Briquettes of straw and dry grass double biogas production

It is of major advantage to compress straw to briquettes if the straw is used for boosting gas production in biogas plants. The gas yield increases relatively to untreated straw, the content of hydrogen sulfide is substantially reduced, and risk of floating covers is eliminated, as demonstrated by new experiments at University of Aarhus.

By Henrik B. Møller and Mogens Møller Hansen

At Research Center Foulum, Aarhus University, large quantities of straw, dry grass and similar solid biomasses are fed to a full scale biogas plant. Before the biomasses are fed to the reactor, it is pre-treated, where the dry crop residues as straw and grass are compressed to briquettes, while the wetter biomass as deep litter and silage are extruded.

By briquetting and extruding, the biomass is exposed to high pressure and temperature. This breaks plant fibers and cell walls open in a manner, which renders the biomass sugars available for bacteria during the biogas process. Extruding is well suited for wet biomass while briquetting requires a relatively dry material.

When pre-treated, it is possible to manage far larger quantities of straw in a biogas plant, relatively to untreated straw. Without any pre-treatment it is only possible to add small quantities of straw, because straw is voluminous, difficult to stir in, and creates floating covers in the reactor.

Briquetting allows for addition of large quantities of straw and increases, at the same time, the biogas yield. In reality it means, that the biogas production can be doubled in biogas plants, which presently are based on animal manure.

By means of a EUDP-financed project (Energy Technology Development and Demonstration Programme), Aarhus University is working to document and optimize the technology of briquetting straw for biogas production. The work is done in co-operation with BioFuel Technology A/S and C. F. Nielsen A/S, which is one the world's leading suppliers of briquetting presses.

Briquetting increases biogas yield

During a year, large quantities of solid biomass are added to Aarhus University biogas plant in Foulum. During summertime, however, the production is reduced because the ▶

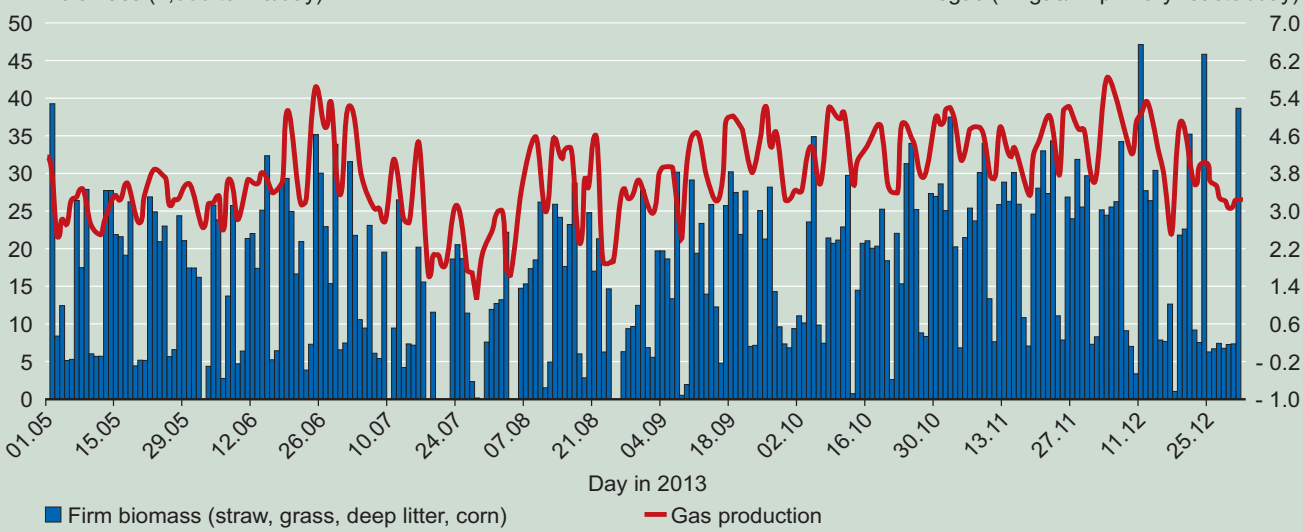

Fig 1: Addition of solid biomass and the associated gas production on the biogas plant at Research Center

Photo: Torben Skøtt/BioPress

The biogas plant in Foulum receives up to 4 tons of briquetted straw/dry grass on a daily basis. The briquetting results an increased gas yield of about 35% relatively to untreated biomass.

