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Article

IOT-Based Hydrogen Sulfide Monitoring at PT. Pertamina Geothermal Energy on Lumut Balai Area

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A B S T R A C T

This research focuses on the development of an Internet of Things (IoT) based tool for remote monitoring of hydrogen sulfide (H2S) concentrations in geothermal environments. H2S is a toxic gas present in geothermal wells and its monitoring is crucial due to its environmental hazards and health risks, exposure the H2S content for 500-700 ppm within 30-60 minutes can cause death the human. The research presents the design and testing of a monitoring system to enhance worker safety and streamline the geothermal energy generation process. The framework involves an input, processing, and output stage in both the transmitter and receiver units. The research draws from previous work involving gas sensors like MQ136, MQ4, and MQ7 for detecting hazardous gases. The tool's functionality is validated through testing, involving measurements of various components such as power supplies, microcontrollers, and sensors. The measurement data is compared to specification values, and the tool's error percentages are calculated. The results show that the tool effectively monitors H2S concentration, triggering alarms “BHY” on an LCD display and adafruit IO sending notifications"hazard of high ppm H2S" to mobile phones who installed IFTTT application when H2S concentration exceeds a specified threshold (10 ppm or higher). The research also discusses the impact of environmental conditions on H2S readings. This IoT-based solution offers real-time monitoring, enhancing worker safety and minimizing exposure risks in geothermal environments.

INTRODUCTION

H2S or Hydrogen Sulfide is a gaseous compound that is colorless, toxic, flammable and smells like rotten eggs that appears due to volcanic activity or places that contain geothermal energy. H2S must be monitored causes the dangerous of H2S contain can be harmful to the environment, and can cause death to a person if inhaled over a long period of time exposure to high ppm h2s (Rumampuk et al., 2021).

PT. Pertamina Geothermal Energy is a company that produces electricity from geothermal energy. The Geothermal Energy itself generated from Geothermal well. In the geothermal well not just contain the geothermal energy but there are also have many contain of minerals especially hydrogen sulfide contain inside.

One of the working areas of PT. Pertamina Geothermal Energy is the Lumut Balai Area which has been operating to produce electrical energy commercially in 2020. In geothermal power plant operations, the fluid used to generate electrical energy is in the form of steam (steam) or water (brine) which contain compounds in the fluid.

H2S is dangerous, because for now to monitor the H2S concentration, a tool held by the worker is still used, namely the H2S detector where the worker must be around the area first so that the tool can monitor the existing H2S content, this is very risky because workers can direct exposure to high or moderate concentrations of H2S for a long time. So the authors hope to create a tool to monitor H2S content remotely without having to approach the source of the hazard first, based on IOT (Susanto & Nurcahyo, 2019) and use the lora communication (Danny Kurnianto, Kemuning Nenden Testy, Prasetya YuliantoroLora, 2022). This is very useful for worker safety and security factors and can streamline the process of monitoring geothermal generation in the geothermal power plant area of PT. Pertamina Geothermal Energy Area Lumut Balai.

I. LITERATURES REVIEW

Based on research previously conducted by Habdi Rizki.A, et al (2020) with the title "DESIGN AND DESIGN OF DANGEROUS GAS MEASUREMENT TOOLS FOR WIRELESS-BASED MINING". The results of this research are that an air quality monitoring system for detecting hazardous contents such as H2S (Hydrogen Sulfide), CO (Carbon Monoxide), and CH4 (methane) can be made using the MQ136, MQ4, and MQ7 Sensors (Rizki et al., 2017).

In a journal entitled "EFFECT OF MQ136 GAS SENSOR READING ON SPREAD AND CHANGES IN AIR SPEED" which was investigated by Fellian Helmi Pristianto, et al (2019). The results of the journal research can be concluded that changes in air speed and speed have an influence on the readings of the MQ136 gas sensor with a reading difference of 0.3 Ppm (Pristianto et al., 2019).

