is less than what was expected. There appeared to be the will from government to make it happen. Regulatory structure in Europe is different, and it will be the Ontario Energy Board that decides in Ontario.
- This is like a cow. Successful dairy farmers have well-fed cows. Successful digesters are well fed, monitored and understood – logical role for government extension service role. Don't see technology companies providing all the information and support.
- Very technical. We may not have the infrastructure in a labour-tight market. Skilled labour force in Ontario limited (e.g. tar sands). Lack the technically skilled people present here. Industry developed over 20 years. Bailer twine versus technical activity. Refinery expertise. Works well if done well. Space for college/universities to step up.
- Political framework has to be right. 3 countries. Germany is happening because 20 years, cash for delivery, cash to bank. Danish, just getting back to it after years of absence due to policy change.

- Mature technology exists, but biogas is a complex system that needs to be implemented with open eyes
- Energy production seems to be secondary in many cases –different countries, different motivations (e.g. US – odour control, Holland – nutrient distribution, Germany – price guarantee with high price, Denmark – civic responsibility and water quality and nutrients). Not just electricity.
- Digesters are being built because people want them. The public is in agreement. Don't need subsidy on capital, but electrical or gas production value is key.
- Can happen in Ontario, but over next 5-10 years. Get agencies, government on-board. Can fit in long term in Ontario because need power. Good alternative to nuclear etc. Co-op has value in having trained operator. Farmers don't have time.
- Individual versus co-op? Hoping for individual, but message may be co-op.
- Larger co-op seems to work better. Perhaps in a few years individual farmers can make it work, but at beginning lots of work to get it to work right. Need external expertise, different inputs, user of heat.
- Technology and feedstocks – can do high dry matter to plug flow, but wrong material in complete mixed can go bad – specific technology means once built, you're limited in your substrate. Do your research up front to know what product you might handle. Design according to feedstock.
- Large scale livestock operation may not be the critical factor. Gas yield from inputs is important. e.g. glycerine addition was key at Skoevbaekgaard, not just manure potential. Put manure into perspective.
- "Got to love it like a cow" said the vendor at Juhnde. Can't tuck it in the back corner like a windmill and leave. Have to feed it and treat it right to make it right.
- A lot of planning to be put into digester – infrastructure, farm operation that will work for you, timing. Not all pieces in place for this individual. The timing in Germany is clearly now. For this individual: more to learn, more planning, and infrastructure has to be in place. New plants as feedstock could be developed in next few years. Why give a race car low octane fuel?
- Could do something, but will require a lot of analysis and time.
- Political policy environment has to be in place. The will to make it happen has to be in place to make it happen. Synergies may be able to come together in inputs, etc, but the business model still needs to be more robust. Biogas industry needs to have the political strength to get to where wind is at. Need political communication. What will make it good for society? Why are we going to do it? Because it's good for society. Germany has decided to support this – how are we going to get Ontario to support it?
- Science has been refined, but equipment hasn't been refined.
- As a kid from the city – realize that this really works – tremendous story – political story: green energy, manage manure, help water table, and it really works! Operating, many profitable, and it works. Need government support at beginning in Ontario from Ontario Power Authority and Hydro One and others to really get this working properly, but it's the right thing to do.

- In 40 years time, world may run out of oil. We need to look at other things. It's likely the way to go. May take a few years because of cost, complexity, time, investment.
- Denmark's electricity price is similar to ours, and 7 year pay back, which is like Ontario, and is okay. But any problem and it's 10 years. In industry 3-5 years payback is required, or don't bother. We should be looking at a similar level. The only way it'll fly in Ontario right now will be tipping fees. For instance in the US one site was getting $30,000/month on tipping fees.
- Biogas is coming to Canada. Farm near Cobden, heat for houses and electricity. Have to learn from others' mistakes, and need to research it.
- What about sand? No ready solutions. There are a few that have potential, but need modifications. Torsten Fischer suggested that you change what you do with your cow to fit the digester – this is not the model we want for Ontario. Solutions are available, but need to figure this out.
- Buy-in from government is key – price is good first step, but likely not enough. Germany is good example of what happens with proper buy-in: you see tremendous growth and opportunities to export technology. There are real success stories that can come of this.
- How big a farm can you be before you can do this? Manure is very necessary. Need the base of manure for cheap system. Easy sell to non-farming community, but too bad it's so technical. Farmers have to be experts in so much today already. Unless highly technical person on farm already, probably will have challenges. For instance, at the Skovbaekgaard site everything needed to work all along the pathway for things to work overall. Exciting future – making something useful that's easy to sell for general public. Got to want to do this and love this to make it work. Need to invest management time as well as capital.
- Ontario is far behind in green energy. Government seems to only look at big projects.
- Have to organize. German Biogas Association – need to lobby. Lobby hard. Have a website (perhaps OMAFRA) – venue for potentially interested people, even if 20 years from now – create big supporting lobby. Blurbs in the paper, email updates. Need OPA and OEB on board with money behind it.
- Do we lobby government for more money (technology is right, process isn't ready) or just go and encourage farmers to do it? If farmers build lots, then 11 ¢/kWh is clearly enough. This trip shows that we need more money. To make this happen broadly with commercial farmers investing their next dollar, then need more money.
- Individual versus partners: Answer is partners, but different blend of partners than expected: Inputs. Use of heat. Technology. More than needing more manure from neighbours. Also recall a number of farmers saying they wish they owned it themselves. Need to put a value on every output.
- Impressed with odour control – huge issue on larger farms. Complaint is actually during spreading and agitation. Futterkamp – didn't smell anything while agitator was going. Went to restaurant and no one threw us out.
- Need to maintain contacts established on this trip.

- In Ontario, only farm-scale units seem to work. Farm scale is the way to go, but not necessarily small farm.

Different or Unexpected Things You Saw, Things That Stand Out

- Lack of use of 2/3 of potential energy – the heat was rarely well used.
- Simpler system would be nice –Europeans seem to pay lots of high quality – can we do it cheaper?
- $100/tonne PAID for glycerine (in Canada it's still a waste).
- Standardized control systems, safety.
- 60 ft tall cylinders of manure – structural requirements – segmented pre-cast is an anomaly in Ontario – huge stresses, volume of steal, etc. Don't have those building systems in Canada. Don't build tanks that way.
- Hats off to LHO – 6:00 am airport, 3 sites, feed them and have a talk, bed at 11:00, then do it again the next day
- Surprised at cost, connection fees – if they needed it, they built it. We can do it cheaper. Even today.
- The commonness of having underground electrical distribution cables, even in rural areas.
- So much variety, no two companies build the same, very good.
- Low biosecurity – very surprising!
- Quality of engineering and pieces together versus home-built. None of it is farm-built. Industrial quality facility versus farm-style. Farm-style not appropriate perhaps.
- Price in Germany is quite lucrative, could be driving strange behaviour.
- Simplified systems and low capital costs may make grants unnecessary or make today's price okay. Need to use heat.
- Variation in plants is surprising.
- Better handle on capital and operating costs.
- Impressed with people on the trip. Having Bryan Young and Bob Singh along was great!
- Lots more to be done on planning.
- Lack of security and safety at the facility. Could wander anywhere, no hearing protection, footwear, etc. Size of engineering companies – are they big or small? Top 5 – who are leaders, how many sites built? Can get that from some websites.
- Safety – farmers are used to doing their own thing, industrial rules have never been applied. Germany is clamping down. Darned bureaucrats are sniffing around – poisonous gas, etc. Looking for new business. Could lead to more centralized professional plants.
- Pig farmer – "we blew this thing to kingdom come, and I'm still smoking 2 packs a day right next to it".
- Above ground versus below ground, mixers, pipes, etc, no commonality. No clear answers.
- Excess heat – nothing too creative.

- Time management for windmill – 2 hours per year. – Would like to put up more of them. Versus biogas and rest of farm.
- So much emphasis on secondary retention and gas recovery off secondary storage or digester. Even feeding secondary digester to capture last bit of energy.
- Comparing systems – cost of production of electricity, etc – need to flesh out table making report card – with emphasis on what's important to us.
- Lack of heat use or creative solutions for it.
- Economic conditions under what they are operating (their price of silage etc) and economic conditions in Ontario.
- Insurance information. May force digesters into specific focus – e.g. centralized. Liked centralized system. Lessons learned.
- Lack of safety emphasis.
- Pumping biogas 2-3 km away to a cogen system. Low cost pumps. Not much equipment.
- Vertical tank for desulfurization – fairly simple.
- Gas engines – I assumed the diesel on/off bi-fuel approach was the best – (Klaesi experience).
- Tour kept on schedule. Pretty amazing, lots of information captured.

APPENDICES

Appendix Index:

Appendix A: LHO Tour Brochure

Appendix B: Marcus Ott, German Biogas Association Power Point Presentation

Appendix C: Itinerary and Maps

Appendix D: Regulation, Standards and References

TO REGISTER:

Note: low-cost flights are now subject to availability. We will make the best deal we can and let you know before you commit.