University has decided not to cool off surplus heat during summer.

The amount of solid biomass, which has been added on a daily basis in second half of 2013, is illustrated in Fig 1. The solid biomass consists of a mixture corn silage, straw, grass and deep litter.

Solid biomass and slurry is added to the reactor separately, so that the solid biomass is stirred in during the biogas process in the reactor. Up to 4 tons briquetted straw/dry grass is added daily. The residence time is very short in the reactor; during the last half of 2013, it was only 12 days. It means that up to 37% of the gas potential is not being produced in the reactor. It is instead being produced during storing in covered tanks with gas collection; however, this is not the case during the coldest month of the year, where the temperature in the store drops below 25 °C.

Briquetting results in less sulfur

During a period of 4 month, controlled experiments were conducted in pilot scale reactors - one reference reactor with cattle slurry and one reactor with cattle slurry and 8.5 % wheat straw. The experiment was stable, and the gas yield is shown is Fig 2. The variations in gas yield on a 24 hour basis are due to the fact that during the weekends only slurry was added to the straw reactor.

The key numbers of the experiment are shown in Table 1. It can be seen that it is possible to manage biomass with a dry matter content of 14% in the reactor without any technical problems regarding stirring of biomass. There was no tendency of buildup of floating covers.

The straw also impacted the content of hydrogen sulfide in the biogas very positively, because it was reduced from 1900 ppm to 365 ppm. The methane yield from the straw was 277 liter CH4/ kg volatile solids, or about 235 Nm3 per tons straw.

Energy consumption can be cut in half

The energy use during briquetting has been measured during a spe-

	Unit	Straw-reactor	Manure-reactor
Gas volume	m^3/tonne slurry	20,4	20,4
Gas volume	m^3 CH_4/tonne straw	235	12,3
Dry matter	percent	14,1	7,6
Gas quality	percent	52	61
Hydrogen sulphide	ppm	365	1.900
Methan (straw)	litre gas/kg VS	277	–
Methan (manure)	litre gas/kg VS	–	199
Residence time	days	24,25	24,70

Table 1: Key numbers for the experiments with addition of straw to cattle slurry.

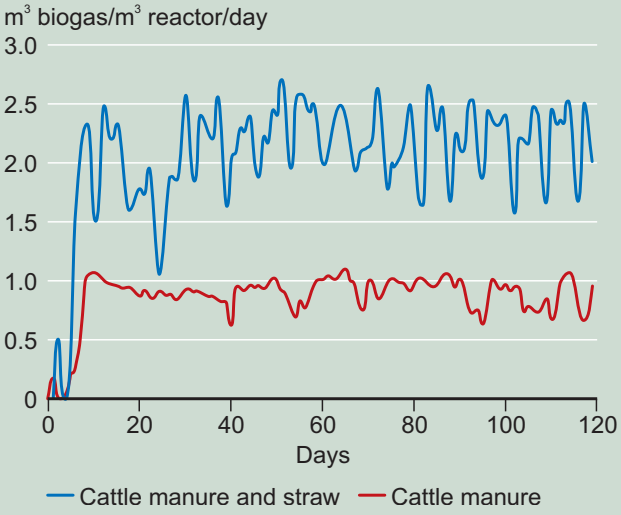

Fig 2: Gas production in reactor with slurry and reactor with slurry plus 8.5 % straw addition.

Photo: BioFuel Technology A/S

Briquette press at Research Center Foulum biogas plant.

cific period to app. 90 kWh per tons straw, at the capacity setting of the experiment in Foulum. According to the producer of the briquetting machine, it is possible to cut the power consumption in half given the full capacity of the machine is used.

