CHAPTER 6

SOLAR-POWERED IOT-BASED SMART TEMPERATURE AND HUMIDITY MONITORING SYSTEM FOR INCUBATORS

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6.1 INTRODUCTION

In modern agriculture, precise control of environmental conditions like temperature and humidity is essential, especially for hatching eggs without brooding hens. Incubators is a device that creates a controlled environment which regulates temperature, humidity, and air circulation to replicate the conditions needed for eggs to hatch successfully [1]. It is widely used in poultry farming to increase productivity and it allows farmers to hatch large numbers of eggs simultaneously, control hatching schedules, and reduce dependency on natural conditions, which can be inconsistent [2]. This project aims to improve hatching rates and reduce energy costs through a sustainable, efficient incubator system targeted at smallholder farmers in remote areas.

This project leverages solar energy as a clean power source combined with wireless communication and offers a sustainable and energy efficient approach to hatching eggs, especially in remote or rural farming operations [3]. Solar-powered incubators often include battery storage to ensure stable operation during the night or during cloudy weather. Batteries keep the incubator's temperature and humidity controls functioning continuously, maintaining optimal conditions for hatching eggs [4]. This approach reduces grid dependency and supports continuous incubator function, even in areas with unreliable electricity.

Furthermore, wireless communication is a key factor in the modernisation and process optimisation of the industrial sector. It will enable more efficient, precise, and data-driven farming practices. The wireless IoT sensors track temperature and humidity inside the incubator and will send the live data via Wi-Fi or Bluetooth to mobile apps through Blynk [5]. However, when there is unstable condition occurs, Blynk will send an alert notification through apps and email to notify the farmer. This allows farmers to monitor and ready to take action once the condition is not in the optimal range, in order to ensure the optimal hatching environment. Hence, this method also will minimize the equipment damage.

6.2 MATERIAL AND METHOD

The research methodology for this project involves several systematic steps. Executing a project requires meticulous planning to ensure every detail is accounted for. Therefore, the first step in this process is selecting the project title, which lays the foundation for development. After addressing various considerations, suitable circuits and components were chosen for this project. A comprehensive and well-thought-out plan has been devised to ensure the final product is safe and reliable. Additionally, a systematic approach is being followed to complete the work within the specified timeline. This includes detailed planning for the Solar-Powered IoT-based smart temperature and humidity monitoring system for the incubator, ensuring all features are implemented effectively. In this project, the flowcharts provide a detailed overview of the operational steps involved in this Smart incubator system. The complete flow of operations is illustrated in Figure 6.1.

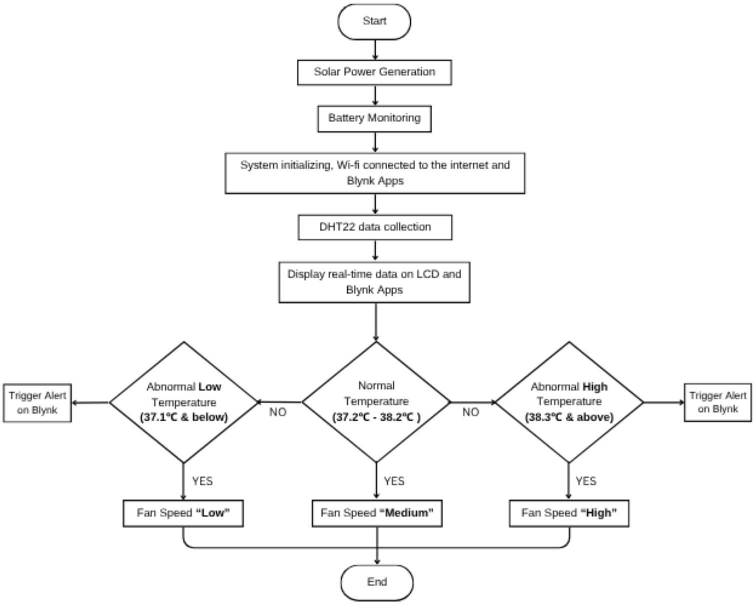


Figure 6.1: Flowchart of the system.

