Research Article

Hybrid Electrical Interchange System in IoT-Based Egg-Hatching Equipment

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Abstract: Manual egg hatching still requires time and human labor every day to regulate temperature, adjust humidity, and turn the eggs. This egg hatcher works using solar panels as an alternative energy source. This study aims to design and determine the results of the effectiveness of testing the hybrid electrical interchange system on IoT-based egg hatchers. The research method used is the R&D method. Based on the results of the research, switching energy sources is declared valid because the tools and applications are integrated. The average voltage difference in the battery in charging condition by turning on the tool is -0.01 Volts, proving that even though it is in charging condition when the tool is turned on, the voltage in the battery will still decrease. The measurement results of the average daily energy demand on the hatchery by applying a hybrid electrical interchange system is 0.142 kWh and without applying the system 0.163 kWh, proving by applying a hybrid electrical interchange system device more efficient use of PLN electricity due to assistance from PLTS. On-off automation of lights and fans can keep the temperature at an ideal state of 37°C-39°C, thus affecting the egg-hatching process. On-off automation using a relay connected to a mist maker also affects keeping humidity at 55%-65% humidity, humidity also affects the egg-hatching process, where the success rate in hatching eggs is maximized. Based on the results of tests carried out by the hybrid electrical interchange system on IoT-based egg hatchers, it can be concluded that this tool can maintain the stability of temperature and humidity automatically in egg hatchers well until the eggs hatch.

Keywords: hybrid system; solar panel; egg hatcher; Internet of Things; temperature

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1. Introduction

The increasing growth and development of the population in Indonesia are directly proportional to the consumption of public will material food, in particular, meat poultry, and eggs are rich in source of protein. His height needs public the to create a breeding process that becomes essential. Reality the not balanced with an optimal breeding process because of Lots of causal factors egg does not hatch. The hatching process is influenced by internal and external factors. Internal factors that influence that is the level of budding power (fertility) of eggs, meanwhile external factors are management arrangement temperature and humidity. The second factor is matter essential that holds a role important in hatching egg poultry [1].

The problem can be overcome by doing the nursery in a way independent of the group cattle. Nursery This can done with the method make a tool hatcher functioning egg to replace parent poultry in brooding egg. The time it should be used for parent poultry to incubate the egg can redirected for ready-lay eggs return. The hatching tool egg is something shaped like a tool room that is heated and used for incubating and the hatching egg is equipped with a heating egg that is lights and temperature sensors so that the temperature of the device hatcher egg can stabilized following provision optimal temperature required. Incubate egg requires temperature room hatch during incubation egg chicken (18 days first) is set around 37°- 38°C, while during the hatching period (approx day to 19-21) temperature can raised A little to 39°C or still left at 38°C. Moreover,

Humidity relatively moment period incubation maintained at 50%-55% and period hatching or day to 19-21 humidity the air rises slightly and ranges from 60%-65%[4].

Hatching tool egg moment This Still uses PLN as a source of energy electricity main. Using PLN as a source of energy will cost high operational, The draft tool Hatcher the Egg will make use of system hybrid energy so capable minimize the use of PLN electricity. A hybrid system is combined from two different supply systems. Making tool hatcher egg These two intermediate supply sources use PLN electricity with source solar panel electricity supplied from power Sun. Hybrid technology is also capable overcome problems PLN electricity goes out.

PLTS system consists of several components namely solar panels are capable tool changing rays sun become energy electricity, and the Solar Charge Controller (SCC) is a tool modifier solar panel output For reach level tension battery and regulate the charging process battery, battery works as storage energy electricity generated by solar panels and used when solar panels No sufficient For supply energy to load, and an inverter is a tool that changes Power current unidirectional (DC) becomes current back and forth come back or (AC)[2]. Hatching tool egg automatic moment This is already lots made like machine hatcher-based Microcontroller. Hatching tool eggs already There is Now Still less than optimal because still needs attention its users to turn on and off the tool or in other words needs controlling around the hatching area.