II. FRAMEWORK

This tool, which is made for the IOT based h2s concentration monitoring, has three stages, namely input, then process, and finally output on each equipment transmitter and receiver (Bhawiyuga & Yahya, 2019). These stages have an important role in each other. The stages are described in the block diagram as follows:

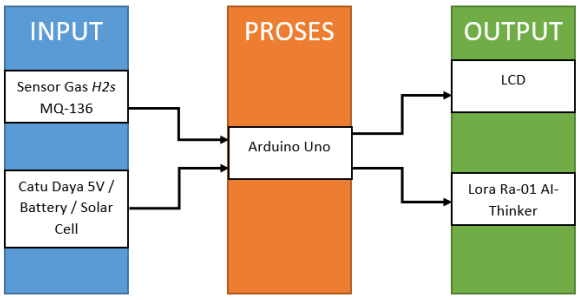

Figure 1. Transmitter System Block Diagram

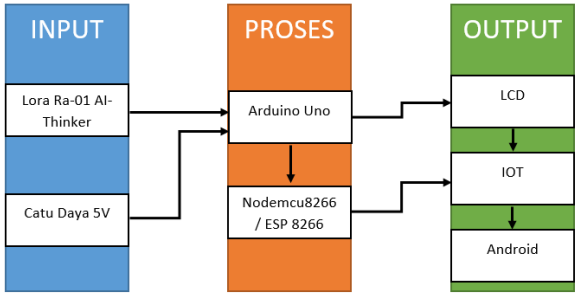

Figure 2. Receiver System Block Diagram

In addition to block diagrams, schematic circuits are also significant in the creation of tools. Circuit design process include schematic circuit design such as wiring.

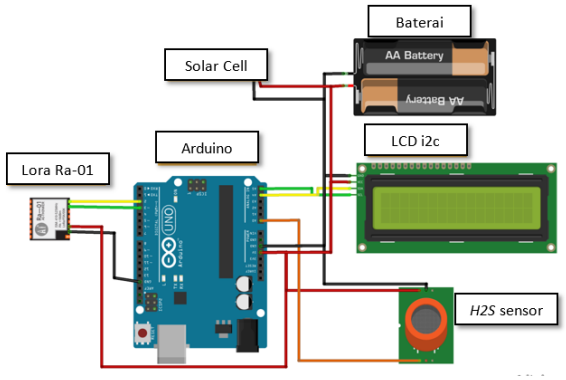

Figure 3. Transmitter Schematic System

The schematic wiring of the equipment is expalained as follows:

The power supply connected to arduino uno, battery and solar cell will backup the power supply if 220 v electricity power black out, pin SCL and SDA are connected to lcd i2c 16x2, pin D2-D6 are connected to lora ra-01 ai thinker, pin A0 is connected to MQ-136 sensor, pin 5v are connected to MQ-136, and lcd i2c 16x2 power supply, pin 3.3v is connected to lora ra-01 ai thinker power supply.

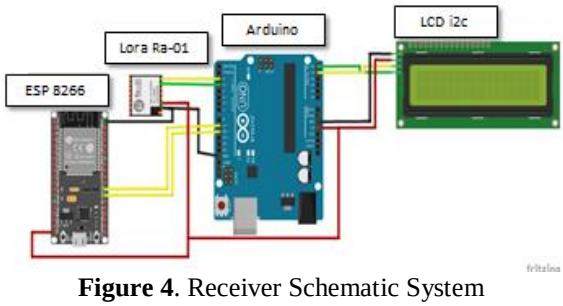

Figure 4. Receiver Schematic System

The schematic wiring of the equipment is expalained as follows:

The power supply connected to arduino uno, pin SCL and SDA are connected to lcd i2c 16x2, pin D2-D6 are connected to lora ra-01 ai thinker, pin D0 and D1 are connected to Nodemcu ESP8266, pin 5v are connected to Nodemcu ESP8266, and lcd i2c 16x2 power supply, pin 3.3v is connected to lora ra-01 ai thinker power supply.