The flowcharts serve as a visual guide to the overall operation of the solar-powered IoT-based smart temperature and humidity monitoring system for incubators. They outline the step-by-step process, starting from how the system is being powered, how the sensor data collection to how does the systems response, including real-time updates via the Blynk platform and the alert notification being activated. This structured representation ensures a clear understanding of how the system functions, enabling efficient monitoring, timely alerts, and automatic control to maintain optimal incubation conditions.

Figure 6.2 shows the project's block diagram, offering a simplified overview of the system by dividing it into key functional components.

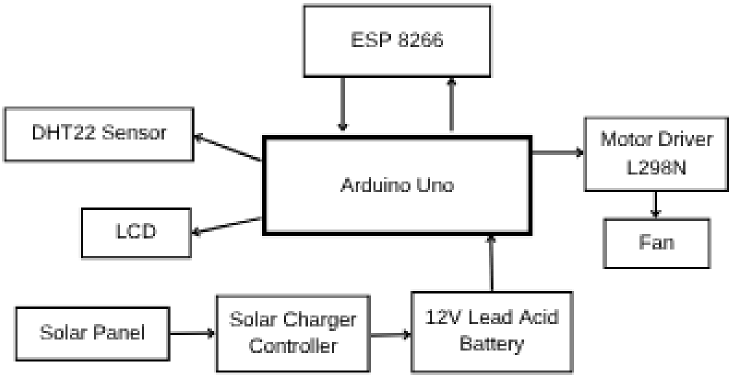


Figure 6.2: Block diagram of the project.

The solar-powered IoT-based smart temperature and humidity monitoring system for incubators combines both hardware and software to ensure stable incubation conditions. The system is powered by a 20W solar panel connected to a 12V rechargeable battery through a charge controller, which supplied energy to all components. An Arduino Uno used as a microcontroller which serves as the central control unit, gathering data from temperature and humidity sensors to continuously monitor the incubator environment. When conditions fall outside the desired range, the system automatically activates the motor driver L298N which control the 12V DC fan in order to restore balance.

The system is programmed using the Arduino IDE, and also includes an LCD screen for local monitoring. Remote monitoring is made possible through the Blynk application, which displays real-time data, while alerts systems such as “High Temperature” will be sent via Blynk apps and email. This system can be done through a Wi-Fi for IoT integration which is Esp8266. Moreover, to ensure the system operates efficiently and reliably in real-world settings, sensor calibration and solar panel performance at various tilt angles (horizontal, vertical, and 45 degrees) were thoroughly tested.

In this setup, all components are properly integrated to form a complete working system. Figure 6.3 and Figure 6.4 presents the configuration of the solar-powered IoT-based smart temperature and humidity monitoring system for incubators, showcasing the overall hardware arrangement and connectivity for this project.

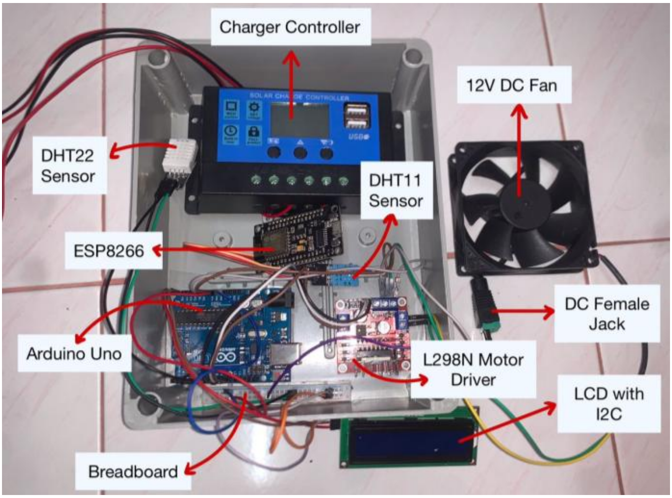
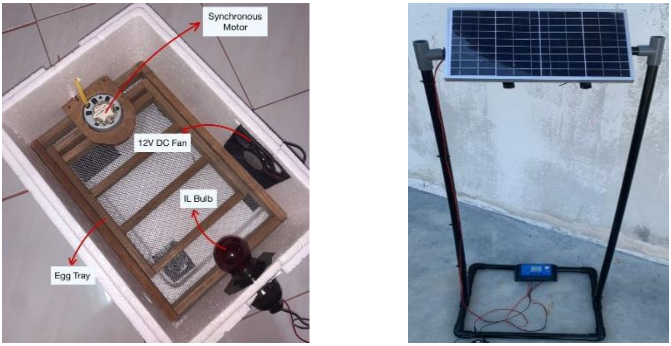