Online monitoring systems in real-time [7-14], [19-25] are considered capable become a solution so monitoring hatching eggs can be more efficient. Monitoring systems using the Internet of Things [15-18] normally called IoT enabled for read condition latest in the incubator hatcher Eggs make it easy to breed, therefore, no need to observe in a way directly. Using the IoT concept for temperature and lighting monitoring systems will more easier and not need to monitor direct incubator hatcher eggs, monitoring can be done through the application, so help farmers in monitoring room incubator hammering the gadget without having to monitor direct to pen. The study was previously carried out in 2020, using the DHT11 sensor as the main sensor, RTC DS3231 as the time counter dripping eggs and time it spins eggs, with the controller main being the microcontroller Arduino Uno. Testing machine hatcher egg automatic This uses testing 17 items of the egg for hatched chickens, setting the temperature at 37-38°C with humidity namely 55-60%. In testing, These 3 eggs failed because no one owns an embryo, meaning an egg the no can hatched by a machine hatch whatever the parent wants. The remaining 1 egg per day to 20 seconds shell egg Already started hatch (hollow), ants - ants small enter the hole small and bite the child chicken which results in it child chicken the death. Means level success machine hatcher egg This almost reaches 100 percent, ie about 98% outside of the 3 eggs that don't own embryo mentioned [6].

A study previously in 2021 related incubator hatcher egg was researched android-based that the implementation of an incubator monitoring system hatcher egg is something system microcontroller that can controlled by a smartphone via communication Internet Network. On the other hand, activation of ESP8266 control with Wi-Fi assistance requires the supply of electricity to power its activation, without Power all system controls experience paralysis [3]. Developments in 2021 regarding "Temperature monitoring and screening systems egg in a way automatically in the incubator hatcher egg duck website -based" however study This only use the web for monitor control tool hatcher egg Where web usage has a weakness that is easily hacked and usually experiencing a bug [5].

Based on the description, then study regarding System In-Change Hybrid Electricity in Hatching Tools Egg IoT- based that can overcome problems that occur. This hybrid system utilizes solar panels and the ray sun as a source of energy mainly utilizing Indonesia's location on the equator as a tropical country which makes this sufficient sunlight big so that use of solar panels This own potency big For sustain Power electricity. Besides that study This applies IoT technology with the objective makes it easier user For can control and monitor the tool hatcher egg through integrated applications with system devices, so can monitor the circumstances hatcher egg Where have you been? Studying this is expected can become a solution to minimizing the use of energy PLN electricity and become a step in beginning public can exercise the use of source energy and minimize the impact bad use of energy electricity that is not renewable in a way excessive. Study

This uses the DHT22 sensor to measure temperature and humidity and uses module Wifi ESP32 as well as the microcontroller will arrange Work from system control. Researchers use DHT22 because own the excess like, more range wider than DHT11 for reading humidity 0-100 with an accuracy more accurate 2-5% as well as reading temperature -40 to 80°C with accuracy ± 0.5°C[3]. Draft Work design system This that is can control the temperature, humidity, and time reversal egg following what was designed in a way automatically, then can monitor the temperature and humidity in the room hatching the egg in real-time from a distance Far via Android with the use Internet Network.

2. Theory

2.1 Hybrid System

Hybrid systems use two systems or more generators of electricity with source different energies (Firman & Irfansyah, 2022). The hybrid system has Lots of applications in the world of technology as in the fields of fishing, animal husbandry, agriculture, etc.

2.2 Internet of Things

Internet of Things is a concept where an object or object implanted technologies such as sensors and software to communicate, control, connect, and exchange data through other devices while Still connected to the internet (Nurdiansyah et al., 2020).

2.3 Solar Panels

Solar panels are tools used to get energy-sourced alternatives from the light sun. The energy produced from solar panels is influenced by several factors, one of them being factor rays coming sun or UV (Ultra Violet) light. Ray sun on each the hour resulting changes Because exists rotation the earth rotates on its axis or normally called rotation earth. cells Sun generally arranged in a pattern like grids on the surface of solar panels.

