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Straw Won't Work with sawdust between one's ears

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Great Britain

Straw Won’t Work with sawdust between one’s ears

Producing biogas exclusively from straw is a real challenge. An agricultural entrepreneur in the UK is mastering it with an industrial-scale plant, designed and built by Agraferm from Germany.

Author: Klaus Sieg

A new Stonehenge made of straw? Or perhaps an Aztec temple complex? Whatever the comparison, the impressive giants standing in a green field beside the country road are certainly impressive. Over 20,000 straw bales stacked into the blue sky. Just a few metres away stands the next giant structure: the Mepal biogas complex in Cambridge, one of the largest on the British Isles.

Parts I to III of the plant comprise twelve digesters – four with a volume of 3,300 cubic metres and eight with 5,800 cubic metres – as well as eight secondary digesters, each with a capacity of 5,000 cubic metres. Total volume: 100,000 cubic metres. Soon, in addition to generating 17 megawatts of electricity, a total of 5,100 cubic metres of biomethane per hour will also be fed into the grid. That's impressive!

Multiple Gas Grid Connection Points

"Mepal I was commissioned ten years ago and, at that time, was one of the largest biogas plants in the world," says Markus Ott, Senior Product Manager at Agraferm GmbH & BTA International GmbH. Mepal I produces electrical energy, heat, and biomethane. Mepal II has been feeding biomethane into the UK grid since last year. Mepal III is under construction and will also be connected this year. The output is already so high that gas has to be fed in at multiple grid connection points. Agraferm has designed, planned and built all three plants for the operator Pretoria Energy Ltd.

The route across the site passes gas pipelines with a diameter of 40 centimetres and a flare almost the size of a lighthouse. In addition to the industrial scale of Mepal, it is above all the feedstock that is exceptional. Mepal I initially operated with sugar beet and maize; however, part of this was replaced by cereal straw. The two new plants run exclusively on cereal straw. This explains the huge stack of straw bales on the surrounding fields. Each plant requires an annual amount of 90,000 tonnes of straw for mono-operation.

Does the feedstock provide an alternative to energy crops, slurry, or other organic waste? Depending on the region, straw may be either in surplus or in short supply. So it can be inexpensive – but not necessarily. Since straw does not contain many nutrients, the digestate from the biogas plant does not count much in terms offertiliser regulations.

Compared to maize silage, wheat straw contains only half as much nitrogen. Straw also has a high dry matter content, so it requires less storage volume after fermentation. However, more process water must be used during digestion. The gas yield from straw, depending on pre-treatment, is approximately 70 per cent that of maize silage.

Feedstock with up to 15 Per Cent DM

Straw presents a challenge in terms of logistics, processing, fermenters, pumps, pipelines and agitators, and thus especially for the plant manufacturer. How can such solid input material be handled effectively without diluting it more and more with water, and without the need to build ever larger digesters? "We make sure that the substrate can be processed at a very thick consistency, with up to 15 per cent dry matter content."

Markus Ott climbs the steel ladder up to one of the digesters. It stands 11 metres tall. The roof is a solid concrete slab, ▶

At the time it was built, the Mepal I biogas plant was one of the largest in the world.

The processing and commercialisation of CO_2 is widespread in the United Kingdom.

One of the external straw storage sites is visible from a long way off.

The paddle mixers designed by Agraferm operate at low revolutions, saving energy and reducing wear.

Photos: Martin Egbert

Only Mepal I generates electrical power via generators.

The transport of liquefied CO_2 is carried out using dedicated tankers.

Even though the hall is open, the operator prefers not to reveal details of the straw pre-treatment process.

A waxy protective layer and dense fibre structure make breaking down straw a technical challenge.

making it walkable and providing a sturdy mount for the agitators. "We designed vertical paddle agitators ourselves. They stir at low rotational speeds – eight to nine revolutions per minute," explains Ott. Stirring gently in a laminar flow instead of agitating turbulently saves energy and reduces wear, although it also means that each digester needs seven agitators. However, they do not all run simultaneously.
Sensors monitor the motors, the fill level of the digester, and the viscosity of the substrate, allowing for largely automated control of the agitators. Agraferm has long worked on speed-controlled agitators. These allow adjustments when the feedstock changes – for example, when coarser straw of lower quality makes the mixture especially viscous. More heavily weathered straw has a higher fibre content. On the other hand, it is cheaper, as it is no longer suitable for use as bedding, for instance.