Figure 6.3: Component setup for the system of the incubator.

The system automates temperature and humidity control using a 12V DC fan that adjusts speed based on sensor readings, while manual elements like egg turning and heating use conventional AC power. The microcontroller processes data from temperature and humidity sensors, while an electronic control unit (ECU) displays real-time information. It also integrated with IoT via the Blynk app, the system allows remote monitoring.

Figure 6(a) illustrates the body of incubator which built with an insulated styrofoam box. It also includes key components such as incandescent bulb heating, a water container for humidity, and an AC synchronous motor for egg rotation. While Figure 6(b) shows solar panel stand that hold solar panel to powers the monitoring system, including sensors and control circuit.



(a) (b)

Figure 6.4: (a) Body of the Incubator (b) Solar Stand.

6.3 RESULTS AND DISCUSSION

This part discusses a performance analysis of the semi-automated egg incubator system with a solar-powered monitoring setup. Key parameters such as temperature, humidity, voltage, current, and power output were evaluated under different conditions. Integration with the Blynk platform enabled real-time monitoring and alerts, enhancing system reliability and user convenience. Overall, the results demonstrate the system's effectiveness in meeting the project objectives.

6.3.1 IRRADIANCE TEST ANALYSIS

The irradiance test analysis is conducted in order to measure the amount of solar energy received by the surface of the solar panel. It is typically expressed in watts per square meter (W/m^2). This analysis is crucial because the performance of a PV system is directly influenced by the level of solar irradiance that is being received. Without sufficient irradiance, the solar panel cannot generate the necessary power to operate the connected system effectively. The test was conducted for three days to ensure more reliable data as tabulated in Figure 6.5.

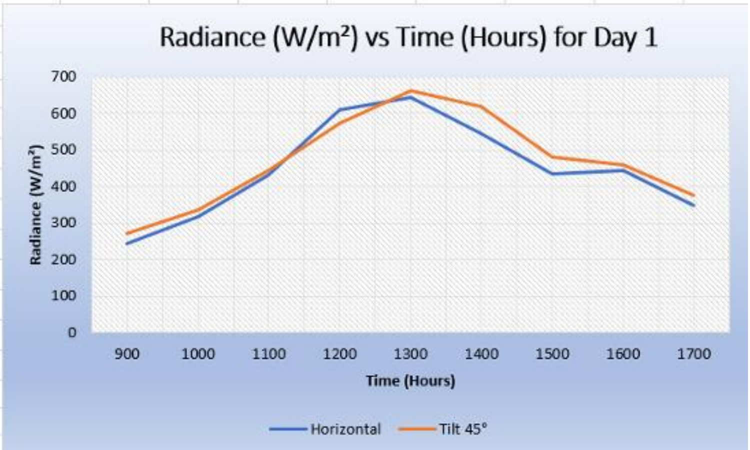


Figure 6.5: Graph of Radiance against Time.

Based on the data collected during the test, the best panel orientation to be used for this project is the 45º tilt axis where the maximum potential performance. This angle allows the solar panel to face the sun more directly for a longer period during the day which results in maximum irradiance absorption. Therefore, to ensure optimal energy collection, it is essential to 52 consider the best testing time, favorable weather conditions, minimal shading, and the most effective panel angle during installation and operation.