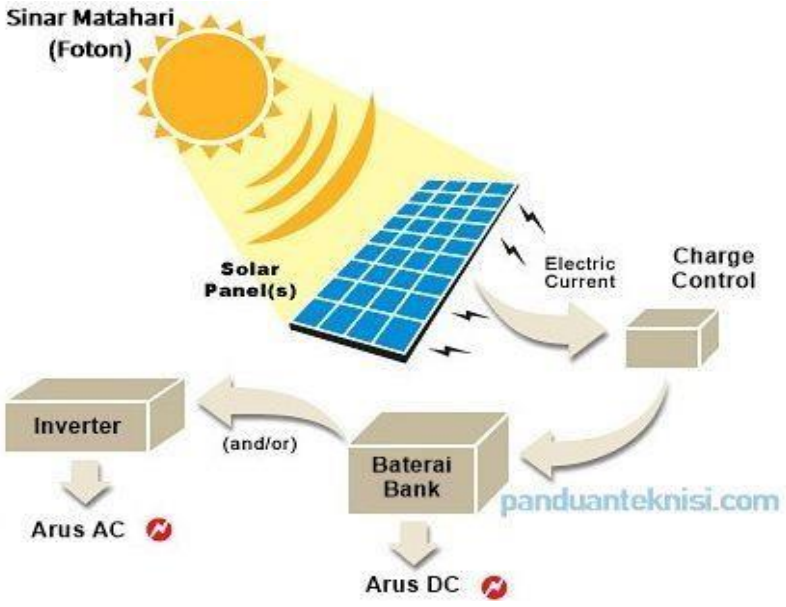


Figure 1. How Solar Panels Work (*Source:* panduanteknisi.com)

2.4 System Monitoring

Monitoring is something encompassing cycle activity data collection, review repeats on something plan activities, activities reporting suitability plan with implementation as well as give action on information provided moment something project currently implemented. This monitoring used for inspection is a moderate performance done following specified targets.

3.Method

3.1 Types of research

Type of research used in research This is development and Research or Research and Development. Research and development or Research and Development (or R&D) is a series of processes or steps to develop something product new or perfect products that have been there so you can ensure an answer. Procedure research in development tool This uses ADDIE stages. ADDIE is an abbreviation of the five stages that must be done in research, namely the analysis stage, design stage, development stage, implementation stage, and evaluation stage.

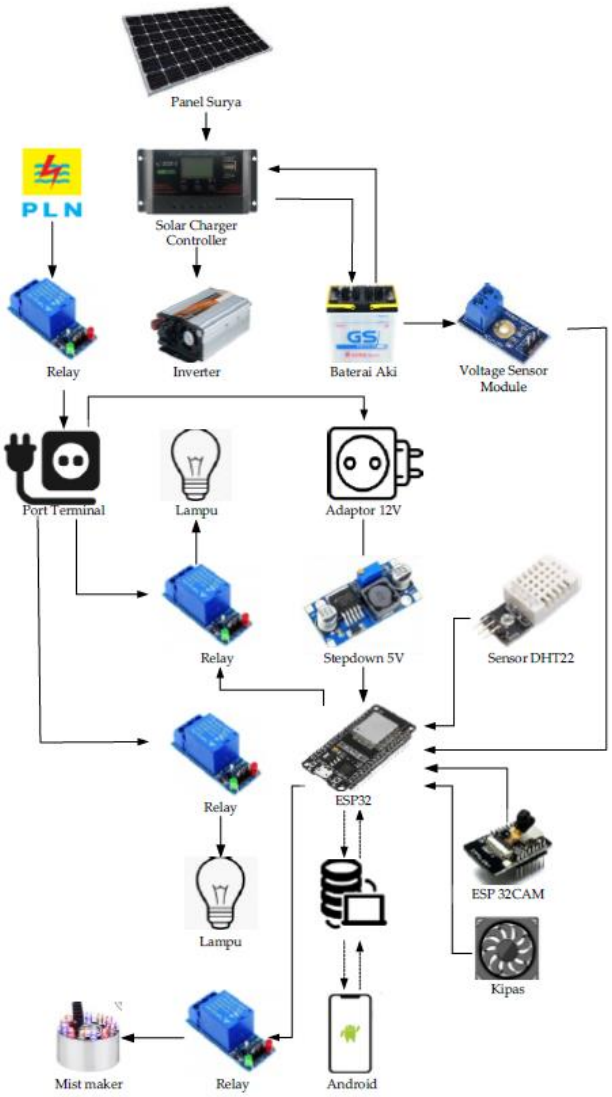


Figure 2. Architecture Hybrid Electrical Interchange System

Moreover, Figure 2 explains that light The sun captured by the Solar Cell Panel is transmitted to the next Charger Control functional to flow incoming DC to the battery or go out to Prevent overcharging and excess voltage from solar panels. Electricity stored in the battery continued to the inverter for change from DC to AC. The Voltage Sensor Module connected to the battery works to monitor energy electricity stored in the battery battery. The inverter connected with relays controlled by the ESP32 microcontroller at once connected with PLN electricity and Port Terminal. This relay works for disconnecting and connecting source electricity from PLN or Battery. The terminal port is a functional channel of electricity for activating lamp 1, lamp 2, and the Control Board adapter.