In addition to the use of power for briquetting power is also used for shredding and milling. At the plant in Foulum it is estimated to app. 40 kWh per tons. For upcoming plants it is expected to be considerably reduced by using less power consuming technology.

Effect on gas yield

The effect of briquetting on the gas yield has been investigated in laboratory scale experiments. Experiments have been conducted with different types of nozzles, addition of additives as acetic acid, and a base in the form of potassium hydroxide.

Some of the data are shown in Fig 3 and 4. The effect of briquetting is more pronounced at short incubations times (during long term laboratory incubations for methane potential measurements). At 15 days an increased yield of 35% was measured. The longer the incubation time the less difference among treated and untreated straw, and after 60 days there is only a marginal effect of briquetting.

Part of the effect of briquetting is due to the treatment in the hammer mill before added to the briquette press. When briquetting grass no effect on biogas potentials of briquetting is seen relatively to using a hammer mill alone.

The combination of additives and briquetting has a very positive impact on gas yield. The biggest impact was found when 1% potassium hydroxide was added, while acetic acids had a smaller effect.

Large quantities of straw

In addition to having a beneficial impact on the gas potential, the briquetting allows for managing large quantities of straw together with slurry. Today, there are no other well documented technologies to add straw in large quantities with slurry. Pure mechanical solutions, which alone comminute the straw, do not produce the same advantages in terms of solubility and the ability to mix in with the slurry.

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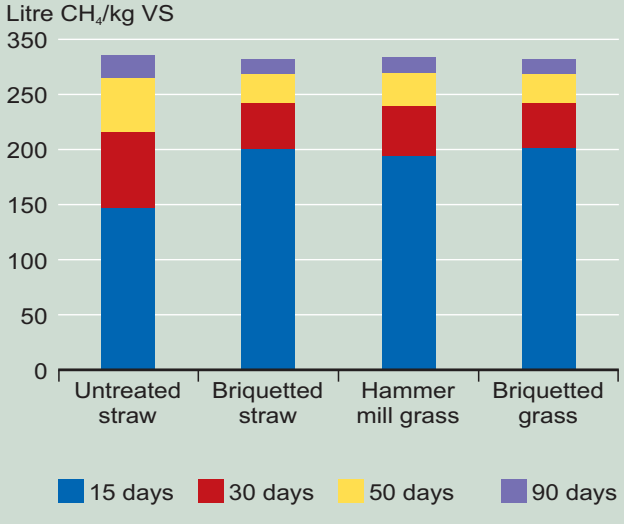

Fig 3: Gas production from straw and grass with different pre-treatments.

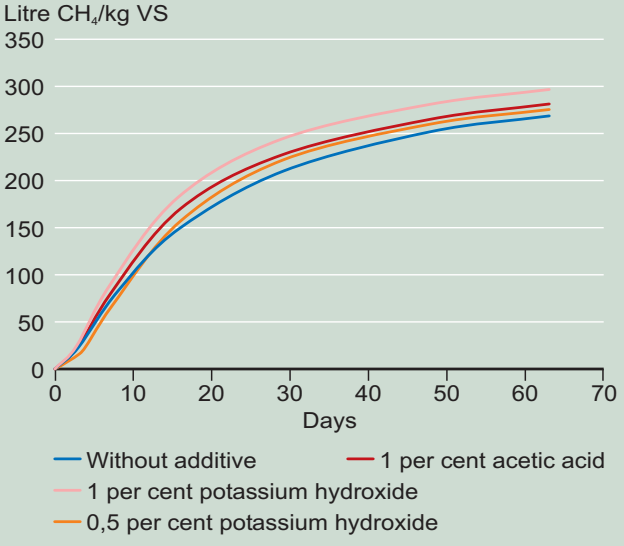

Fig 4: Effect of addition of various acids and bases.