Complete the information below and return to:

LHO c/o Carol Anne Pinkney
62 Thomas Blvd. Elora, Ontario N0B 1S0
p. 519-846-8756 f: 519-846-2016
e: capinkney@sentex.ca www.lho-ontario.ca

Name(s): ______________________________
____
Mailing Address: ________________________
____
Phone: (_______) _______________________
Fax: (_______) _______________________
Email: ________________________________

REGISTRATION FEES:

Registration (tour activities, local transport, meals, double accommodation) $2600 ______
Flight (subject to availability) $900 ______
Single Room Supplement $400 ______
LHO Member Discount deduct $200 ______
Total: $ _______

To share accommodation with a specific person please submit both names on the same form.

Make cheques payable to *"Ontario Large Herd Operators".* For credit card payment provide:
Visa # ________________________________
MasterCard # ___________________________
Expiry Date:_____/_____Amount: $_________
Signature: ______________________________

LHO membership is $50 per year or $100 for 3 years and includes 12 issues per year of Dairy Herd Management magazine, discounts on group activities, and monthly newsletters. ***For more information on membership or the tour contact: Carol Anne Pinkney (above).***

TOUR OVERVIEW

The tour objective is to visit anaerobic digestion systems that demonstrate the following:

- The production of biogas at a variety of agricultural locations.
- Different inputs: manure, corn silage and other energy crops, food processing byproducts, and household organic waste
- On-farm and community digesters: ownership, partnerships, manure transport
- Standardized design and companies with proven track-records
- Maintenance experience and down time
- The use or sharing of excess heat, including partnerships with greenhouses

The tour will be hosted by OMAFRA staff Jack Rodenburg and Jake DeBruyn.

PRELIMINARY TOUR ITINERARY

Mon. Aug. 21 - **Depart Pearson Airport Toronto 4:30 p.m. - Air Transat Flight 138**

Tues. Aug. 22 - Arrive Amsterdam (Schiphol) Airport 6:00 a.m. If we are in good time, we will be on the bus by 7:30 a.m. and make a quick stop at the **Aalsmeer Flower Auction,** a 250 acre building, where 5400 flower growers worldwide, market 20 million flowers and 2 million plants daily on "Dutch clocks". Then we travel to the farm of **Arend VanderLouw** at Zeewolde, featuring a new 160 cow freestall barn and a modern windmill. The VanderLouws, who own three windmills on three polder farms, will discuss experiences with this technology. From here we head to Stadskanaal, near the German border and visit **Eissen Dairy**, featuring Lely robotic milking systems and two 1500 m^3 **Plan ET digesters** operating on dairy manure and corn silage. After lunch we cross into Germany and visit an industrial size digester near the town of Wertle. This **Krieg and Fischer Biogas Plant** is owned by 130 farmers who deliver 180 tonnes of manure daily to be co-digested with 120 tons of slaughter wastes. Tonight we retire early at our hotel in the Osnabruck area.

Wed. Aug. 23 – Breakfast is at 7:30 and at 8:30 we depart for Beesten, where we visit a **Lipp Vertical Digester** fed 30 tons of corn silage and 30 tons of cattle and/or hog manure daily. The system is owned by a partnership of 4 farmers and produces 9000 kW hrs per day. Then it's on to the town of Vreden to visit a **Plan ET** installation, **Temenhoff II** fed with only energy crops including corn silage, milled rye and wheat. Surplus heat from this facility is directed to an onsite greenhouse operation. Liquids are recycled and output is 500kW. After lunch we head to Bielefeld and stop at a **Biogas Nord digester** where glycerine from a biodiesel plant and clay used to bleach vegetable oils are mixed with hog manure. The heat is sold to a local airport and the system is shut down to remove clay residues when required. Dinner is followed by an informal meeting with a representative of the German Biogas Association.

Thurs. Aug. 24 – Following breakfast we depart at 8:30 a.m. to visit the **Fuechtorf BioEnergy Biogas** facility at Bad Oeyenhausen. This low maintenance, plug flow reactor is fed dry turkey manure & corn silage and has a retention time of 80 days. Surplus heat is used in turkey barns. Our next stop is the **Suedhorsten ARCHEA** horizontal steel drum and plug flow reactor. Hog manure, green rye & silage provide the feedstock and sand is removed through holes in the bottom. Following lunch we turn north and head for the town of Uelzen to visit a 1100 m^3 **Krieg and Fisher** system using potatoes, cull vegetables and hog manure. We overnight in Luneburg, about 50 km south of Hamburg.

Fri. Aug. 25 – This morning we head into former East Germany to the village of Kaarssen to visit the **Siemke Dairy**. This 1700 cow dairy farm owned by a Dutch investor is expanding to 5000 head and features an 80 stall rotary parlor. All manure is processed with a roughly 30 day retention time, through a series of digestion chambers built by **Bioconstruct.** At 70% of the total, manure is the main feedstock in this system, which is also fed corn silage. After lunch we continue north to visit the **Futterkamp Research Station** This regional practical research farm features a digester as well as demonstration trials of numerous commercial flooring materials, stall types and other equipment in their dairy station. An early dinner reception and discussion with station staff will be followed by bus ride into Denmark, arriving at our hotel in Ribe late in the evening.

Sat. Aug. 26 - Today our bags stay put as we tour three facilities in the area. Spouses looking for a day off can stay behind for R and R. The bus will head out at 8:30 a.m and stop at the **Ribe Centralized Biogas Plant** which treats manure from more than 80 farmers in the southwest portion of Jutland. 75% dairy, 25% hog & 25% food processing wastes are added to the plant. We also visit the **Studsgaard Centralized Plant**, run by the municipality. This plant receives manure from 49 farms plus organic inputs from food processing plants & separated household waste. Our third stop is the **Hegnal Biogas Plant** which is a **Xerg**i farm based system operating at a 1050 sow farrow to finish operation. Manure is transported from barns on adjacent farms by pipeline.

Sun. Aug. 27 – Today will be a long day on the bus as we head out by 8:00 a.m. for a 6 hour drive to Amsterdam through the Danish, German and Dutch countryside. In Holland we will stop on the "Afsluitdijk", the 32 km long barrier dam built in the late 1920's as storm protection as well as for land reclamation, and time and weather permitting we will stop at Zaanse Schans, a tourist spot featuring 8 industrial windmills dating back to the 16th century. We arrive in Amsterdam in time for dinner and an evening canal tour. We stay two nights in this hotel, so spouses can spend Monday in the city.

Mon. Aug. 28 – Today we travel through the Dutch polders to our final commercial digester, the **Stichting Natuur Energie, Oostellingwerf**, or SNO facility on the farm of **Kees Gorter** at Makkinga. This PlanET installation digests 4000 m^3 of dairy manure from the 120 cow slatted floor barn on site. 2700 tonnes of corn silage and some sugar beet tops are added yearly. Special high energy corn varieties are being tested here. The facility is owned by Mr. Gorter and two other farmers. The farm visit will be followed by a stop at the **Nij Bosma Zathe Dairy Research Station** in Leeuwarden. Research on anaerobic digestion of energy crops, testing food wastes for use in digesters and robotic milking are all featured here. We return to Amsterdam in time for dinner.

Tues. Aug. 29 – We will load the bus at 5:00 a.m. and head for the airport. Air Transat Flight 139 departs at 7:45 a.m. and arrives at 10:05 a.m. at Pearson Airport in Toronto.

To inquire about other flight dates, travel insurance or passport requirements please contact Diane at Robert Q travel, 519-539-8124 and mention LHO. Other flight dates are subject to availability and may cost more.

Fees are due at the time of registration and include all transportation, accommodation, and meals. Stops are tentative and final locations may be slightly different those listed here. All non-farm, "tourist activities" are subject to available time and are not included. No budget is ever totally clear in advance and as a non profit organization, LHO will pay for extras if finances allow it and in the event of a large surplus it is our custom to issue refunds. Fees are non refundable so we suggest you purchase insurance, but in the event of a cancellation we will only charge you with our actual costs, which vary with our ability to resell the seat.

For emergency purposes, contact can be made through Steffen Preusser, our English speaking contact from the Canadian Embassy in Berlin who will be with us on the bus. Emails to his Blackberry can be sent to:

steffen.preusser@international.gc.ca

You can call his cell phone from Canada at:

011 49 170 910 4013

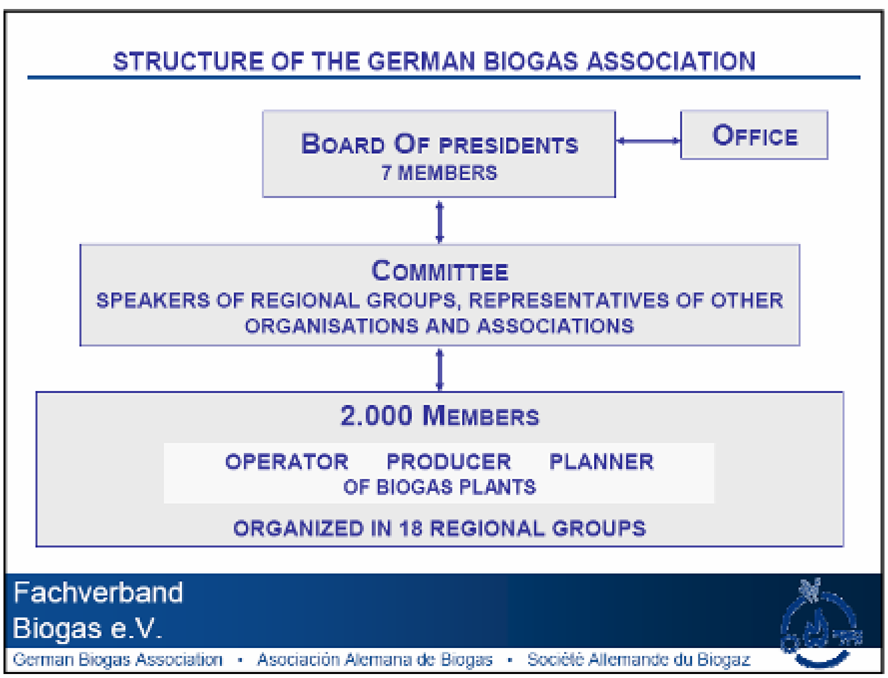
ONTARIO LARGE HERD OPERATORS

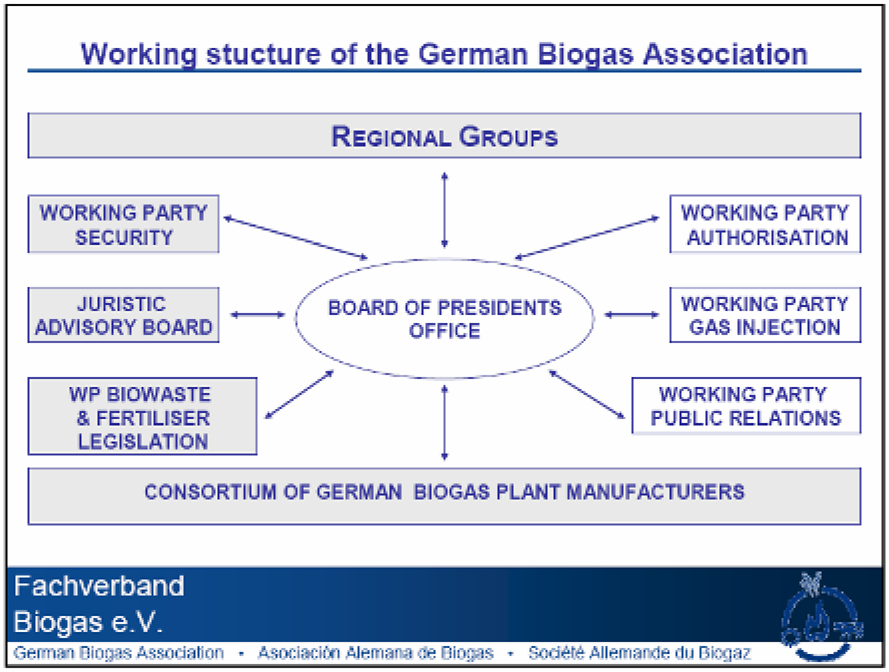
European Anaerobic Digestion Tour

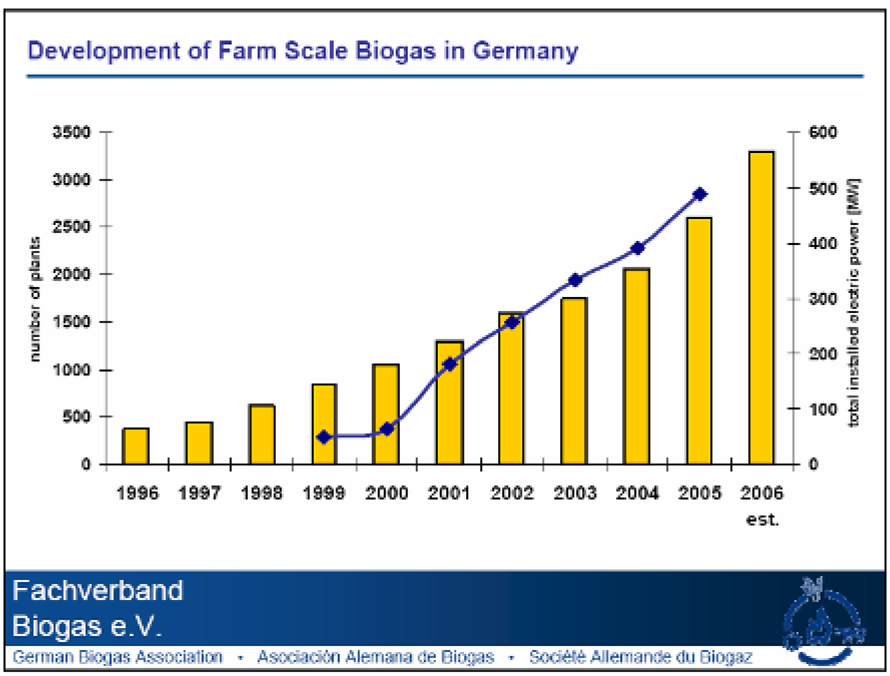
Germany, Denmark & the Netherlands August 21-29, 2006

For updates and details check the website at www.lho-ontario.ca

Appendix B: Marcus Ott, German Biogas Association Power Point Presentation




Working stucture of the German Biogas Association
REGIONAL GROUPS
WORKING PARTY SECURITY
WORKING PARTY AUTHORISATION
JURISTIC ADVISORY BOARD
BOARD OF PRESIDENTS OFFICE
WORKING PARTY GAS INJECTION
WP BIOWASTE & FERTILISER LEGISLATION
WORKING PARTY PUBLIC RELATIONS
CONSORTIUM OF GERMAN BIOGAS PLANT MANUFACTURERS
Fachverband Biogas e.V.
German Biogas Association • Asociación Alemana de Biogas • Société Allemande du Biogaz


Development of Farm Scale Biogas in Germany
number of plants
total installed electric power [MW]
3500
3000
2500
2000
1500
1000
500
0
600
500
400
300
200
100
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006 est.
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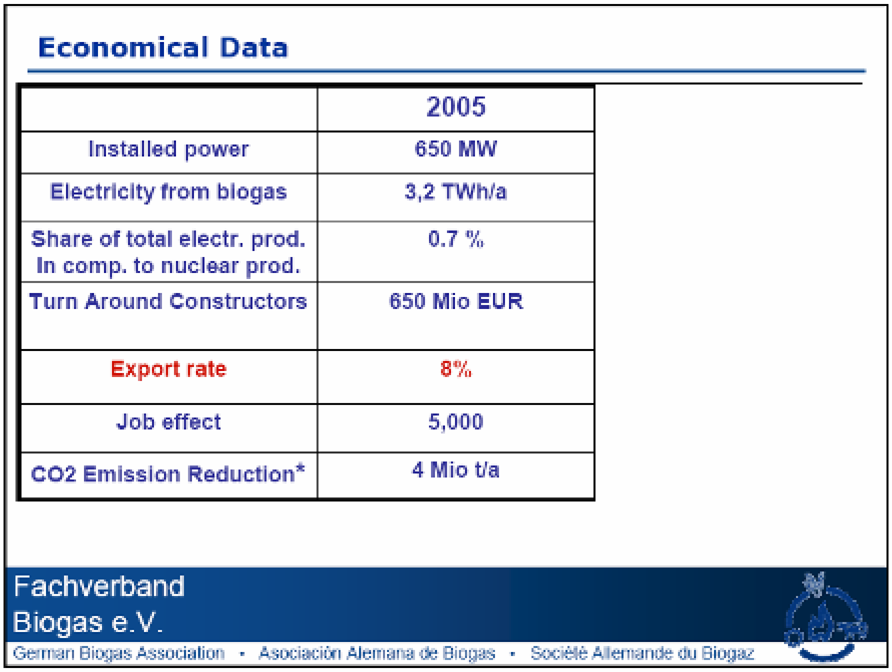

Economical Data

	2005
Installed power	650 MW
Electricity from biogas	3,2 TWh/a
Share of total electr. prod. In comp. to nuclear prod.	0.7 %
Turn Around Constructors	650 Mio EUR
Export rate	8%
Job effect	5,000
CO2 Emission Reduction*	4 Mio t/a

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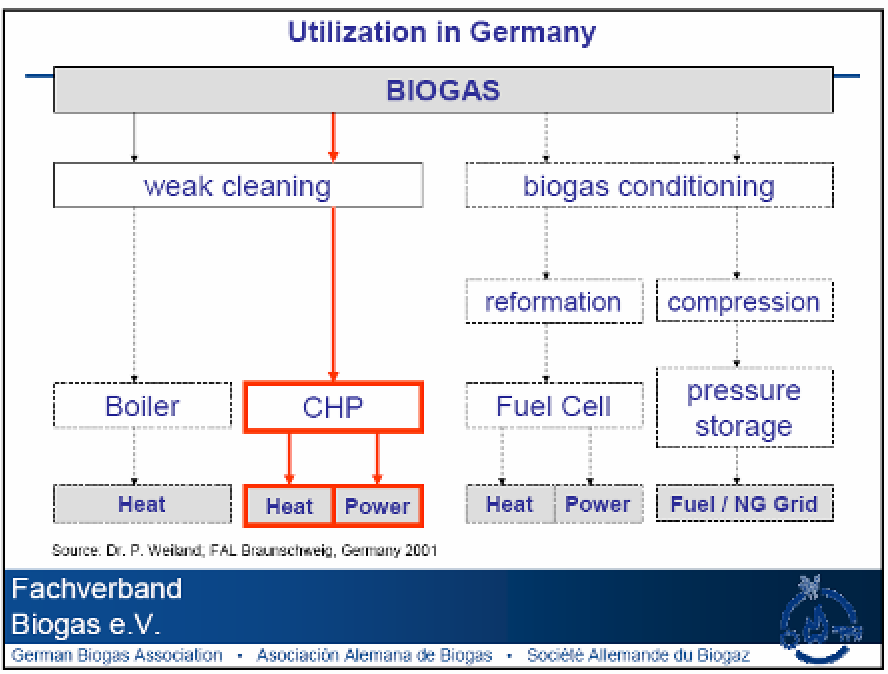
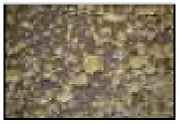


Biogas - substrates and motivation

Organic
municipal waste
industrial

environmental protection
waste management, disposal
cost structure: gate fees



feedstock residues
manure

environmental protection
energy production
cost structure: input for free

energy crops

environmental protection
energy production
cost structure: targeted production

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Electricity from biomass by anaerobic digestion

A rough impression:

1 ha maize	=	ab. 50 t	=	2 – 2.5 kWel.
1 ha corn	=	ab. 12 t	=	1.5 – 1.8 kWel.
1 ha gras	=	ab. 25 t	=	0.8 – 1.2kWel.
1 cow	=		=	0.2 kWel.