The Control Board consists of Relay 1 and Relay 2 which are connected with a working ESP32 For turning off and on the light. DHT 22 sensor is used to read temperature and humidity in the incubator while ESP32 CAM is used to catch pictures from inside the incubator. Mist maker works to produce dew/vapor to stabilize indoor humidity. All data will be sent through the internet network to the Firebase server and displayed return in a way real-time on the system controller and monitor Android. Firebase is selected because it not only provides facility data storage but also provides an API for implementing web sockets.

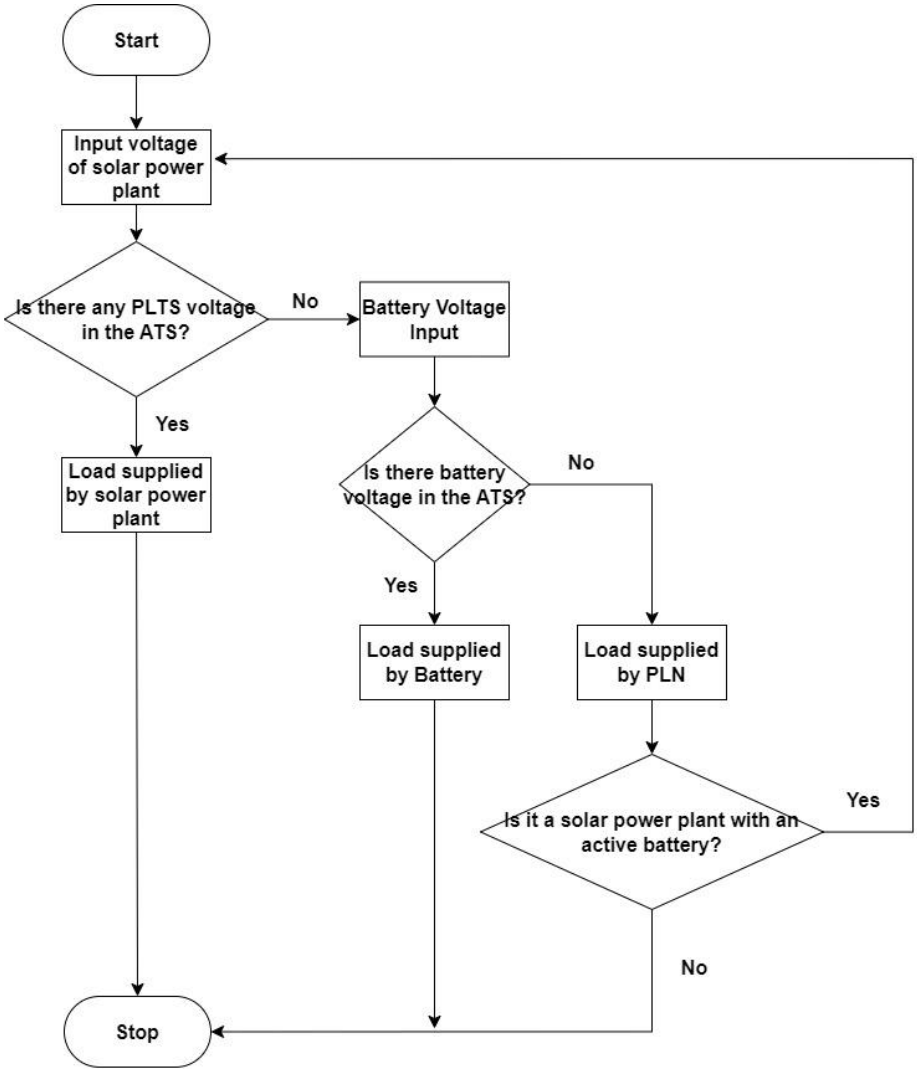


Figure 3. Automatic Transfer Switch Flowchart

Moreover, figure 3 explains that the control and monitoring system for the Automatic Transfer Switch PLTS and PLN aims to move the supply of electricity from the supplied Power main namely PLTS to the supply Power reserve namely PLN. Source Power main namely PLTS will change energy hot become energy electricity. Solar Cells will connected to the Solar Charger Controller used to arrange current in the direction filled to the battery and taken from the battery to burden. Solar Charge Controller regulates overcharging charging Because the battery is already full) and excess voltage from solar panels. Excess voltage and charging will reduce the age battery. Solar Charge Controller sets Pulse Width Modulation (PWM) technology for arranging function charging the battery and releasing current from battery to burden.