III. METHODS

The preparation of this scientific work is based on several studies related to h2s and the dangers of h2s itself. This research inspired the authors to create a tool that can function to monitor system (Dasmen & Prayitno, 2023). Monitor sytem to monitor H2S content in real time to minimize the negative impact that can be caused by h2s on workers who work in geothermal environments that contain lots of h2s.

In order for the research process to proceed without any difficulties, it is essential to use a research method with distinct research stages, such as the action research method used in this research. This method is a research-stage design that can explain and describe conditions for improvement purposes.(Dasmen & Kurniawan, 2021)

Figure 5. Methods of action research.(Kurniati & Dasmen, 2019)

The methods of action research shown in Figure 5 are explained as follows:

3.1 Diagnosing

At this stage, the researchers conducted a survey of several previous research results as well as some reports related to IOT-Based H2S monitoring systems.

3.2 Action Planning

Following the survey, the researchers developed a strategy for providing appropriate problem - solving assistance (Dasmen & Akbar, 2023)

3.3 Action Taking

After creating plans and designing scenarios, the researchers used the hardware or software needed to create IOT-Based H2S monitoring systems on adafruit io website.(Dasmen & Haq, 2023)

3.4 Evaluation

At this stage, the researchers evaluated the findings, which could be displayed on the adafruit io website.

3.5 Learning

This stage is the final stage of the research method. At this stage the researchers monitored the h2s content in real time in the geothermal well. In addition, a solution is provided if you want to improve the accuracy of reading the h2s content, you must use a special sensor only to detect h2s (Setiawan et al., 2022).

IV. RESULT

4.1 Tool Asembly

Figure 6. Transmitter

Figure 7. Receiver

In Figure 6 & 7, all the components that have been assembled are installed. All components are connected and placed on the table that has been created. Installation of power supply components such as transformers, diodes, capacitors, and IC regulators which are useful as a source of electricity.

At the design stage, the expected objectives for this tool had been determined. It was intended that the tool would function properly throughout the manufacturing process so that it could be used perfectly as desired. The purpose of the kit design is to determine the component arrangement so that they can be installed correctly and in the correct order. In addition, a flowchart was needed to design this tool. The purpose of this flowchart is to outline the steps in the process by which this tool can achieve the desired result.

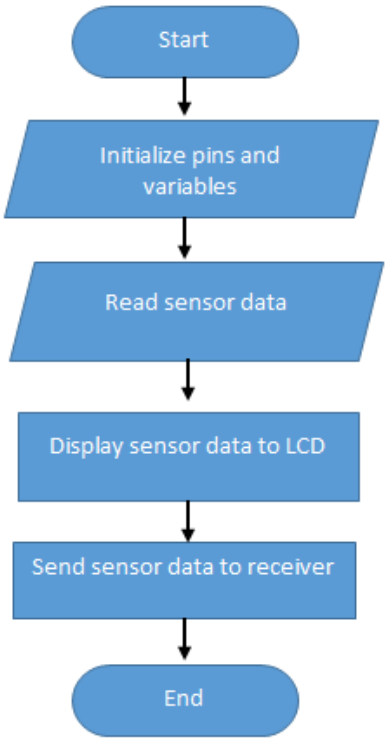

Figure 8. Transmitter Flowchart System

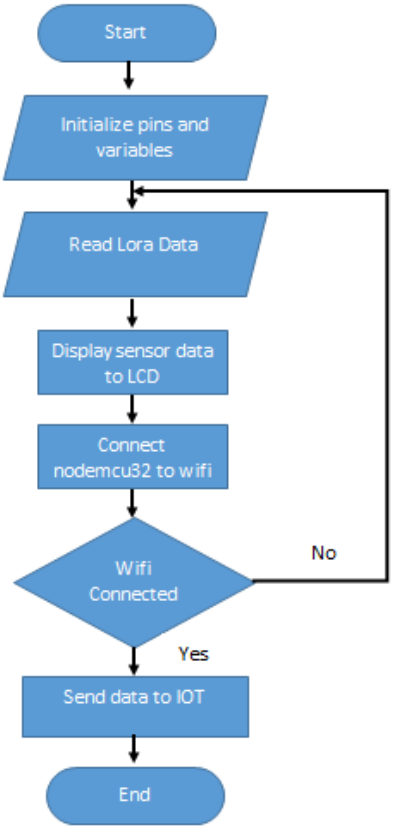

Figure 9. Receiver Flowchart System

The flow chart in Figure 8 & 9 is explained as follows:

The working system of the tool made is where the MQ-136 Gas Sensor on the transmitter functions to detect the value of the H2S content in the geothermal power plant area. Arduino uno is used to create programs to control electronic components or devices along with the sensors found on the Transmitter and Receiver devices. The 5V power supply is used as the main power source for Arduino Uno on the Transmitter device. To back up the power, a battery / solar panel / solar cell is used. The Receiver tool uses a 5v power supply as a voltage source for arduino and other components. On the transmitter, the H2S content content data read by the MQ-136 type gas sensor which has been programmed using Arduino Uno will then be displayed via the i2C LCD locally for realtime parameter readings locally and some will be sent to the receiver via long distance radio communication. away by using the LoRa Ra-01 AI-Thinker. Then on the receiver there is an Arduino Uno which has been programmed to read data that has been sent using the LoRa Ra-01 AI-Thinker which then the data obtained will be displayed again via the i2C LCD on the receiver and also displayed via the internet of things using the adafruit io display. where to be able to communicate the data remotely via the internet an ESP8266 module is needed which has wifi media in it. On the adafruit io website display, we can read the value of the H2S content in the geothermal power plant area. When the H2S content readable 10 ppm or more, a "BHY" alarm will appear on the 16x2 I2C LCD screen, and from the Adafruit IO website a notification will be sent "h2s high ppm hazard" which will appear on mobile phones that have the external application "IFTTT" installed. ”.

4.2 Tool Testing

Tool testing is done by collecting data directly on the components that have been installed. Testing is done by measuring components such as power supplies, microcontrollers, and sensors. The image of the measurement points carried out for testing the tool can be seen in Figure 10 as follows:

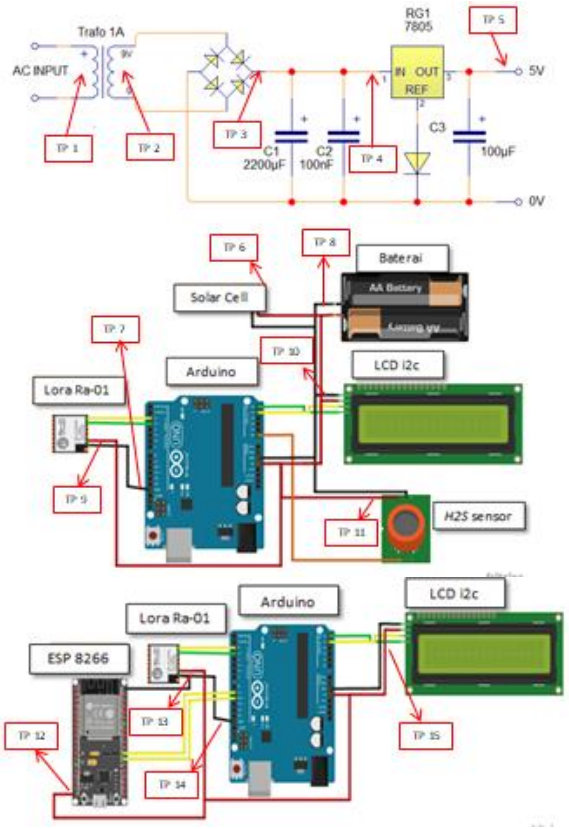

Figure 10. Measurement Testing Point

To get a good measurement value, measurements were carried out 5 times for each component. So the measurement results require an average value to get the measurement value. The formula for calculating the average of the measurement values is.

$$\overline{X} = \frac{X_1+X_2+X_3+X_4+X_5}{n} = \frac{\sum X_i}{n}$$

$\overline{X}$ = average measurement value

$\sum X$i = total number of samples

n = number of measurements

The tool testing process includes measuring height with a tool that has been designed and will be compared with manual height measurement and testing of sound output. Tool testing data from measurements and calculations can be seen in Table 1.