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Fixed price system for biogas electricity

average power	guaranteed fixed price [€Ct / kWh el.]			
	Basic price organic waste	Bonus for agricultural plants manure, energy crops	Bonus for heat usage	
0 – 150 kW	11,5	+ 6	+ 2	max. 19,5
150 - 500 kW	9,9	+ 6	+ 2	max. 17,9
500 - 5.000 kW	8,9	+ 6	+ 2	max. 16,9
> 5.000	8,4	+ 6	+ 2	max. 16,4

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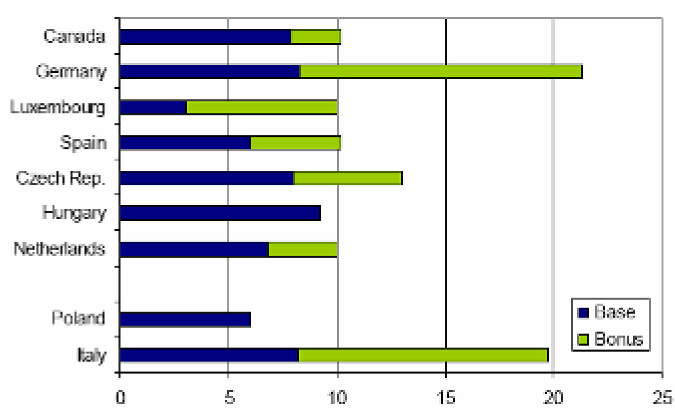
Feed-in Tarifs for Electricity from Biogas



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Legislative Framework

- **The level and type of the German support mechanisms are crucial.**
- **The experience of the leading countries show the following aspects to be effective one for biogas:**
  - Attractive prices for electricity
  - Guaranteed access to the electricity grid
  - National demonstration programmes
  - Potential for the transport sector
  - Coordinated national approach

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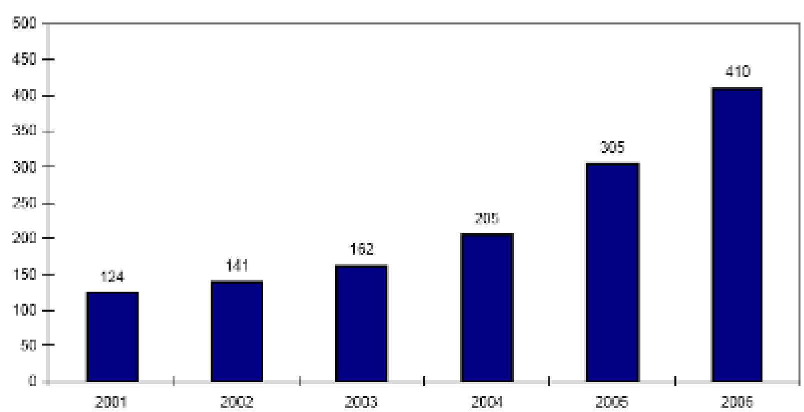
Biogas Related Companies



Members in the German Biogas Ass.

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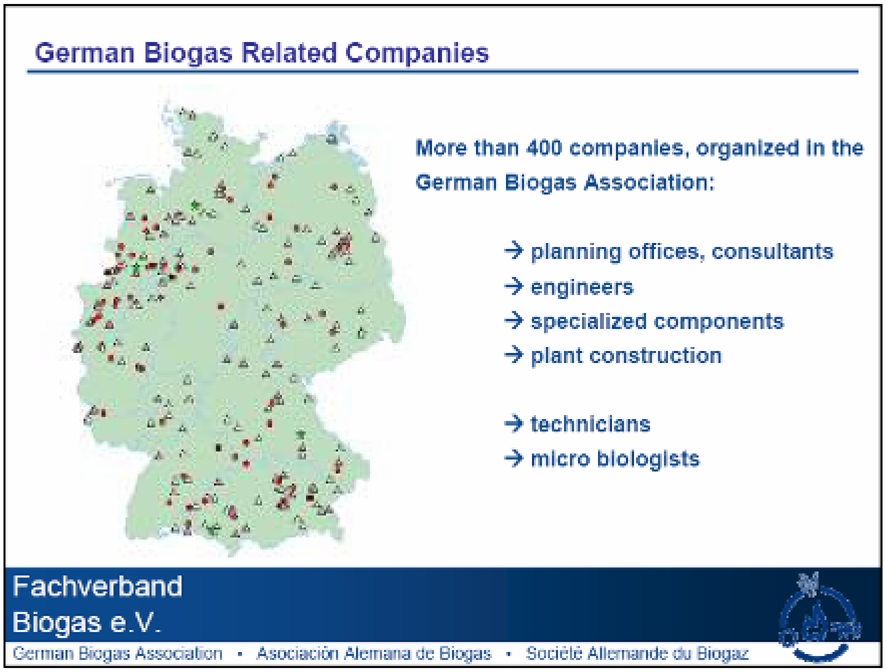
German Biogas Related Companies
More than 400 companies, organized in the German Biogas Association:
→ planning offices, consultants
→ engineers
→ specialized components
→ plant construction
→ technicians
→ micro biologists
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Specialized Components: Biomass Handling
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Technical Innovations
Gas Storage Technologies
Biomass Handling
Digester Technologies
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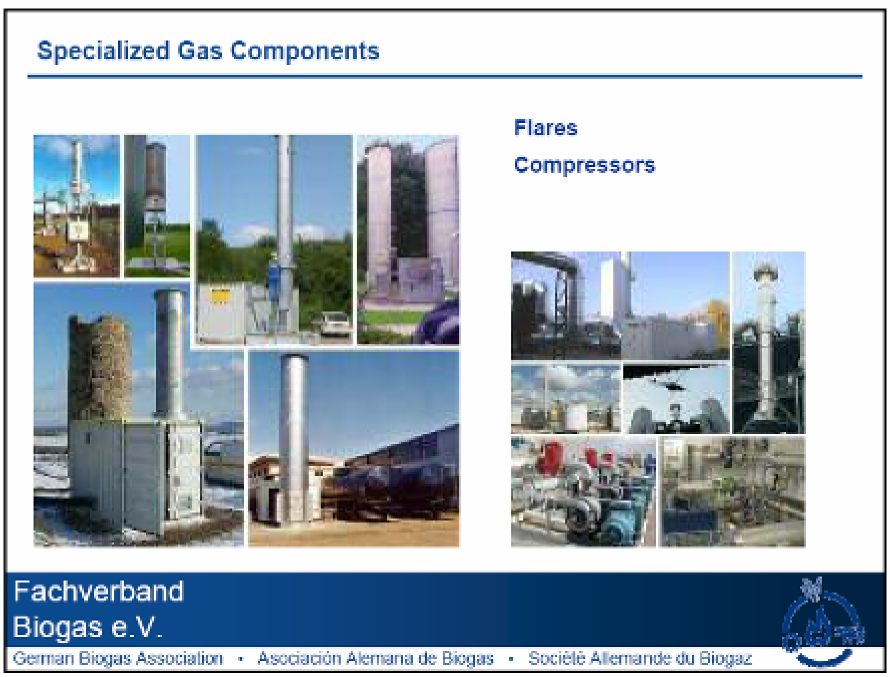
Specialized Gas Components
Flares
Compressors
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Specialized Components
Pressure Vessels
Desulfurization Units
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Specialized Components: Biogas CHPS
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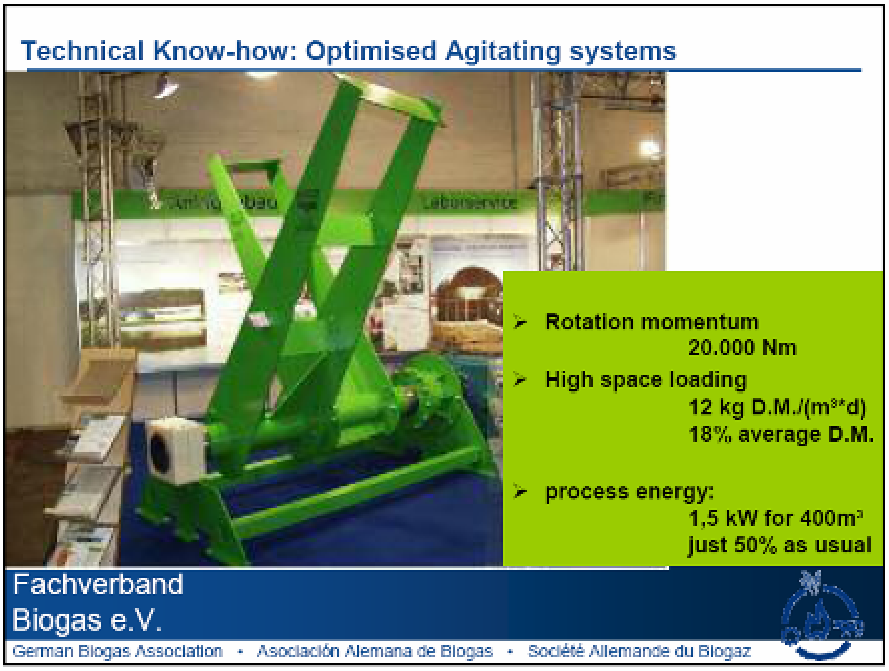
Technical Know-how: Optimised Agitating systems
Rotation momentum 20.000 Nm
High space loading 12 kg D.M./(m³*d) 18% average D.M.
process energy: 1,5 kW for 400m³ just 50% as usual
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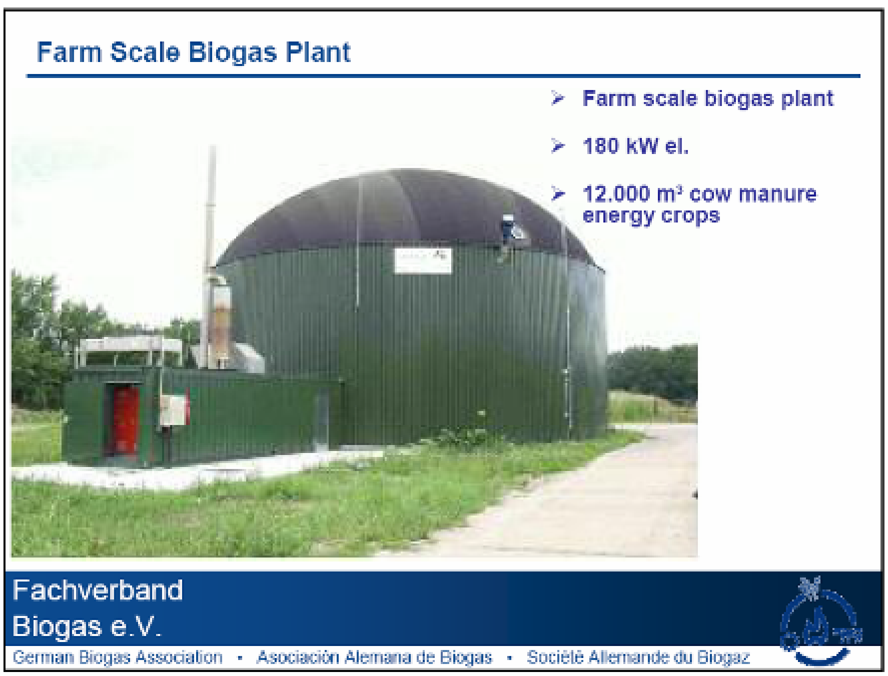
Farm Scale Biogas Plant
Farm scale biogas plant
180 kW el.
12.000 m³ cow manure energy crops
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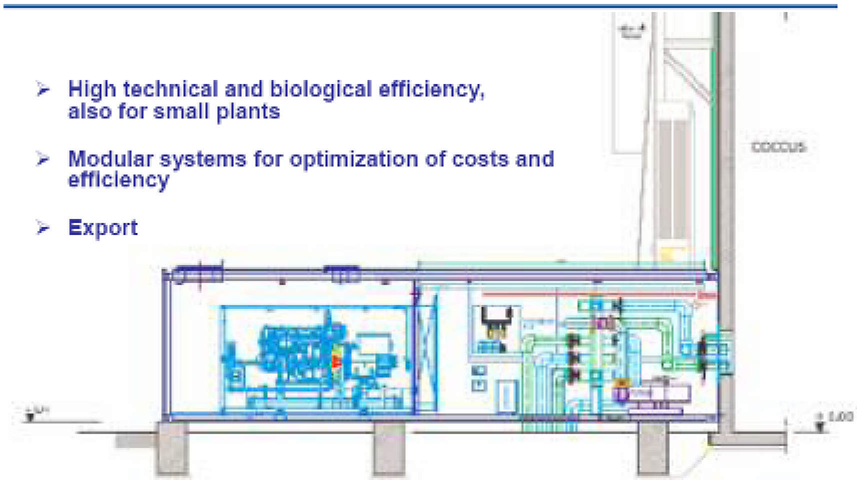
Modular biogas plants

