

ABSTRACT

The growing demand for renewable energy encourages the utilization of biogas as an environmentally friendly alternative. However, in the Smart Microgrid Center of Excellence (CoE) Laboratory, there is no real-time monitoring system capable of detecting carbon dioxide (CO₂) concentration and gas pressure in the biogas production process. This study aims to design and implement an Internet of Things (IoT)-based monitoring system to observe both parameters in real time, with a focus on measurement accuracy, system efficiency, and ease of data access. The system is limited to the use of MH-Z19B and MPX5700AP sensors, with monitoring only in the biodigester tank area of the laboratory.

The method includes hardware design using an ESP32 microcontroller integrated with CO₂ and gas pressure sensors, which are then connected to the Firebase platform for remote data storage and monitoring. The system is also equipped with a 16x2 LCD for local display and a Flutter-based mobile application as a user interface. Testing was carried out through sensor calibration, system performance evaluation, and data transmission to the cloud, including latency measurement and communication stability.

The results show that the IoT-based monitoring system provides accurate real-time data on CO₂ and gas pressure. Calibration of the MH-Z19B sensor produced an average absolute error of 8.85 ppm with an average percentage error of 1.77%, all within the manufacturer's tolerance (± 50 ppm + 3% of reading) with an accuracy of 98.23%. The MPX5700AP sensor achieved an average error of 0.40% with an accuracy of 99.60%, showing good linearity and response. Integration with Firebase worked effectively with an average latency of ± 300 ms, supported by an informative mobile interface, making the system useful for monitoring and decision-making, as well as supporting biogas management in the laboratory and the development of renewable energy technologies.

Keywords: *Biogas, Internet of Things (IoT), Monitoring System, Carbon Dioxide Gas.*