IEA Bioenergy
Technology Collaboration Programme

Deep bedding – a codigestion substrate with significant potential

Case Story

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Danish experience with handling and feeding deep bedding to biogas plants

Figure 1: Deep bedding supplied at Nature Energy Videbæk

Benefits of co-digesting deep bedding

In Denmark, about one-third of all dry matter in livestock manure is contained in deep bedding. Over the last decade, most Danish biogas plants added deep litter to their co-digestion substrates. This not only increased the biogas production, but also brought about environmental and agro-economic benefits. Mono-digestion of animal slurries can yield 15-25 Nm^3 biogas / t biomass, depending on quality. However biogas plants need 35-45 Nm^3 biogas / t to allow a financialy sustainable facility. In a situation with shortage of biomass and high gate fees for industrial high yielding biomethane wastes, co-digestion of deep litter is an obvious solution. Deep litter also can often be obtained free of charge.

Deep bedding varies in composition and nutrient content (Table 1); this variation impacts how it can be used in biogas production. Raising the dry matter content of the feedstock in the reactor increases the biogas production significantly. Danish experience shows that increasing the dry matter content from 6.8 to 14 % can increase gas yield from about 20 to 36 m^3/t.

Biomass	Dry matter %	N - P- K Kg/t	Biomethane m^3/kgVS
Deep bedding from dairy cattle	27	7-1- 7.2	200-250
Deep bedding from pigs	30	10.8 – 2.4 – 7.1	250-275
Deep bedding from horses	31	10.9 – 1.9 – 11.9	180-225
Deep bedding from poultry	58	28.7 – 7.2 – 15.5	190-280
Pig slurry	5 - 6	5 – 1.2 – 2.6	290-320
Cattle slurry	8	4.9 – 0.8 – 4.4	190-210

Table 1: Examples of average values for some deep bedding types and slurries. Volatile Soliods (VS) is usually 75-80% of Dry Matter (DM). The values are indicative only and can vary significantly from farm to farm. *Source: PlanEnergi, Food and BioCluster Denmark* and *Møller*

Economic, environmental, and agricultural benefits are also achieved through better fertiliser quality. Compared to untreated deep bedding, digested deep bedding is easier and cheaper to apply and incorporate in soil, and with a higher nitrogen utilistion efficiency (Table 2).

	Digested deep bedding	Untreated deep bedding
Storage	12 kr/t	10 kr/t
Handling	easy	difficult
Application on fields	15 kr/t	27 kr/t
Incorporation in soil	138 kr/ha	155 kr/ha
N-utilisation	65-70%	45 %

Table 2: Applying digested vs untreated deep bedding as fertiliser ; *Source: PlanEnergi*
Kr is a Danish Krone.

Technologies and equipments for handling dry biomass

Table 3 outlines technologies and equipments commonly used by Danish biogas plants for handling deep bedding

Dry feeding Dry feeding often takes place without any mincing or chopping of the biomass. The deep bedding is fed into the reactor tank using a powerful screw conveyor. Alternatively, the material is pushed into the reactor via a funnel.
Mixing in a pre-tank using a biomixer Newer systems, consisting of mixing deep bedding with manure in a relatively small vigorously stirred pre-tank. The mixed biomass is fed to the reactor by a cutting pump, equipped with a macerator further into the reactor. The main suppliers are Lundsby and Combigas (in collaboration with Landia).
Mixing in a pump stream (PreMix) A relatively new system, consisting of a mixer, where the deep bedding is homogenized and transferred by a screw conveyor to the PreMix unit, where it is mixed with a pumped flow of liquid manure. The biomass mixture passes through a macerator, integrated into the PreMix unit, and after mixing and mincing is pumped into the reactor. A cavity, placed in front of the blades of the macerator, allows small size physical impurities to sink into a collecting vessel and be removed. The supplier of PreMix is Vogelsang.
Powerful mechanical breakdown There are various types of equipment for heavy mincing of deep bedding, followed by mixing with manure in a pre-tank. Most of them consist of rotating hammers / clubs / chains and operate with high energy consumption. There is considerable wear on the moving parts, especially if the material also contains physical impurities. No comparative test of existing sytems has been carried out, but the Teknologisk Institut estimates that all are suitable to convert deep bedding into an attractive substrate for biogas production. Numerous suppliers are on the market, offering various systems and brands.
Cavitation and electronic disintegration A pump flow of biomass is introduced through a drum. A strong rotation in the drum creates cavitation in the biomass, causing biomass to disintegrate. There is only one biogas plant in Denmark equipped with this process. Known suppliers are: C-Biotech /BigBang, Röhring/PlurryMax and Vogelsang/BioCrack.

Table 3: Technologies and equipments commonly used by Danish biogas plants for handling deep bedding. *Source: Teknologisk Institut*

A challenging substrate

Physical impurities

Co-digesting deep bedding can be a challenge due to high DM content; this can lead to formation of floating layers inside the reactor. The material is also likely to contain physical impurities and foreign bodies. Most anaerobic digestion (AD) systems are capable of handling smaller physical impurities, but larger ones must be removed before entering the AD system, as they cause increased wear and tear of choppers and pumps. Special equipment is recommended that can capture stones and scraps of metal, before the deep bedding enters the AD system. Economic incentives may be required to deep bedding suppliers, to process the deep bedding to minimise the content of impurities.

Ammonia emissions

Odours and ammonia are released when deep bedding and manure are handled. Many biogas plants using deep bedding have therefore established a special hall for handling and pre-treating of the material. To prevent ammonia emissions causing damage to the electronic systems of the pretreatment installations, many plants have implemented various air suction solutions in these pretreatment halls. At Ribe Biogas, an air extraction point, situated above the mixer, leads the odours and ammonia to a filter. Nature Energy implemented a solution where the air from the entire hall is continuously sucked out of the hall and filtered.

Choosing the suitable technology

Co-digesting deep bedding requires investments in equipment for handling dry biomass. There is also an extra cost in operating and maintaining such equipment. Extra storage capacity for the digested biomass will be needed, but no extra digester capacity is required. The choice of equipment and technology depends to a large extent on how the biogas plant is otherwise equipped and configured, and of what is intended to be achieved: increased pumpability, flexible heat exchange, increased biogas yield, less tendency to form floating layers, reduction in costs. In general, for plants with shorter residence time (few weeks), use of tougher shredding technologies have proven to significantly increase biogas yield. The reactors must be able to handle high DM substrates. For plants with relatively long residence time, the PreMix technology is the most prevalent. On farms scale plants, cheap solutions, such as stirring in the front tank, followed by a chopper-pump and macerator work best and are in widespread use. Mobile shredders/choppers, with large capacity are also popular, as low cost and flexible solutions. Dry feeding is only used by few biogas plants in Denmark.

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