VI Costs of Anaerobic Digestion

1 Investment cost for the anaerobic treatment of organic substances

The anaerobic digestion plants differ in substance, in conditions for biodegradation and in the form of the used reactor systems. Possible alternative procedures are:

- Single-stage/ two-stage/ multiple stage procedures,
- Wet anaerobic digestion/ dry anaerobic digestion,
- Mesophilic (35-37 °C)/ thermophilic (55-60 °C) methanisation (methane anaerobic digestion),
- Dis-continual / continual service.

The anaerobic treatment of the organic matter also needs a treatment of the feedstock before feeding the digestion vessels and a post treatment of the digested material. The following treatment steps are necessary (adapted from Widmann, 2000):

1. Bunker
2. Preparation

a. Sight-control of the delivered material concerning big disturbing pieces,
b. Iron-metal-removal,
c. Shredding of material, the desired size of the pieces is usually between 10 and 45 cm,
d. Screening to produce various fraction sizes,
e. Separators for division into a heavy- and light-fraction.

3. Anaerobic digestion,
4. Subsequent treatment
5. Subsequent decomposition (composting)
6. Fine preparation
7. Store

The delivered waste is treated in the anaerobic digestion reactor after passing through the refuse. The remnants of anaerobic digestion are mixed with structure-material, e.g. shredded green waste, and undergo secondary composting in a closed decay system.

There are two different kinds of plants: central plants, where Waste and cosubstrates are treated following the described steps, and small plants, where not all described step are carried out. The small plant are often situated in animal farms. For the running of those agricultural plants no additional infrastructure is required. The existing infrastructure of the farm can be used. In those small plants the manure of the animals is treated often together with agricultural cosubstrates and/or waste as well. For the treatment of the manure now special pre-treatment is required and the digested material can

be applied directly. This liquid organic fertiliser is spread by special vehicles of the fields.

Thus, the different kind of plants show different investment costs. For agricultural biogas plans investments about 600-3.000 per cattle are usual (Market, 1999; Kern, 1999). Hence the specific investment costs for those plants are between 45 to 167 DM per t. The next table shows the German investment costs for biogas plants including the treatment steps described before, except all post-treatment after the digestion of the substrate-

Table 1: Investmentcosts

Plant capacity	**6.000 t/a**	**20.000 t/a**	**25.000 t/a**	**50.000 t/a**
Investment cost €/t	00 - 900	200 - 500	200 - 400	50 - 350
Operation cost €/t	80 - 120	40 - 120	35 - 100	30 - 90

The given investment and operation costs for anaerobic digestion plants depend on the German market. The costs consider construction material, technical equipment, plot of land and other expenses. Therefor the figures can only give a first insight in the cost structure. Probably the mentioned costs can be reduced for Chines conditions up to 30%-50%.

The real cost for a organic waste treatment plant have to be calculated by each case.

2 Cost of Anaerobic Processes for Dairy Waste

The cost of a dairy waste management system can be subdivided into the following elements:

- Housing – Determines the percentage of manure actually collected
- Collection – A means of collecting the waste by manual, or automatic scraper, vacuum truck, or flush.
- Pre-processing – Screening and or sedimentation prior to digestion
- Anaerobic Digestion – The solids conversion process
- Post-processing – The concentration of solids after digestion
- Energy Production – Engine Generator or Turbine with heat recovery
- Liquid Handling & Irrigation – The storage and disposal of liquid waste
- Solids Disposal

As pointed out earlier, use of any particular system will have an effect on the other. For example, if a flush system is used the anaerobic digester must be larger. If pre screening and sedimentation are used, the amount of energy produced will be lower. Post processing will establish the cost of ultimate solids disposal. In many cases, solids must be exported from the site. The use of an anaerobic digestion system may eliminate the need for pre-processing or screening and sedimentation.

The cost of a complete dairy waste management system may exceed $1,200 per cow. Anaerobic digestion system costs however, are confined to the cost of the anaerobic process, post solids handling, and energy production.

A review of the anaerobic digestion system costs at U.S. dairies compiled by Lusk has established that the typical anaerobic system constructed in the U.S. had an average cost of $470 per cow. The proposed thermophilic digestion project at Three Mile Farm (21,000 cows) in Oregon projected a cost of $710 per cow. The proposed contact process at Myrtle Point (4,500 cows) Oregon has a proposed cost of $678 per cow for digestion, solids handling, and power generation. The recently constructed Cal Polly flush system anaerobic lagoon had a cost of $800 per cow.

Anaerobic systems for digestion, solids processing, and generation are expected to cost $500 to $800 per cow. The per-cow capital cost estimates can be deceptive since some processes treat the entire waste stream while others treat only a portion of the waste stream. For example, the plug flow systems documented by Lusk treat only the concentrated portion of the manure while excluding the milk parlor waste (15% of dairy manure). The table below presents the corrected capital costs for the entire waste stream (100% of cow manure).

Table 2 Adjusted Capital Costs

	Large 1 MW 5000 Cow Facility	Small 25 kW 125 Cow Farm
Capital Cost	$9,113,000	$500,000
Annual Operating Cost	$643,000	$8,800
Power Sale Rate $/kW	$0.06	$0.06
Heat Sale $/kW	$0.01	$0.01
Solids Sales	$700,000	$20,000

Even the adjusted capital cost per cow does not tell the full economic story. Some systems are far more efficient than others in producing power and sequestering nutrients. The best approach is to report the capital costs in terms of dollars per MBtu generated during the first year of operation or dollars per net kW of power sale capacity. There is little data available in those units for US systems. The costs of a wide variety of European systems have been reported in those units. The capital costs of European systems vary from country to country. Germany produces anaerobic digesters for the least cost per gallon while the Danish systems produce greater amounts of biogas per pound of solids introduced to the digester. German digester systems are constructed for an average cost of $1.52 per gallon. Danish digesters have a capital cost of $50 per GJ or $5.26 per annual biogas therm (100,000 Btu or 1.06 GJ). Power is produced for a capital cost of $10,000 per kW of export capacity. The table below presents the capital and operating cost of European systems for a large facility and a small on farm system.

Table 3 Capital and Operating Costs of European Digestion Systems

System	% Treated	Reported Cost $ / Cow	Adjusted Cost $ / Cow
Lusk U.S. Average	85	$470	$552
Three Mile Farm Thermo	80	$710	$887
Myrtle Point Oregon	80	$678	$847
Cal Poly (lagoon)	100	$800	$800

It must be noted that the capital and operation and maintenance costs are considerably greater in Europe than those reported the US. On the other hand, income derived from the sale of the solids is considerably greater in Europe. The capital cost of dairy waste systems in Idaho are expected to be from $2,700 / kW to $6,000 / kW exclusive of sales tax, power connection to the site and financing costs (27 to 60% of the European cost).