6.3.2 INCUBATOR SYSTEM OPERATION USING BLYNK APPS

The integration of the Blynk app with the incubator system enables smart, real-time monitoring and control. By using the ESP8266 Wi-Fi module, the system connects to the internet, allowing temperature and humidity data from DHT22 sensors to be sent to the Blynk cloud. Farmers can remotely monitor these parameters via the Blynk app or web dashboard and receive alerts if conditions deviate from the ideal range. This setup offers a convenient and efficient IoT-based solution for reliable incubator management as shown in Figure 6.6.

The ESP8266 connects to Wi-Fi and sends sensor data, such as temperature and humidity from the DHT22, to the Blynk Cloud using virtual pins. This data is displayed in real time on the Blynk app or web dashboard, enabling remote monitoring. With a continuous connection to the Blynk server, the ESP8266 ensures efficient and reliable IoT-based system performance.

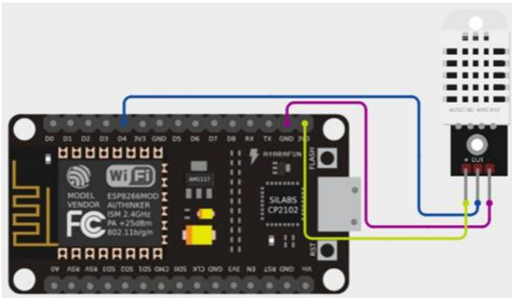


Figure 6.6: Connection for Alert System.

On the Blynk mobile app or web dashboard, farmers can view real-time data through various widgets such as gauges, labels, or graphs as shown in Figure 6.7. The interface can also include a notification system that alerts users immediately when the temperature or humidity levels go beyond a defined safe range. This is achieved using the Blynk function, which triggers an event that sends a push notification to the user’s phone. For example, once the temperature rises above 38.5°C, the system will alert the user about the anomaly and send the notifications through email and the Blynk apps as shown in Figure 6.8.

These notification alerts are important in an incubator monitoring system because they provide immediate awareness of any abnormal conditions that could affect the success of the incubation process. Since the parameters like temperature and humidity must remain within a specific range to ensure optimal conditions for egg development. These alerts act as a preventive measure, reducing the risk of unnoticed failures and ensuring the system remains reliable.

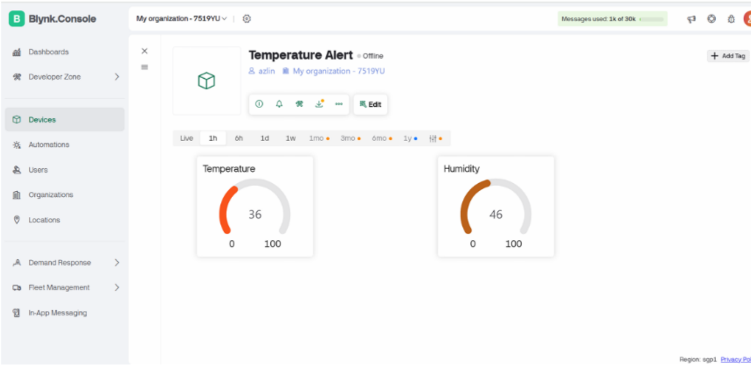


Figure 6.7: Web Dashboard of the Blynk.

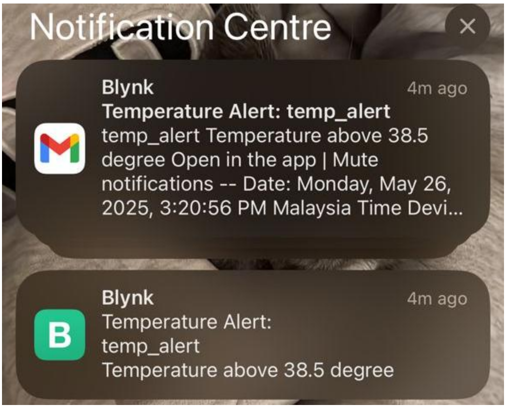
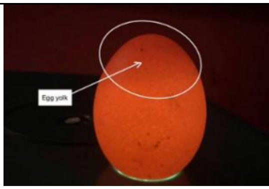
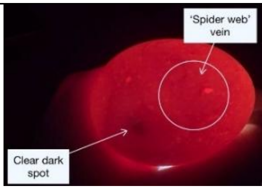
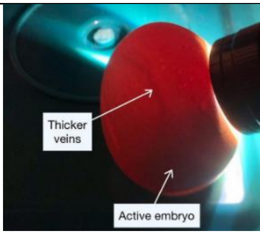
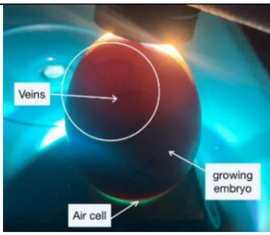
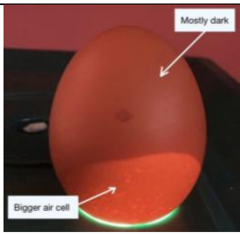