3.2 Research Design

Figure 4. Incubator and solar cell circuit

Figure 5. Solar Cell Circuits and Circuits System

Figure 4 is the system installation process Incubator and solar cell circuit, and Figure 5 shows a picture of a series of Hybrid Electrical Interchange Systems on Hatch Equipment Egg IoT-based can is known as cable red (+) and cable black (-) of the Solar Cell Panel is connected with ports 1 (+) and 2 (-) on the Solar Charge Controller (SCC). Ports 3 (+) and 4 (-) SCC are connected with (+) and (-) battery ports. Ports 5 (+) and 6 (-) SCC are connected with (+) and (-) inverter input ports. The output ports (+) and (-) of the inverter are connected with a relay in the circuit systems and networks system connected with lights, fans, and mist makers.

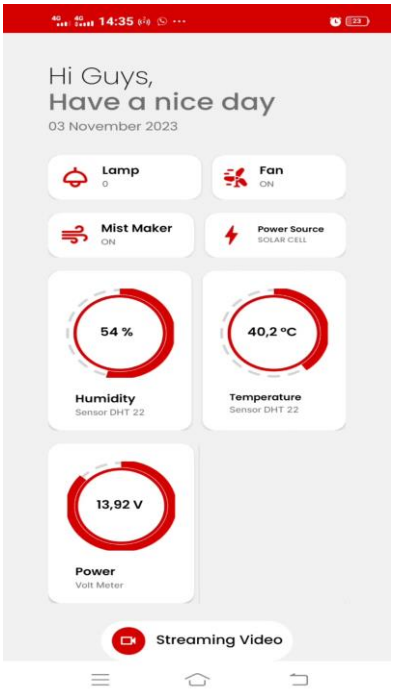
4. Result and Discussion

From the results of testing the Hybrid Electrical Interchange System in Hatch Equipment, Egg IoT-based can Work following what was expected. Based on the results of data testing the voltage sensor module can read the voltage on the battery and sends voltage data with good, therefore, display on the application. Usage average electricity in the tool hatcher with implementing this system is 0.142 volts. Meanwhile, the average usage of electricity daily without implementing the system is 0.163 volts. Accuracy DHT22 temperature and humidity sensor readings with comparison data that is Thermohygrometer stated to be accurate because difference the difference is very minimal. Conditioning the lights, mist maker, and fan Already following provisions applied to the system, testing This is done on time dawn, morning, afternoon, evening, and night. Data results for conditioning the lights, mist maker, and fan are already following provisions that have been applied to the system, where If results DHT22 sensor reading temperature is≥ 38°C then the fan will be on, and if the results reading humidity is ≤50% then the mist maker will light up. As for the number of lights on the device hatcher adapts temperature in the hatcher. Testing final namely esp32cam, where esp32cam can connect with good and can send streaming video to the application.

4.1 Source Switching Energy

Test source switching energy electricity This aims to know whether automatic source switching energy electricity can Work with Good or Not. This system works based on voltage data on the battery from the results voltage sensor module reading.

Table 1. Source Switching Energy

Condition battery on the app	Voltage	Source energy	Information
	13.92	Solar cells	Valid

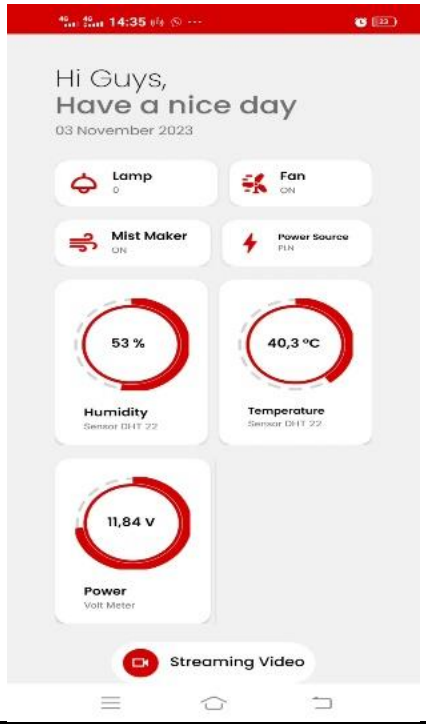
Condition battery on the app	Voltage	Source energy	Information
	11.84	PLN	Valid

Table 1 shows when the system reads the voltage on the battery is 13.92 volts then the source energy The electricity used by the system is solar cells, meanwhile when the voltage on the battery battery down to 11.84 volts or below 13.1 volts then the source energy electricity used switch to PLN. So that can concluded that feature hybrid electrical interchange system switching automation can Work with good (valid).