Table 1. Testing Tool Voltage

Measurement Point	Measurement Voltages					
	V_1	V_2	V_3	V_4	V_5	$V_{Average}$
Power Supply (MP1) – Vac	224	225	223	224	225	224,2
Trafo (MP2) – Vac	11,9	12	11,7	11,9	12	11,9
Capasitor (MP3) – Vdc	12,53	12,54	12,6	12,62	12,61	12,58
Diode (MP4) – Vdc	12,24	12,27	12,23	12,25	12,24	12,246
IC7805 (MP5) – Vdc	5,24	5,23	5,22	5,24	5,25	5,236
Solar Cell (MP6) – Vdc	12,34	12,37	12,27	12,4	12,31	12,338
Arduino Uno (MP7) – Vdc	4,89	4,88	4,9	4,87	4,9	4,888
Battery 5 V (MP8) – Vdc	3,77	3,77	3,75	3,76	3,77	3,764
Lora Ra-01 (MP9) – Vdc	3,27	3,3	3,25	3,32	3,35	3,298
LCD 16x2 (MP 10) – Vdc	4,82	4,97	4,85	4,96	4,85	4,89
Sensor Mq-136 (MP 11) - Vdc	4,71	4,82	4,75	4,84	4,76	4,776
ESP 8266 (MP 12) – Vdc	4,6	4,56	4,54	4,58	4,6	4,576
Lora Ra-01 (MP 13) – Vdc	3,14	3,21	3,17	3,19	3,2	3,182
Arduino Uno (MP 14) – Vdc	4,73	4,76	4,77	4,75	4,78	4,758
LCD 16x2 (MP 15) – Vdc	4,64	4,64	4,71	4,68	4,65	4,664

The form of application of diodes as a rectifier for alternating current to direct current, usually this rectifier circuit uses four diodes arranged in a rectangular shape with a diode on each

side. To find out the bridge diode voltage before it is filtered by the capacitor, it can be calculated using the formula below. To find out the bridge diode voltage before it is filtered by the capacitor, it can be calculated by the formula below

$V_m = V_{rms} \sqrt{2}$

Ex:

Vm = Vmax

Vrms = Secondary transformer voltage

The percentage error is the difference between the estimated value and the exact value and the percentage of the exact value. To find out the percentage of errors from the tool, it is necessary to compare the test data with the specifications of the tool. The formula for calculating the percentage of errors is.

$$\% \text{ Error} = \frac{|\text{Measurement Value} - \text{Specification Value}|}{\text{Specification Value}} \text{x } 100$$

A measuring tool is used to determine the quality and value of the component to be measured. Data comparison of measurement values and tool specification values can be seen in Table 2.

Table 2. Error Percentage

Measurement Point	$V_{Average}$	$V_{Specification}$	$V_{Calculation}$	% Error
Power Supply (MP1) – Vac	224,2	220	-	0,019
Trafo (MP2) – Vac	11,9	12	12,13	0,0083
Capasitor (MP3) – Vdc	12,58	-	10,25	0,261
Diode (MP4) – Vdc	12,246	-	16,51	0,27
IC7805 (MP5) – Vdc	5,236	5	-	0,0472
Solar Cell (MP6) – Vdc	12,338	12-17	-	*In Range*
Arduino Uno (MP7) – Vdc	4,888	5	-	0,0224
Battery 5 V (MP8) – Vdc	3,764	3,7	-	0,0172
Lora Ra-01 (MP9) – Vdc	3,298	3,3	-	0,0006
LCD 16x2 (MP 10) – Vdc	4,89	4,7-5,3	-	*In Range*
Sensor Mq-136 (MP 11) - Vdc	4,776	5	-	0,0448
ESP 8266 (MP 12) – Vdc	4,576	3,3	-	0,386
Lora Ra-01 (MP 13) – Vdc	3,182	3,3	-	0,0357
Arduino Uno (MP 14) – Vdc	4,758	5	-	0,0484
LCD 16x2 (MP 15) – Vdc	4,664	4,7-5,3	-	0,0076