- High technical and biological efficiency, also for small plants
- Modular systems for optimization of costs and efficiency
- Export



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Specialized Components: Output Processing.

Membrane Filtration

Revers Osmosis

→ Water Pollution

→ Specification of Fertilizers

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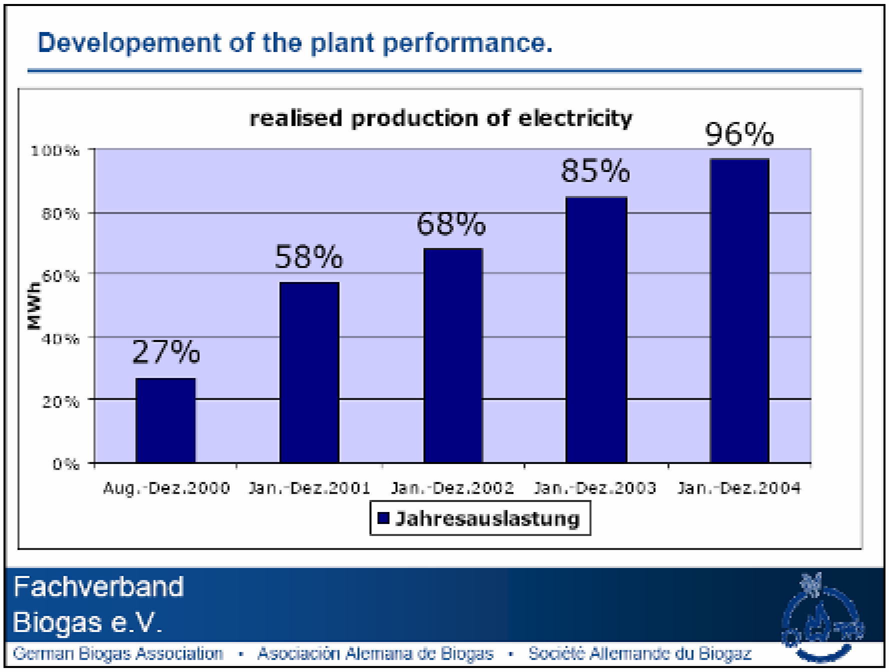
Developement of the plant performance.
realised production of electricity
100%
80%
60%
40%
20%
0%
MWh
27%
58%
68%
85%
96%
Aug.-Dez.2000
Jan.-Dez.2001
Jan.-Dez.2002
Jan.-Dez.2003
Jan.-Dez.2004
Jahresauslastung
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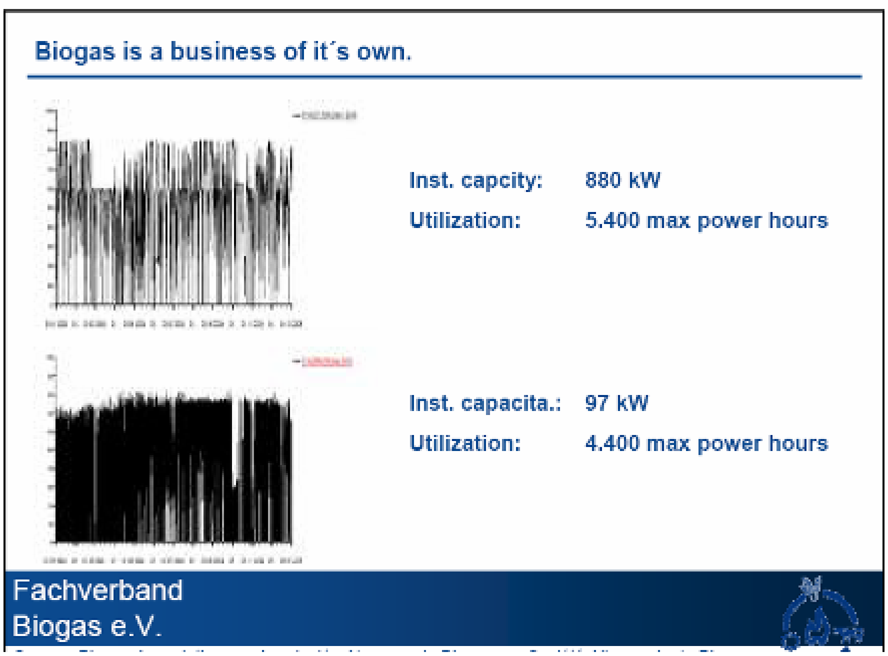
Biogas is a business of it´s own.
Inst. capcity: 880 kW
Utilization: 5.400 max power hours
Inst. capacita.: 97 kW
Utilization: 4.400 max power hours
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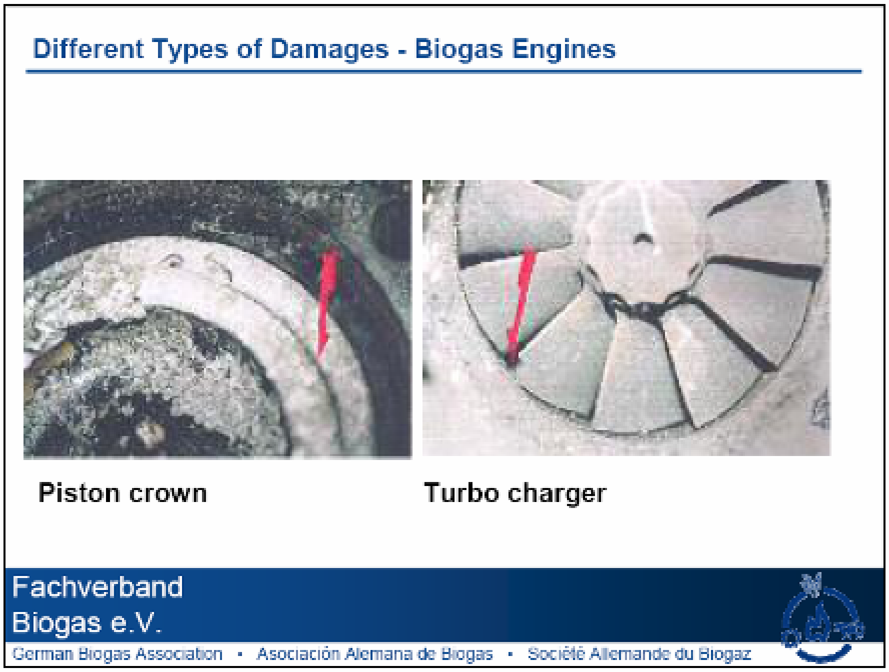
Different Types of Damages - Biogas Engines
Piston crown
Turbo charger
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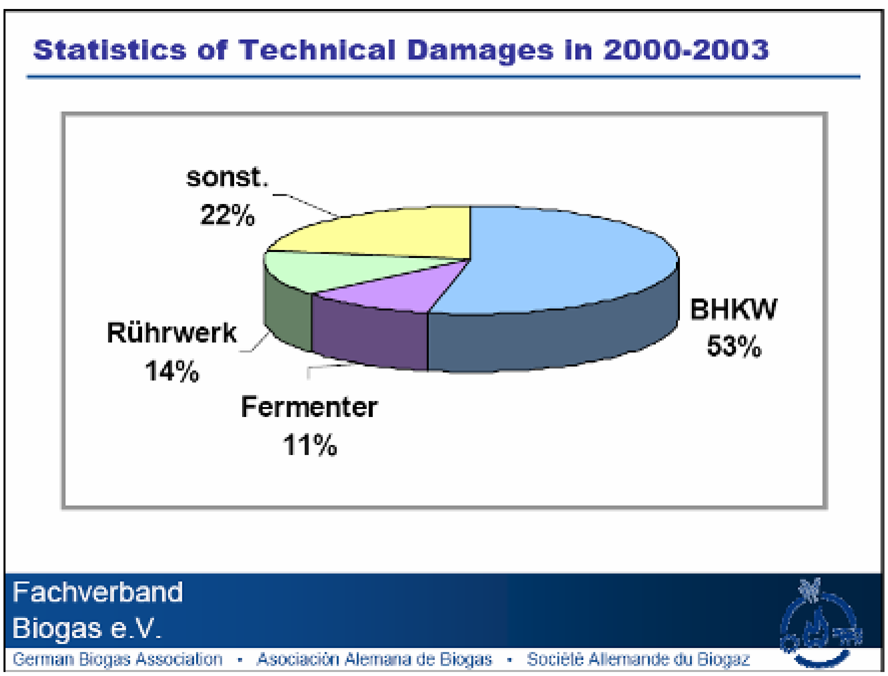
Statistics of Technical Damages in 2000-2003
