Operational problems occurring during the production of biogas and energy in a modern agricultural biogas plants

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The growing interest in agricultural biogas plants among farmers and entrepreneurs is driven by investment opportunities and the increasing demand for energy. These plants, utilizing agricultural and food waste, including fruit, vegetable, and meat processing residues, offer a sustainable solution for generating affordable renewable energy. Understanding the industry's potential and the benefits it offers is crucial for business success and environmental sustainability.

The biogas production process involves several stages, with anaerobic methane fermentation at its core. This process results in biogas, a gas mixture primarily composed of methane and carbon dioxide, with minor amounts of hydrogen sulfide, nitrogen, oxygen, ammonia, and hydrogen. The cogeneration engine, central of the energy conversion, enables the production of electrical and thermal energy. This energy can be utilized for the plant's technological needs or supplied to external consumers, showcasing the plant's multifaceted utility.

Despite the extensive knowledge of technologists and operators, completely eliminating operational problems and emergency situations in a biogas plant is challenging. Often, these issues arise from technological limitations and the quality of raw materials used in the installation. The following sections of this article describe the operational problems encountered during the process of biogas and energy production, based on collected data and experiences faced by operators under real working conditions.

Operational Problems

Pretreatment and Contamination in Raw Materials: Proper preparation of the substrate for methane fermentation is as crucial as maintaining the correct process parameters inside the fermenter. Before being introduced into the tank, the material undergoes preliminary processing, including delivery, storage, foreign body separation, and grinding. The successful execution of these operations is essential for the effective functioning of the installation and achieving a positive economic return on the investment.

The described biogas plant processes both solid and liquid substrates. Liquid substrate is transported via tanker trucks to a buffer tank equipped with a pump. After mixing, the substrate is directed to one of three fermentation chambers where the biogas production process occurs. Solid substrate is stored in designated piles and then, using conveyors, is fed into the fermentation tank following the same path as the liquid substrate.

Engine Operation: The engine, being the biogas plant's core, requires proper use and maintenance as per the manufacturer's guidelines, including oil and coolant replacement and spark plug maintenance. The featured biogas plant operates two GE Jenbacher J 320 GS-C25 cogeneration engines **Table 1.**
Each engine is equipped with a STAMFORD electric power generator of 1063 kW **Table 2**.

Table 1.Engine Technical Specifications	
Engine Type	J 320 GS-C25
Electrical Power	1063 kW
Useful Thermal Power	599 kW
Heat Recovered from Exhaust	440 kW
Number of Cylinders	20
Engine Capacity/Displacement	48,67 L

Table 2. Generator Technical Specifications	
Type	PE 734 C2
Nominal Electrical Power	1063 kW
Frequency	50 Hz
Voltage	400 kV
Speed (Revolutions per Minute)	1500

In addition to producing electrical energy, the CHP cogenerator allows for the recovery of thermal energy from two sources: the engine cooling process (plate heat exchanger) and from the exhaust gases (recovery steam boiler) **Table 3**. The recovered heat is used to generate a flow of hot water and produce process steam. To recover heat from exhaust gases, the system is equipped with a two-segment steam boiler (**Table 4**), specifically designed for two GE Jenbacher J 320 GS-C25 engines.

Table 3. Heat Recovery – Water Circuits – Engine Cooling, Oil Cooling	
Total Useful Thermal Power	599 kW
Return Temperature	70°C
Outlet Temperature	90°C
Amount of Water in Circulation	25,7 m^3
Nominal Water Pressure	10 bar

Fig. 1. Raw material contaminants after 4-years exploitation

Table 4. Steam Boiler Technical Specifications			
Heat Exchange Surface		142 m^2	
Power		880 kW	
Total Length		5600 mm	
Shell Diameter		2000 mm	
Quantity of Saturated Steam at 8 bar Pressure		1340 kg/h	
Exhaust Gases		**Medium (Water/Saturated Steam 8 bar)**	
Quantity of Exhaust Gases kg/h	2 x 5645	Quantity	1340 kg/h
Inlet Temperature of Exhaust Gases °C	450	Inlet /Outlet Temperature	105 /175,4 °C
Outlet Temperature of Exhaust Gases °C	200	Maximum Working Pressure	11 bar

Biogas Desulfurization and CHP Cogenerator Efficiency: The biogas produced needs purification before being used in CHP units for energy production. Hydrogen sulfide in biogas, combined with water vapor, forms highly corrosive sulfuric acid, negatively impacting not just the engine but also other installation components.

Ensuring Constant Heat Utilization: The quality of circulating water, regular water replenishment, cleanliness of heat exchangers, maintenance of networks, valves, pumps, and filters are crucial for efficient operation.

Fermentation Tank Maintenance: Regular inspections and maintenance, including oil changes for mixers and heating system maintenance (circulation pumps, filters, water replenishment), are necessary. Periodic cleaning of tanks from raw material contaminants (every 4 years) is essential to maintain heating efficiency.

Waste Management: Proper disposal of cooling fluids and used oils to authorized entities is and environmental challenge and operational cost.

Wastewater Management: Wastewater, mainly generated from the biogas desulfurization station, is directed to sewage treatment plants.

This article systematically addresses the operational challenges encountered in modern biogas plants. Key areas of focus include raw material contamination, engine operation, biogas purification, efficient heat utilization, fermentation tank maintenance, as well as waste and wastewater management. The study highlights the complexities of managing and maintaining biogas production processes, emphasizing the importance of meticulous operational practices for achieving efficiency and sustainability. The insights gained underline the necessity for continuous improvement and adaptation in the biogas industry to meet both environmental standards and economic viability.