4.2 Measurement of Average Daily Energy Requirements in Hatchers

Table 2. Daily Requirements in Hatching Tools with Apply System

No.	Time Start (O'clock)	Energy (kWh)	End Time (Hours)	Energy End (kWh)	Difference (kWh)
1	09.00	0.001	12.00	0.103	0.102
2	12.00	0.103	15.00	0.183	0.080
3	15.00	0.183	18.00	0.243	0.060
4	18.00	0.243	21.00	0.397	0.154
5	21.00	0.397	00.00	0.581	0.184
6	00.00	0.581	03.00	0.765	0.184
7	03.00	0.765	06.00	0.956	0.191
8	06.00	0.956	09.00	1,142	0.186
		Flat – flat need energy per three hours			0.142

Table 3. Daily Energy Requirements in Hatching Tools without Apply System

No.	Time Start (O'clock)	Energy (kWh)	End Time (Hours)	Final Energy (kWh)	Difference (kWh)
1	09.30	0,000	12.30	0.212	0.212
2	12.30	0.212	15.30	0.344	0.132
3	15.30	0.344	18.30	0.478	0.134
4	18.30	0.478	21.30	0.599	0.121
5	21.30	0.599	00.30	0.681	0.082
6	00.30	0.681	03.30	0.930	0.249
7	03.30	0.930	06.30	1,193	0.263
8	06.30	1,193	09.30	1,305	0.112
		Flat – flat need energy per three hours			0.163

Based on the data in Tables 2 and 3 it can be known that the average difference in use of electricity with the apply system is 0.142 kWh, whereas without an apply system is 0.163 kWh. Need electricity daily for turn on tool hatcher with apply more hybrid electrical interchange system devices economical use PLN electricity due to help from PLTS.

4.3 Measuring the Accuracy of DHT22 Sensor Temperature and Humidity Reading Results

Table 4. Measurements Accuracy of Reading Results Dawn Temperature

No.	Time	Sensor DataTemperature	Data Thermohygrometer	Difference
1	03.00	37.8	37.8	0
2	03.05	37.7	37.6	0.1
3	03.10	37.5	37.6	0.1
4	03.15	37.5	37.6	0.1
5	03.20	37.5	37.6	0.1
6	03.25	38.0	37.1	0.9
7	03.30	36.2	35.9	0.3
8	03.35	36.7	36.7	0
9	03.40	37.0	37.0	0
10	03.45	37.1	37.0	0.1

No.	Time	Sensor DataTemperature	Data Thermohygrometer	Difference
11	03.50	37.1	37.0	0.1
12	03.55	37.1	37.0	0.1
13	04.00	37.1	36.9	0.2
14	04.05	37.1	36.9	0.2
15	04.10	37.1	36.9	0.2
16	04.15	37.1	36.8	0.3
17	04.20	37.1	36.6	0.5
18	04.25	37.1	36.6	0.5
19	04.30	37.0	36.6	0.4
20	04.35	37.0	36.5	0.5
21	04.40	37.0	36.5	0.5
22	04.45	37.0	36.5	0.5
23	04.50	37.0	36.5	0.5
24	04.55	36.9	36.5	0.4
25	05.00	36.9	36.4	0.5
		Average error		0.2

Table 5. Measurements Accuracy of Reading Results Dawn Humidity

No.	Time	Sensor datahumidity	Data thermohygrometer	Difference
1	03.00	61%	65%	4%
2	03.05	61%	65%	4%
3	03.10	60%	64%	4%
4	03.15	60%	64%	4%

No.	Time	Sensor datahumidity	Data thermohygrometer	Difference
5	03.20	60%	64%	4%
6	03.25	57%	63%	6%
7	03.30	60%	64%	4%
8	03.35	61%	64%	3%
9	03.40	62%	64%	2%
10	03.45	62%	64%	2%
11	03.50	62%	64%	2%
12	03.55	62%	64%	2%
13	04.00	62%	64%	2%
14	04.05	61%	63%	2%
15	04.10	61%	63%	2%
16	04.15	61%	62%	1%
17	04.20	61%	62%	1%
18	04.25	61%	62%	1%
19	04.30	60%	63%	3%
20	04.35	60%	64%	4%
21	04.40	60%	64%	4%
22	04.45	60%	64%	4%
23	04.50	60%	64%	4%
24	04.55	60%	64%	4%
25	05.00	60%	65%	5%
		Average error		**3%**

4.4 Average Difference Temperature

Moreover, Figure 6 shows data comparing the average temperature difference from morning to evening. Measurements taken at dawn had an average difference of 0.2. Measurements taken in the morning have an average difference of 0.5. Measurements taken during the day have an average difference of 0.4. Measurements taken in the afternoon averaged a difference of 1.2. Measurements taken at night have an average difference of 0.5. So it can be concluded that the difference is very low which proves that the accuracy of the DHT22 sensor temperature reading at any time is declared accurate because it can adjust to the environmental temperature.