sonst.
22%
BHKW
53%
Rührwerk
14%
Fermenter
11%
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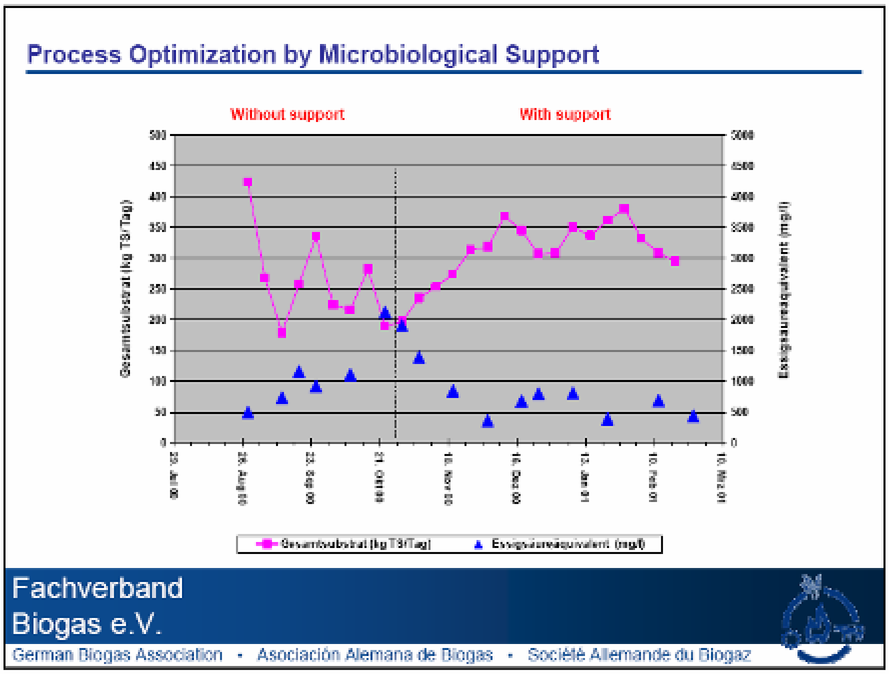

Process Optimization by Microbiological Support
Without support
With support
Gesamtsubstrat [kg TS/Tag]
Essigsäureäquivalent (mg/l)
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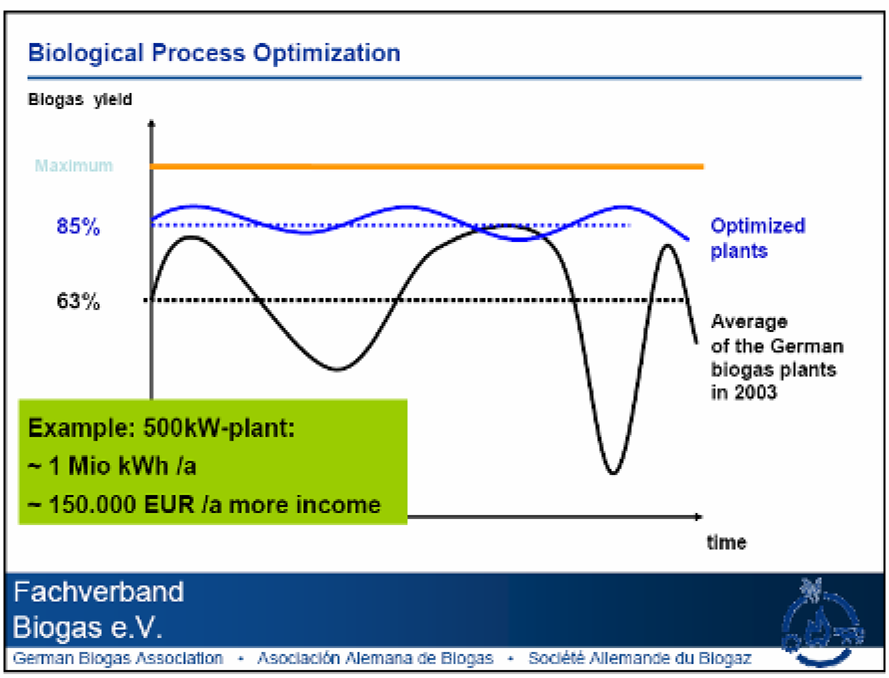

Biological Process Optimization
Biogas yield
Maximum
85%
63%
Optimized plants
Average of the German biogas plants in 2003
Example: 500kW-plant:
~ 1 Mio kWh /a
~ 150.000 EUR /a more income
time
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Economy: Influence of the operational factors.

		positive	negative
feed-in price	Ct/kWh	16,3	16,3
inst. power	kW	350	350
specif. invest	€/kW	3.000	3.000
total invest	€	1.050.000	1.050.000
	€/a	105.000	105.000
max. power utilization	h	8.000	6.000
produced electricity	kWh	2.800.000	2.100.000
	€/a	456.400	342.300
energetical share of energy	%	80%	80%
costs for input	€/kWh	0,035	0,070
	€/a	78.400	117.600
maintenance costs	€/kWh	0,015	0,035
	€/a	42.000	73.500
annual profit	€	**231.000**	**46.200**
difference	€	-184.800	

