IEA Bioenergy
Technology Collaboration Programme

Corn straw biogas production in cold northern region of China

Case Story

IEA Bioenergy: Task 37: 12 2021

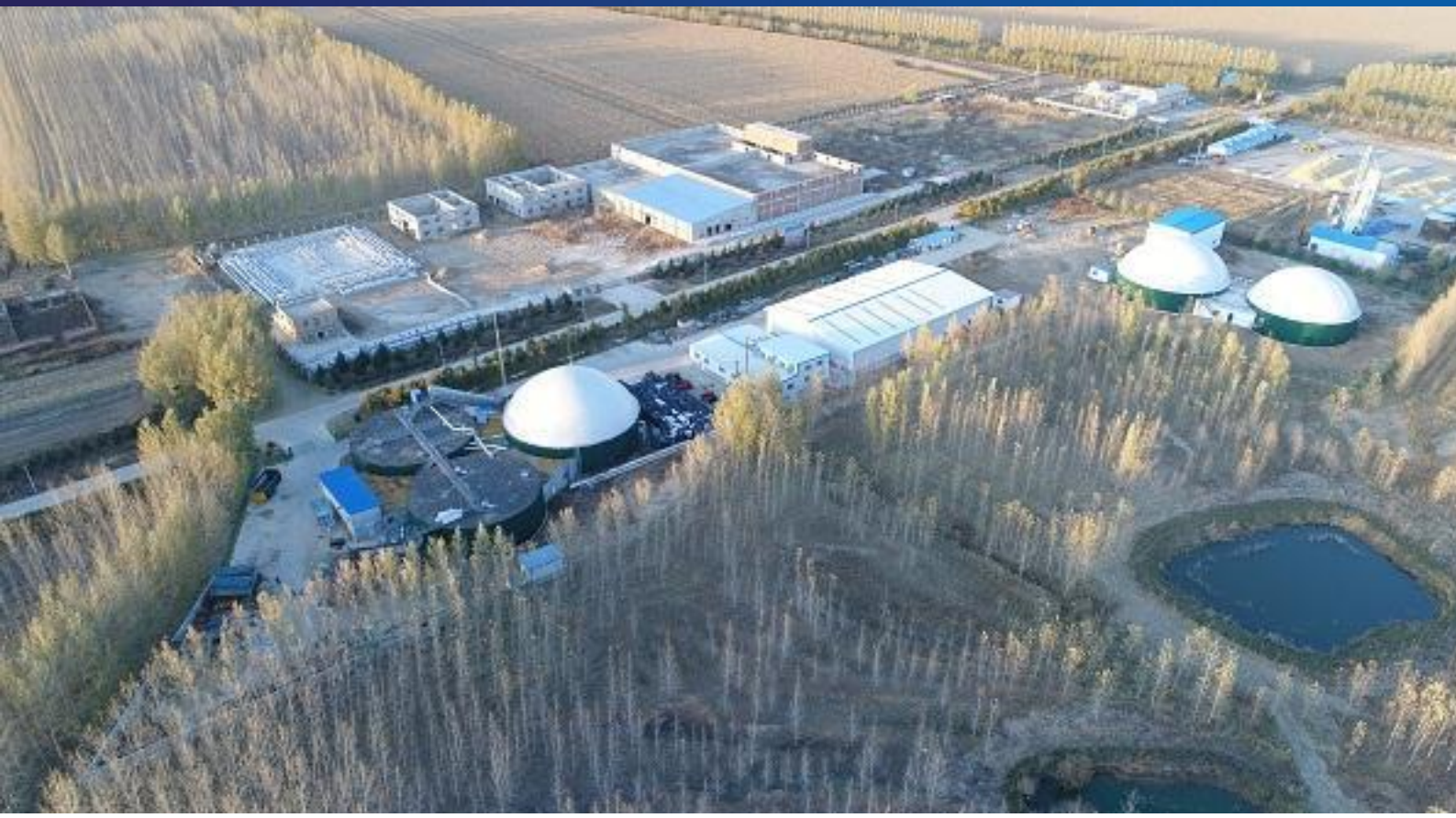

Figure 1: Layout of Fuyu biogas CHP plant

The problems in digesting corn straw

Corn straw has a high dry matter content, with a strong binding force of cellulose, hemicellulose and lignin. Biogas production from straw is exemplified by low yield and low rate of production, necessitating long retention times. Furthermore dark yellow lignocellulosic materials have poor hydrophilicity and as such straw is prone to float and generate crusts on the liquor surface of the digestion tank; this impacts negatively on the efficiency of anaerobic digestion. To further add to difficulties, the ambient temperature in this northern region of China is low in winter; fluctuations in temperature within the digestion tank may also lead to instability in biogas production.