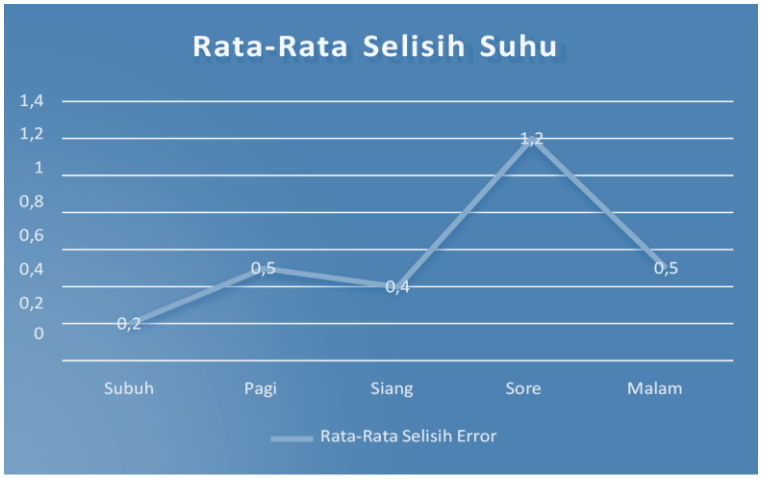


Figure 6. Average Difference Graphs Temperature

4.5 Average Difference Humidity

Furthermore, Figure 7 shows data comparing the average differences in temperature at time dawn until Evening. Measurements are made in time dawn average difference 3. Measurements made at time morning average difference 4. Measurements made at a time during the day, the average difference is 1. Measurements made in the afternoon have an average difference of 3. Measurements made during the day and night the average difference is 2. So can concluded that the very low difference proves its accuracy reading DHT22 humidity sensor each time stated to be accurate because can adapt to temperature and humidity environment.

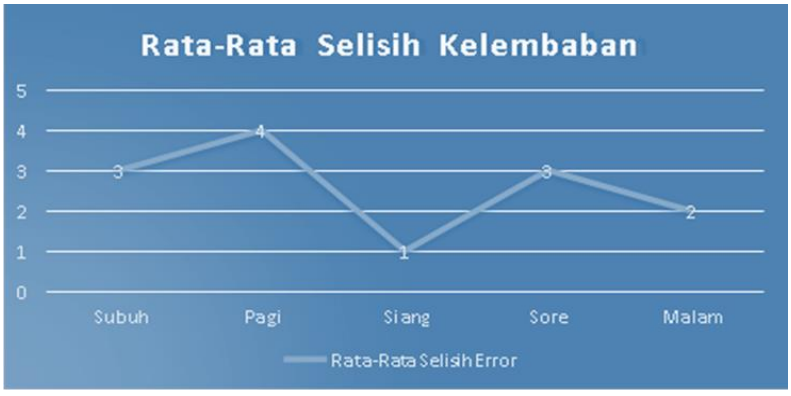


Figure 7. Average Difference Graphs Humidity

4.6 ESP32 CAM Testing

Table 6. ESP32 CAM Accuracy testing

No.	Day	Condition Camera	Condition Egg	Information
1	1st	Can be accessed	Seen	Not yet hatch
2	2nd	Can be accessed	Seen	Not yet hatch
3	3rd	Can be accessed	Seen	Not yet hatch
4	4th	Can be accessed	Seen	Not yet hatch
5	5th	Can be accessed	Seen	Not yet hatch
6	6th	Can be accessed	Seen	Not yet hatch
7	7th	Can be accessed	Seen	Not yet hatch
8	8th	Can be accessed	Seen	Not yet hatch
9	9th	Can be accessed	Seen	Not yet hatch
10	10th	Can be accessed	Seen	Not yet hatch
11	11th	Can be accessed	Seen	Not hatched yet
12	12th	Can be accessed	Seen	Not hatched yet
13	13th	Can be accessed	Seen	Not hatched yet
14	14th	Can be accessed	Seen	Not hatched yet
15	15th	Can be accessed	Seen	Not hatched yet
16	16th	Can be accessed	Seen	Not hatched yet
17	17th	Can be accessed	Seen	Not hatched yet
18	18th	Can be accessed	Seen	Not hatched yet
19	19th	Can be accessed	Seen	Not hatched yet
20	20th	Can be accessed	Seen	Starting to crack
21	21st	Can be accessed	Seen	Hatch 5