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Export

1. **Just now, the German companies focus on the German market. In the next few years the role of the export market will increase.**

2. **There are different possibilities of export business:**

   - **know-how** (feasibility studies, project development)
   - **components** (CHPS, Gas Analysers, Controlling units, biomass handling systems)
   - **construction** (licensing / sales contracts, joint ventures, branch companies)

3. **Important :**
   - **appropriate partner companies**
   - **long term stability of conditions**
   - **public grants for the first projects**

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Research and Development Outlook

- Farming solutions for biogas: → multi cropping

- Automisation and operation controlling
- Biotechnological process optimisation

- Biogas cleaning
- Optimal biogas usage / logistics of biogas usage:

  → production of peak electricity
  → microgas turbines
  → fuel cells
  → biogas as a fuel

- Qualification programs for plant operators

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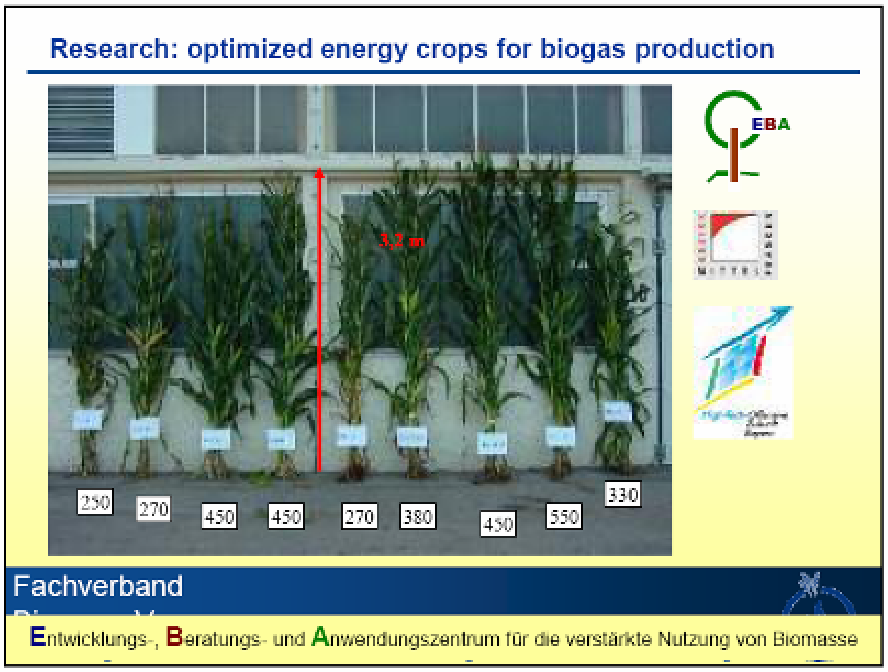
Research: optimized energy crops for biogas production
3,2 m
250
270
450
450
270
380
450
550
330
EBA
Fachverband
Entwicklungs-, Beratungs- und Anwendungszentrum für die verstärkte Nutzung von Biomasse


R & D in Plant Production
Multi Cropping
Sunflower // Corn
New sorts
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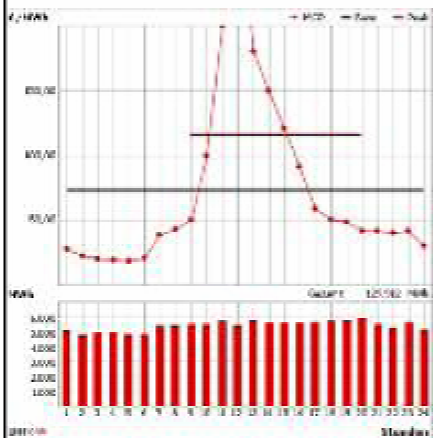
Future: Peak Electricity from Biogas



Prices at Leipziger trade market for electricity, August 2003

- price for peak electricity: 2 € / kWh
- combination of biogas plants to virtual power plants

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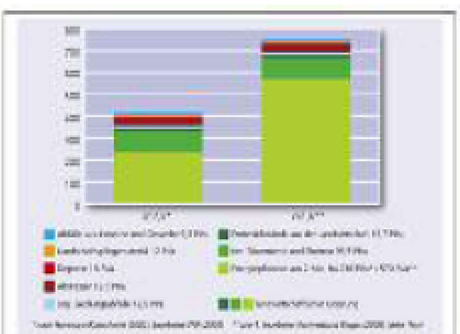
Total Biogas Energy Potential in Germany



The total biogas potential either corresponds to

- 17 % of the electricity consumption
  or
- 20 % of the natural gas consumptio
  or
- 35 % of the traffic volume

→ The future main source for biogas are energy crops (chart: light green)

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Conclusions

1. The German market is growing fast. According to this, technological optimization and operational know-how are growing, too.
2. The related activities in research and development will enhance the global leading position of German companies.
3. That includes the digestion of animal farming residues , of organic waste and of energy crops as well. All of them contribute to the potential for biogas.
4. In 2020 the export volume will be 30% of the total biogas engineering market.

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Appendix C

Detailed Tour Itinerary

European Anaerobic Digestion Tour
Germany, Denmark & the Netherlands
August 22-29, 2006

Tuesday, August 22

6 am	arrive at Amsterdam Airport
6:45 am	Bus pick-up at Schiphol
7:00 am	depart for Aalsmeer approx. 5 km / 10 min
7:15 am	**Aalsmeer Flower Auction** (3,50 Euro p.person for self-guided tour of about 1 h duration or 3,50 Euro p.person + 75 Euro for 1,5 h guided tour)
8:00 am	depart for Zeewolde approx. 71 km / 1 h
9:00 am	visit **VanderLouw Farm** Zeewolde
10:30 am	depart for Stadskanaal approx. 160 km/ 2 h
12:30 – 1:30 pm	lunch in Stadskanaal
1:30 pm	visit **Eissen Dairy biogas plant** meet with rep of PlanET
3 pm	depart for Löningen approx. 75 km / 1h 20min
4:30 pm	visit **Bio-Energie Hasetal GmbH** www.bio-energie-hasetal.de biogas plant & “Manure Exchange-Market” Industriepark 3 49624 Löningen Tel: 0 54 32 / 90 42 95 Fax: 0 54 32 / 90 42 19 plant by Schmack-Biogas AG www.schmack-biogas.de plant info: built in 2001, feedstock: hog & cow manure + silage, approx. 86,000 tons p.a., energy output: 800 kW
5:15 pm	depart for hotel in Löningen

5:20 pm	hotel check-in **Huckelriederfeld Hof** Paul und Inge Friedhoff Hahnenmoorstraße 7 49624 Löningen Telefon: 05432 3713 / Telefax: 05432 3748 www.huckelriederfeld-hof.de
6 pm	dinner at Huckelriederfeld Hof (meals prepared from produce from their farm will be served) presentation by rep of 3N, the Lower Saxony Network for Renewable Resources

Wednesday, August 23

8:40 am	depart for Werlte approx. 15 km / 15 min
9 am	visit **Werlte Biogas Plant** (confirmed) meet with Torsten Fischer Loruper Str. 80 49757 Werlte Tel: 04962-9131-200 www.bga-werlte.de plant by Krieg & Fischer Ingenieure GmbH www.kriegfischer.de plant info: built in 2002, feedstock: cow manure + food/slaughter waste, approx. 110,000 tons p.a., energy output: 2.5 MW
10:30 am	depart for Beesten approx. 85 km / 1h 15min
11:45 am	**Beesten biogas plant** (confirmed) meet with rep of Lipp GmbH Frerenerstr. 28 49832 Beesten plant by Lipp GmbH www.lipp-system.de plant info: built in 2005, feedstock: hog & cattle manure + silage, approx. 25,000 tons p.a., energy output: 440 kW
1:15 pm	lunch at **Lünne Brewery** / 6 km from Beesten www.emslaender-brauhaus.de possibly with participation by a rep of Storm GmbH – technology & service for engines (their HQ is in close-by Spelle) tbc OR a rep of 2-G GmbH, http://www.2-g.de/sys-seitenid,23/langid,2/
2:30 pm	depart for Füchtorf approx. 85 km / 1h 15min

4 pm	visit **"Spargelhof Querdel" Füchtorf biogas plant** (confirmed) meet with rep of Bio Energy Biogas GmbH Elve 27 48336 Sassenberg / Füchtorf plant by Bio Energy Biogas GmbH www.bioenergy.de plant info: built in 2005, feedstock: turkey manure + silage, approx. 4,500 tons p.a., energy output: 350 kW
5:30 pm	depart for Paderborn approx. 80 km / 1h 30min
7 pm	hotel check-in **Hotel Stadthaus ***** Hathumarstraße 22 33098 Paderborn Tel: 05251-188991-0 / Fax: 05251-188991-555 www.hotel-stadthaus.de
8 pm	dinner in Paderborn with Markus Ott, Vice-CEO of German Biogas Association