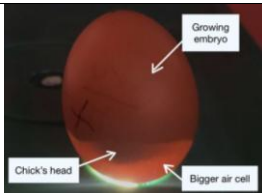
Figure 6.8: Alert Notification Received.

6.3.3 CHICKEN EGG DEVELOPMENT

One of the most fascinating processes in nature is how a simple egg turns into a living, breathing chick in just 21 days as tabulated in Table 6.1. It's hard to fully understand how a chick develops without studying how animals grow before they are born. Therefore, in this part it will show how does the egg develop from the egg yolk into a single chick through candling.

Table 6.1: Egg development progress during candling.

Days	Egg Development	Candling Signs
1 - 3		No growth, the embryo is not yet active.
4 - 7		Tiny dark spot on the yolk appears, spider web' of veins slightly visible.
8 - 10		Veins are more visible, active movement can be seen during candling.
11 - 14		A larger dark mass is visible, veins spread further, the air cell remains at the top.
15 - 17		Veins start to fade, the air cell become larger, the egg appears mostly dark.

18		Chick's shadow can be seen, also there is movement near the air cell.
19-20		The eggshell finally cracked, there is a chirping sound.
21		The chick is fully hatch!

The results of the project indicate that the temperature and humidity monitoring system successfully maintained the required environmental conditions for egg incubation. The internal temperature was kept constant within the ideal range 56 upon the integration of automated fan control. Consequently, the system facilitated a successful hatching process, proving its dependability and effectiveness.

6.4 CONCLUSION

In conclusion, this project successfully developed a semi-automated egg incubator system with a solar-powered IoT-based monitoring setup. It is aimed to improve egg hatching efficiency and promoting sustainability for small-scale farmers in remote areas. The system automates temperature and humidity control while using AC power for heating and egg turning. Moreover, solar energy powers the monitoring system, reducing electricity costs and grid dependency. Through integration with the Blynk platform, farmers can remotely monitor conditions and receive real-time alerts, allowing quick response to any changes. This not only improves hatch rates but also supports smart farming practices. Overall, the project meets its objectives by offering a practical, efficient, and environmentally friendly solution for rural poultry farming.

BIBLIOGRAPHY

[1] Kumar P. V. & Obulesu Y. P. (2021, November 29). Solar Incubator for Hatching of Eggs using Different Controllers: A Critical Review. Retrieved from https://ieeexplore.ieee.org/document/9696724

[2] Che Amran A. et al. (2019, August 8). Analysis of Light Bulb Temperature Control Egg Incubator Design. Retrieved from https://publisher.uthm.edu.my/ojs/index.php/ijie/article/view/4715

[3] Peprah F. et al. (2021, November 7). Design and construction of smart solar powered incubator based on GSM/IoT. https://www.sciencedirect.com/science/article/pii/S2468227622002332?via%3Dihu

[4] Tsamaase K. et al. (2020, January 2). Construction and Operation of Solar Powered Egg Incubator. Retrieved from https://www.researchgate.net/publication/342116265

[5] Abdullah A. H. & Hamdan R. (2023, July 6). Smart Monitoring Temperature and Humidity Based on the Incubator System using IoT. Retrieved from https://publisher.uthm.edu.my/periodicals/index.php/eeee/article/view/12574/4134.