4.3 Tool Experiment Results

The experiment was carried out by taking data measured by the sensors that have been installed on the device. The measurement results are in the form of readings of the ppm content from the h2s sensor, namely the MQ-136 sensor which is displayed on the i2c LCD and the Adafruit io website. Measurement data is displayed on the LCD as shown in Figure 11 and displayed on the Adafruit io website as shown in Figure 12 below:

Figure 11. I2C LCD Display

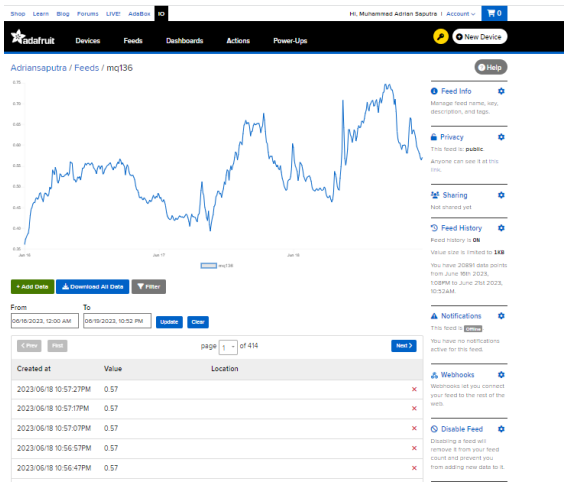

Figure 12. Adafruit IO Display

The range that can be covered through communication between the Lora Ra-01 Ai Thinker on the Transmitter & Receiver is as far as 5.4km, as shown in Figure 12 below:

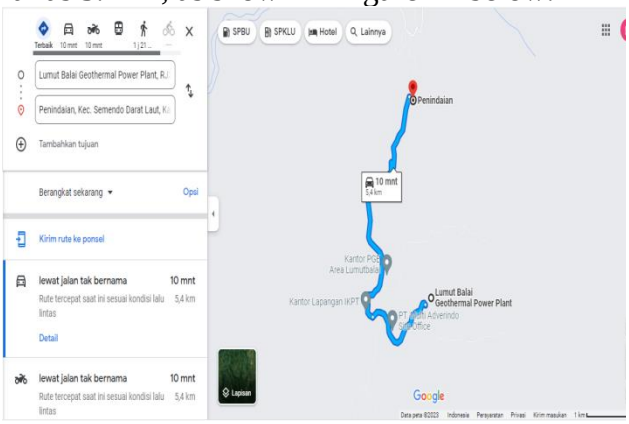

Figure 12. Lora Ra-01 Cover Range

When the H2S sensor MQ-136 detects a value of h2s content of 10 ppm or more, the I2C LCD screen will display a "BHY" notification as shown in Figure 13 below:

Figure 13. Notification LCD

Then from the Adafruit IO website it will send a notification "Hazard of high ppm h2s" on mobile devices that have installed the IFTTT external application as shown in Figure 14 below:

Figure 14. Notification Adafruit IO

Sample Measurement Data for 3 time, at 09:00 am, 04:30 pm, and 00:00 am shown in Figure 15 below :