No Floating Layers

On the way back down, Markus Ott stops at the round inspection window. The substrate is thick, almost firm enough to cut. "Nothing floats, but it's wet." Ott nods with satisfaction. Agraferm systems accurately measure, calculate, and regulate the proportion of dry matter that can still be mixed and mobilised. Sensors also monitor pressure.
Due to the size of the digester and the viscosity of the substrate, the raw gas must overcome a high pressure to rise. However, it is essential to prevent the formation of any dead zones within the digester. "In the past, people mocked us for this level of precision, calling us academics," Ott recalls. But with a feedstock like straw, this precision pays off.
The many access points for flushing and sampling throughout the plant are a direct response to this requirement. The Mepal facility also features a built-in level of redundancy. Three pumps are available for two digesters, in case one fails. The feed system is also secured in the same way. One unit stands on either side of each digester in the row. This setup allows four digesters to be supplied and safeguarded using five feeding systems. "In a plant like this, a day without raw gas from the main fermenter costs a lot of money," Ott explains – which is why the effort is worthwhile.

Straw: Degradation Rate Over 90 Percent

Straw typically remains in the digesters for just under 50 days, with 25 to 30 of those days spent in the first stage, where over 80 percent of the feedstock is already broken down. In the end, the results are impressive, with a degradation rate of 93 to 94 percent. Depending on the total retention time, this yields between 280 and 300 normal cubic metres (Nm^3) of methane per kilogram of organic dry matter.
This is also thanks to the pre-treatment of the straw. The hall dedicated to this process is at least 100 metres long. Forklifts feed straw bales into the shredding unit. Access to the interior of the hall is restricted – it's considered a trade secret. Operator Steven Ripley has further developed the pre-treatment process and monitors it using numerous cameras. Straw is considered one of the most difficult feedstock to break down. Cellulose and hemicellulose are shielded by a waxy coating, a dense fibrous structure, and lignin. While ensiling aids in breaking them down, it is not sufficient on its own.

Not exactly small either, like Mepal II, the third plant is designed exclusively to produce biomethane for injection into the grid

The size of the gas flares illustrates the scale of the facility.

A broad-shouldered man of action: Self-made entrepreneur Steven Ripley.

The cladding has not been installed yet, ongoing work on one of the digesters at Mepal III.

Straw can be shredded or cut, crushed or ground. In any case, water is required to allow it to swell and to bind the dust. The more thoroughly the structure is broken down, the better. "However, the effort must be proportionate to the increase in methane yield," Ott points out. Agraferm operates a dedicated straw line at another biogas site in England, equipped with a hammer mill and an extruder featuring two counter-rotating screws that break down the straw using pressure and heat. Here, effort and benefit are carefully balanced.

Straw Pre-Treatment with Steam and Pressure

"We work with steam and pressure," Steven Ripley eventually reveals. "Thanks to the five combined heat and power units from 2G in Mepal I, we have the electricity and heat for it, so it's not that expensive for us." The route to the operator and main owner of the Mepal biogas plant leads past fields of deep black soil and drainage ditches over which white seagulls glide in the brisk wind.

The tower of the mighty cathedral of Ely is visible on the horizon. Lorries loaded with straw pass by in the opposite direction. The small town of Chatteris begins with a cricket pitch with neatly trimmed grass. It was in Chatteris that Steven Ripley built his first biogas plant, also by Agraferm.

Large potato crates are stacked in the yard of his company. Lorries manoeuvre back and forth. Ripley trades in potatoes. He cultivates them on 600 hectares, producing 30,000 tonnes per year for crisps and chips factories. He is therefore well- ▶

Still in shell construction: The concrete roofs of the digesters at Mepal III are clearly visible.

versed in transporting large volumes of biomass. To procure straw for Mepal I to III, he founded a new company specifically for this purpose, purchasing the straw unprocessed straight from the field within a 50-kilometre radius.

"We bale it ourselves, so we get it much cheaper than the usual market price of around 70 to 80 euros per tonne." Behind his small desk, the self-made man looks like a boxer just before the attack. His energy fills the room. Ten employees work in Ripley's potato business. Pretoria Energy Ltd, his biogas company, now employs 137 people. To realise a project the size of Mepal, he sold 35 percent of the company to the Swiss oil trading firm Mercuria Energy Group. His long-time business partner holds ten percent.

The figures roll off his tongue like gunfire. He is less specific when it comes to questions about the income from his biogas plants. He feeds biomethane into the grid under a feed-in tariff, supplies filling stations with it, sells certificates for the use of the residual material straw, and trades in green CO_2 – evidenced by the tankers at the Pentair gas upgrading unit in Mepal.

"You've got to juggle the different income sources creatively, and the industry has to produce as green as possible in the future," Ripley believes. He sees us off with a firm handshake. His operation with straw seems to offer opportunities for both. ●

After the rain comes sunshine again, creating a striking reflection of the Mepal II secondary digester in the puddles.

Constantly in motion: The wheel loader feeding the plant with pretreated straw.

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