Corn straw biogas plant in Fuyu county, Heilongjiang, China

The biogas plant located in a state-owned farm (Fanrong stock farm, Fuyu county, Qiqihar city, Heilongjiang Porvince) is the first biogas CHP facility to use pure yellow corn straw as feedstock in the alpine region of China. The 2MWe facility consumes 30,000 tonnes of yellow corn straw on a site of 2.3 ha; it was constructed (and is operated) by Nanjing General New Energy Power Co. Ltd. at a total investment cost of 55 million yuan. The project started commissioning in November 2016 and has been running continuously for over 30,000 hours. The processes employed (Figure 2) seek to optimise the efficiency of biogas production and the overall economics by producing high-value "breeding seedling soil" from biogas residue.

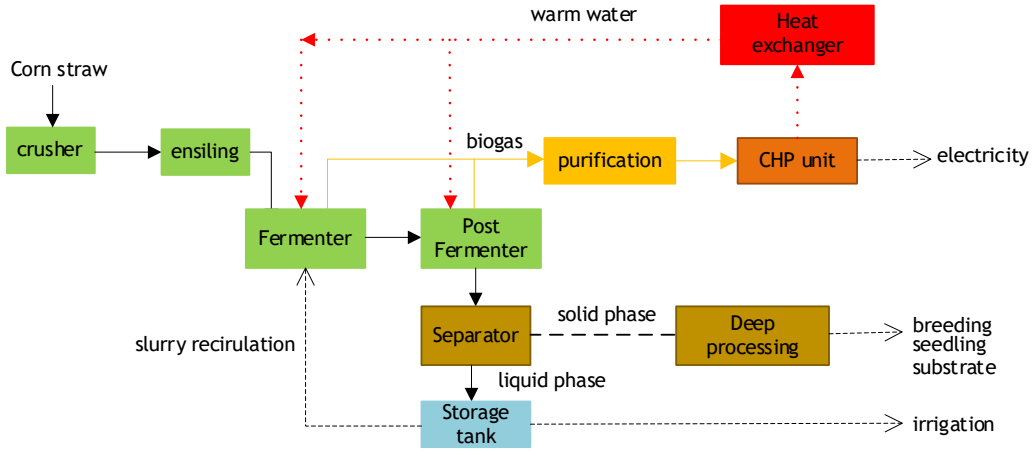

Figure 2: Basic flow chart of the project

Technical solutions and co-benefits

Raw material pretreatment

The dry matter content of the straw after harvest is greater than 85% with a particle size in the range 10 to 20cm. The straw is first crushed to smaller pieces (less than 3cm). It is then ensiled in silos where the the moisture content is adjusted to about 60% by adding water (Figure 3). Compression is applied layer by layer and straw is covered with films to remove air. This can reduce dry matter loss with typically 80% less loss of dry matter as compared to open storage. During ensiling organic acids are produced, which shorten the required hydraulic retention times in digestion to less than 35 days.

Figure 3: Particle size after and before crushing (left) and ensiling storage (right)

Biogas production

Each fermenter tank has a volume of about 4000m^3. Precast concrete elements were used in the fermenters with an average erection period of 7 days (Figure 4). The total solids concentration with the fermentors is kept in the range 8 to 10%. A combined mixing using long-shaft mixers, submersible mixers and slurry recirculation improves homogenization and avoids floating straw and crust formation. The biogas yield reaches 320-350m^3/t DM at a hydraulic retention time of 35d equating to a volumetric gas production rate of 1.4m^3/m^3·d.

Figure 4: Erection of the fermenters (left), and submersible mixer (right)

Co-generation

Around 16 million kWh of electricity are generated per year; 8% is used to satisfy the electricity demand on site, the rest is fed into the grid for sale. The exhaust heat of the CHP units is used to warm the substrate and maintain a constant temperature in the fermentation tanks. No additional heat source is required. The project reduces carbon dioxide emissions by 17,000 tonnes per year, equivalent to saving 6,440 tonnes of standard coal.

High-value utilization of biogas digestate

The digestate is segregated and the solid fraction of digestate is treated by composting and further processed to a fertilizer used for breeding rice seeds (Figure 5). The facility is situated in the main rice producing area, so the market for fetiliser is guaranteed. The facility produces 20,000 tonnes per year of digestate fertiliser with a sale price of 400-450 yuan/t. The successful use of this biogas residue has improved the economic benefits of the project.

Figure 5: Compost tank of solid residue (left), application of breeding seedling soil (right)

Information summary of the Fuyu corn straw biogas plant

Basic information		Operation parameters	
Area (ha)	2.3	Total solid content in the digester	8~10%
Total investment (million RMB)	55	Hydraulic retention time (HRT) days	35
Annual treatment (t)	30,000	Digester volume (single digester) m^3	18,000(4,000)
Power capacity (MW_e)	2	Biogas yield (m^3/t DM)	320-350
First Year of operation	2016	Volumetric gas production ($m^3/m^3 \cdot d$)	1.4
Dry matter of raw corn straw	>85%	Annual power generation (kWh)	16 million
Water content of ensiling process	~60%	On site electricity consumption	8%
AD type	CSTR	Annual coal savings (t/a)	6,440
		Annual CO_2 reduction (t)	17,000

IEA Bioenergy Task 37 "Energy from Biogas" http://task37.ieabioenergy.com

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