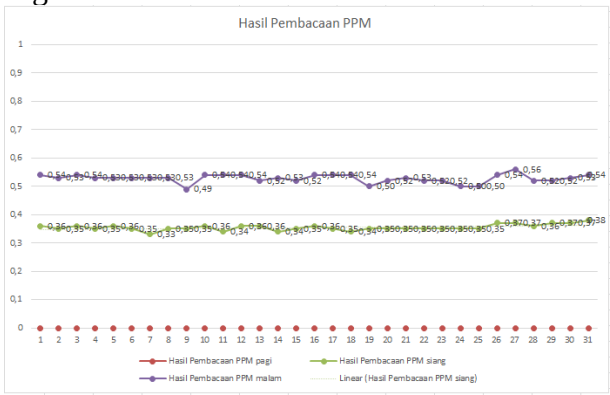

Figure 15. Sample Measurement Graphic Value

V. DISCUSSION

The test and measurement of this tool aims to ensure that the tool is able to function properly and the measurement results are in accordance with the specifications of each component. From the experimental results on this tool it can be seen that this tool can function properly to monitor H2S concentrations around the geothermal well area, this tool will also display a “BHY” alarm on the I2C LCD screen display on the transmitter and from the Adafruit IO website it will send Notification of "hazard of high ppm h2s" on mobile phones who installed IFTTT application when the local H2S content is high (10 ppm or more).

The lowest H2S data recorded on the adafruit io server on this tool is at 0 ppm. Meanwhile, the highest parameter value read by the MQ-136 sensor during data collection is 0.54 ppm. For the farthest range that can be covered during data retrieval via communication between the Lora Ra-01 Ai Thinker from Transmitter to Receiver, which is 5.4 km, while the specifications for the Lora Ra-01 Ai Thinker are 10 km (Version, 2020). This happens because the installation location of the tool is blocked by tall trees so that the transmission range of data from the Lora Ra-01 Ai Thinker is smaller than specification.

From the results of measurements and calculations on the tool it can be seen that the measurement results are within the specification range of each component so that it shows the condition of the tool to work and function properly. From the sample data collection results, it can be seen that at 09:00, the average H2S reading is at 0 ppm, this is because usually at this time the weather conditions around are not foggy so that H2S can decompose perfectly in the air, while in the afternoon and evening a day when the weather around is often foggy so that H2S cannot be decomposed by the air and H2S will drop down into the surrounding environment so that the potential for workers to be exposed to H2S content that has accumulated in high enough levels can be harmful to workers if inhaled exposure to H2S in high concentrations and in a long time.

VI. CONCLUSION

Based on the research of the "IOT-Based Hydrogen Sulfide Monitoring At PT. Pertamina Geothermal Energy on Lumut Balai Area" Equipment can be concluded that The Internet of Things system is capable of monitoring H2S concentration which can be displayed on the LCD and the Adafruit IO website. The highest parameter value read by the MQ-136 sensor during data collection is 0.54 ppm. In the morning the H2S concentration read by the sensor very small, average at 0 ppm, in the afternoon the H2S concentration is read on average at 0.34-0.38 ppm, and at night the H2S concentration is read at 0.49-0.54 ppm. When the MQ-136 sensor reads the concentration of H2S content for 10 ppm or more, an alarm "BHY" will appear on the i2c LCD display on the transmitter and adafruit io Server will send a notification "hazard high ppm h2s" indicating that the local H2S content is moderate to high and should not approach the source of H2S exposure without using safety equipment for monitoring geothermal wells. The farthest distance of data that can be transmitted via Lora Ra-01 Ai Thinker at the transmitter to Lora Ra-01 Ai Thinker at the receiver is ± 5.4 km.

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BIOGRAPHY

Rahmat Novrianda Dasmen Graduated of Master of Informatics Engineering from Bina Darma University who currently teaches in the computer Engineering and Electrical Engineering Study Programs.

Muhammad Adrian Saputra Graduated associate's degree from Polytechnic State Of Sriwijaya Palembang on 2017 while writing this scientific journal, he was currently for bachelor degree, which was a graduation requirement at Bina Darma University, Palembang and now was work at PT. Pertamina Geothermal Energy Lumut Balai Area