ABSTRACT

The development of renewable energy has become a critical necessity in reducing dependence on fossil fuels. One of the promising renewable energy sources is biogas, particularly that produced from the anaerobic digestion of organic waste. However, the utilization of biogas in laboratory environments still faces challenges, especially in the real-time monitoring of critical parameters. This research aims to design and implement an Internet of Things (IoT)-based monitoring system for methane gas (CH_4) concentration and pH levels in the biogas fermentation process at the Smart Microgrid CoE Laboratory, Telkom University.

The system consists of two ESP32 microcontrollers, an MQ-4 sensor for methane gas detection within a closed sampling chamber, and a pH 4502C sensor connected directly to the biogas digestate. Data is transmitted to Firebase in real-time and displayed through a mobile application developed with Flutter. The sensor data conversion process utilizes a multi-segment linear interpolation method for the MQ-4 and linear regression for the pH sensor.

The test results demonstrate high accuracy, with the average relative error for both CH_4 and pH sensor readings below 2%. The system successfully monitored fluctuations and anomalies in methane production and identified the relationship between pH values and CH_4 emissions. The IoT communication test revealed stable connectivity, an average latency of ±417 ms, and a 100% data transmission success rate. Based on these results, the system is deemed suitable for automatic, accurate, and real-time monitoring of biogas energy on a laboratory scale.

Keywords: *Biogas, Methane, pH, Internet Of Thing, Firebase, Flutter*