No.	Day	Condition Camera	Condition Egg	Information
22	22nd	Can be accessed	Seen	Hatch 6
23	23rd	Can be accessed	Seen	Hatch 4

4.7 Flame Conditioning of Lamps, Fans, and Mist Makers Based on Temperature and Humidity in the Incubator

Table 7. Conditioning the lights, fans, and mist makers

No.	Temperature	Amount light light up	Fan (on/off)	Humidity	Mist Maker (on/off)	Information
1	36.9	2	Off	59%	Off	In accordance
2	37.0	2	Off	59%	Off	In accordance
3	37.1	2	Off	59%	Off	In accordance
4	37.2	2	Off	58%	Off	In accordance
5	37.3	2	Off	58%	Off	In accordance
6	37.5	2	Off	58%	Off	In accordance
7	37.6	2	Off	58%	Off	In accordance
8	37.7	2	Off	58%	Off	In accordance
9	37.9	2	Off	58%	Off	In accordance
10	38.0	2	On	58%	Off	In accordance
11	38.0	2	On	58%	Off	In accordance
12	38.0	2	On	57%	Off	In accordance
13	38.0	2	On	57%	Off	In accordance
14	37.8	2	Off	57%	Off	In accordance
15	38.0	2	On	57%	Off	In accordance
16	38.0	2	On	57%	Off	In accordance
17	38.0	2	On	57%	Off	In accordance
18	38.0	2	On	56%	Off	In accordance
19	37.9	2	Off	55%	Off	In accordance

No.	Temperature	Amount light light up	Fan (on/off)	Humidity	Mist Maker (on/off)	Information
20	38.0	2	On	56%	Off	In accordance
21	37.6	2	Off	58%	Off	In accordance
22	37.9	2	Off	57%	Off	In accordance
23	38.0	2	On	57%	Off	In accordance
24	37.9	2	Off	56%	Off	In accordance
25	38.0	2	On	56%	Off	In accordance

Table 3 shows the condition temperature and humidity in the tool hatching is carried out for 2 hours every 5 minutes Already following temperature and humidity that have been specified in the system namely 37-39C and humidity 55-60%. Appropriate temperature and humidity generated from conditioning the running lights, fans, and mist makers with Good following those who have determined. Amount lights on will adapt need for the tools hatcher following the reading temperature on the DHT22 sensor, The data above show only 2 lights are used. On the ESP32 microcontroller, it has implanted program logic ie temperature detected above 37.9°C then the fan is on/ lighting to stabilize the return temperature in the hatch, and when the temperature Already below 38°C, the fan will be off/ dead. If humidity is detected below 55% then the mist maker will turn on and if humidity is above 54% then the mist maker will turn off.

5. Conclusions

Based on the design hybrid electrical interchange system on the tool hatcher IoT-based egg. This tool is designed to make it easier to monitor temperature and humidity in hatching eggs. This tool is designed to Work based on several principles main. First, solar panels are used as sources derived hybrid energy from the ray sun. Solar panels are exposed the sun will convert energy and electricity will used to operate the tool. Second, this system Works with esp32 in use as a center processing data from sensors. Third, the ESP32 cam works to retrieve image data.

Based on the results tests carried out indicate source switching energy declared valid because tools and data shown on the application are Already following the existing system applied to the tool. The average difference test results voltage on the battery when the battery is in charging condition turned on the tool is -0.01 Volt, so can concluded that even when the charging tool is turned on so voltage on the battery battery will still reduce. The average requirements daily energy in the device hatcher by applying a hybrid electrical interchange system is 0.142 kWh and without applying a 0.163 kWh system, so can concluded that applying device more hybrid electrical interchange systems economical use PLN electricity due to help from PLTS.

Effectiveness testing shows a level of success Because the system Already succeeds adapt temperature and humidity in the incubator following optimal conditions that have been applied to automation systems. Automation of turning on and off lights and fans can guard temperature remains at ideal conditions, namely 37°C-39°C which influences the hatching process egg. On-off automation using connected relays with a mist maker also affects guard humidity still is at a humidity of 55%-65%, so level success in hatching egg more maximum and system hybrid PLTS running as desired that is as source energy The main thing is the tool hatcher egg and run system with Good.

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Author contributions: All authors are responsible for building Conceptualization, Methodology, analysis, investigation, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision of project administration, funding acquisition, and have read and agreed to the published version of the manuscript.

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