Thursday, August 24

8:30 am	depart for Büren-Ahden approx. 19 km / 30 min
9 am	visit **Bioenergie Ahden GmbH & Co. KG** biogas plant (conf.) meet with rep of Biogas Nord Schokamp 2 33142 Büren-Ahden plant by Biogas Nord GmbH www.biogas-nord.de plant info: built in 2005, feedstock: hog manure + waste food, approx. 14,000 tons p.a., energy output: 750 kW
10:30 am	depart for Jühnde bioenergy village approx. 135 km / 1h 20min
12 pm	visit **Jühnde Bioenergy Village** (confirmed) includes visit to dairy farm & biogas plant tour meet with rep of Haase GmbH Koppelweg 1 37127 Jühnde www.bioenergiedorf.de plant by Haase GmbH www.haase-energietechnik.de plant info: built in 2006, feedstock: cow manure + silage, 1:30 pm lunch in Jühnde
2:30 pm	depart for Hohne approx. 170 km / 2h

4:30 pm	visit **Hohne biogas plant** (Kuhls family) meet with Mr Wawra of Archea GmbH (+ Ms Dubois & Mr Nacke) Wiesenstr. 2 29362 Hohne plant by Archea GmbH www.archea.de plant info: new plant (just finished), feedstock: corn silage mix, approx. 8,500 tons p.a., energy output: 850 kW special feature: horizontal reactors with sand removal installations
5:30 pm	depart for Celle approx. 25 km / 30min
6 pm	hotel check-in **Fürstenhof Celle Hotel ***** Hannoversche Straße 55/56 29221 Celle Tel: +49 (0)5141 / 201 - 0 / Fax: +49 (0)5141 / 201 - 120 www.fuerstenhof-celle.com
6 pm	dinner approx 8 pm Celle guided tour in English 1,5 h

Friday, August 25

8 am	depart for Jameln approx. 100 km / 1h 30min
9:30 am	visit **Jameln Biogas gas station** RWG Jameln Bahnhofstr. 37 29479 Jameln Tel: 05864-9880 Germany's first biogas gas station is supplied with biogas from an adjacent biogas plant.
10:15 am	depart for Kaarssen approx. 35 km / 30 min
10:45 am	visit **Agrarenergie Kaarßen GmbH & Co. KG** biogas plant and dairy farm meet with Henrik Borgmeyer of Bioconstruct GmbH Laaver Straße 2 19273 Kaarßen Tel: 038845-44194 Plant by Bioconstruct GmbH www.bioconstruct.de plant info: built in 2005, feedstock: cow manure + silage, approx. 130,000 tons p.a., energy output: 2.8 MW

12:30 pm	lunch “to go” delivery from Vielanker Brauhaus http://www.vielanker-brauhaus.de/gastro.htm Tel: 038759-33588 depart for Futterkamp Research Station approx. 210 km / 2,5 h
3 pm	visit **Futterkamp Research Station** 24327 Blekendorf Tel: 04381/90090 meet with Dr. Eckhard Boll, director biogas plant tour + stall/ dairy technology
4:30 pm	early dinner with Futterkamp staff / Dr. Boll
6:30 pm	depart for Ribe / Denmark approx. 215 km / 3h
10 pm	Ribe hotel check-in **Hotel Dagmar ******* Torvet 1 DK-6760 Ribe Tel: +45 7542 0033 / Fax: +45 7542 3652 www.hoteldagmar.dk

Saturday, August 26

9:00 am	visit **Ribe Biogas Plant** (confirmed) Koldingvej 19 DK-6760 Ribe Tel +45-75-410410 meet with Jens Bo Holm-Nielsen University of Southern Denmark, Bioenergy Department (in charge of the monitoring of the biogas plant)
10:30 am	depart for Hemmet approx. 85 km / 1h 30min
12:00 pm	Lunch with Kent Skaaning, Mayor of Hemmet, and owner of Hegndal biogas.
1:00 pm	visit **Hegndal Biogas Plant** http://hegndal.dk/ Tinghojvej 13 DK-6893 Hemmet Tel +45-97-375216
2:30 pm	depart for Holsted
3 pm	visit **Skovbaekgaard Biogas Plant** Treagervej 12 6670 Holsted, Denmark Tel: +45-7539-2720 www.skovbaekgaard.com

4:30 pm	depart for Ribe approx. 115 km / 2h
6:30 pm	arrive in Ribe **Hotel Dagmar** Torvet 1 DK-6760 Ribe Tel: +45 7542 0033 – Fax: +45 7542 3652
7 pm	dinner

Sunday, August 27

8:30 am	Drive from Ribe to Groningen Approx. 530 km / 6,5h
4:00 pm	Hotel check-in **Hotel Schimmelpenninck Huys** Oosterstraat 53 9711 NR Groningen Tel. +31-50-3189502 / Fax +31-50-3183164 www.schimmelpenninckhuys.nl evening debriefing session dinner

Monday, August 28

8:30 am	depart for Makkinga approx. 60 km / 1h
9:30 am	visit **Stichting Natuurenergie Oostellingwerf SNO** Kuinderweg 1 Makkinga meet with Kees Gorter
11 am	depart for Goutum approx. 60 km / 1h
12 pm	lunch at or near **Nij Bosma Zathe Dairy Research Station**
1 pm	visit & tour of **Nij Bosma Zathe** (tbc)
3 pm	depart for Amsterdam approx. 145 km / 1h 40min
5 pm	hotel check in Best Western Lancaster Hotel Plantage Middenlaan 48 1018 DH Amsterdam +31-(0)20-5356884 www.edenhotelgroup.com
6 pm	dinner in Amsterdam

Tuesday, August 29

5 am	depart for Schiphol Airport
7:45 am	Air Transat flight

End of Tour

Tour Sponsors: Ontario GE Jenbacher Agricultural Adaptation Council

Appendix D
Regulations, Standards and References

Pasteurization: EU Standard 1774, 2001. 25 countries, each with their own version
Laws have 3 categories of material: “worst” is brains from Specified Risk Material – not allowed in digesters Paunch is lowest risk.

Germany:
Gas fired flare. 2 permission documents: small plants have local government regulations
Large plants have a higher level approvals, and then have standards for flares.
German Safety Regulations for biogas (the Bible) requires that for systems with potential for a >20 cu.m/hr blow-off require an “other solution”. That solution is typically a flare.

Netherlands:
There is a “positive list” – Google “positieve lijst” to find out the allowable inputs.

Netherlands:
Feeding into gas pipeline network. Law is already in place to do this, but it must be clean: 70-80% methane. But, since no subsidy in place, this is not economical today

Extract from pre-tour report by Steffen Preusser, Canadian Embassy, Berlin Germany (June 2006).

<u>Pasteurization Step</u>
The EU requires pasteurization or sterilization of organic food or food processing waste, if it is to be on agricultural land. This includes such feedstock as slaughter waste, food processing waste and expired packaged food. The pasteurization requires that the substrate is heated to 70ºC for one hour. The heated material can then be directly put into the digester. Agricultural byproducts such as crop residuals or energy crops (corn silage) do not need to be pasteurized.

<u>Electricity Feed-in Tariffs for Germany</u>
The Renewable Energy Law in Germany ensured the growth of the biogas sector because it guaranteed two key elements.
First it set a minimum price for the green electricity that was generated. This guaranteed a rate of return for the investors. The prices were guaranteed for a fixed period of time, so that the subsidies could not continue for an indeterminate period of time.
The second element was the guaranteed access of green electricity to the grid. It required that the electricity companies create the infrastructure to any property where green electricity was produced (on the property itself, the owner assumed responsibility). The law set prices for wind energy, biogas and solar cell-based electricity generation. The additional costs generated by the guaranteed minimum prices were to be paid for by the consumers and not subsidised by the state. Hence the electrical companies would divide the added costs among all consumers. The government regularly checks the books of the electrical companies to ensure fairness.

The Renewable Energy Law in Germany was modified in 2004 with improvements for the biogas industry. The original law in 2000 calculated the minimum price of biogas-electricity at Euro 0.10 /kWh ($CDN 0.16 / kWh). This assumed that feedstock was free (e.g. liquid manure on a dairy farm or biomass waste). The modified version foresaw the additional costs of growing energy plants for biogas production. So bonuses were added for biomass. In Germany, the most popular energy plant grown for biogas feedstock is corn. The following are the prices guaranteed by the Renewable Energy Law for electricity generated by biogas plants.

	Guaranteed Price Euro-cents/kWh	in CDN-cents/kWh
Base prices for biogas plants		
up to 150 kW	11.5	18.4
up to 500 kW	9.9	15.8
up to 5 MW	8.9	14.2
5 to 20 MW	8.4	13.4
use of waste wood	3.9	6.2
Biomass bonus for biogas plants		
up to 500 kW	6	9.6
500 kW to 5MW	4	6.4
up to 5 MW using wood	2.5	4
Co-generation Bonus	2	3.2
Technology bonus	2	3.2

The bonuses are cumulative and are added to the base prices. The price structure is set for 20 years, from 2004 to 2024. The base prices are reduced by 1.5% per annum so that in 2024 (the final year of the program), a 150 kW plant will receive 70% of the 11.5 Euro-cent price or 8.05 Euro-cents / kWh. The rates for the bonuses remain constant over the 20 year period.

(For details in German see www.bmu.de). The operator of a typical small biogas plant using biomass receives approximately Euro 0.16/kWh ($CDN 0.256 / kWh). Biogas plants that use a combination of manure and biomass receive the biomass bonus. Plants that also use slaughter waste, glycerine or food waste (expired food or canteen leftovers) do not receive the biomass bonus. They would be eligible for the technology bonus and the co-generation bonus.