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Smart Cultivation System: Innovation Concept for Designing a Modern and Automatic Shrimp Farming Technology System Powered by Renewable Energy

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ABSTRAK

The research presents a comprehensive exploration of energy calculations and pond design for smart cultivation systems, with a focus on shrimp ponds. Through interviews and analysis, the energy consumption of various components such as lights, waterwheels, and pumps was determined, leading to the calculation of total power consumption and the specification of necessary equipment like inverters, batteries, and solar panels. Furthermore, the study proposes the integration of renewable energy sources, such as solar and wind power, into the pond system, enhancing sustainability and reducing environmental impact. The incorporation of IoT technology facilitates real-time energy monitoring and optimization. Additionally, innovative solutions like water filtration systems and solar-powered automatic feeders are introduced to improve water quality and feeding efficiency, respectively. The application of microcontroller-based solar street lighting enhances energy efficiency and maintenance ease. A SWOT analysis underscores the strengths, weaknesses, opportunities, and threats of the proposed smart cultivation system, emphasizing its potential for energy efficiency, environmental friendliness, and long-term cost savings despite challenges such as weather dependence and technological limitations. Overall, the research underscores the feasibility and benefits of integrating renewable energy and modern technology in shrimp pond management for sustainable and efficient aquaculture practices.

Keywords:

Automatic, Pond, Renewable Energy, Shrimp Farming, Smart Cultivation System

INTRODUCTION

Indonesia has had one of the breakthroughs through the Ministry of Maritime Affairs and Fisheries (KKP) with the development of export-based aquaculture with shrimp as one of the leading commodities (Nugroho et al., 2022). In 2014, total production from the world aquaculture sector reached 167.2 million tons, which was 64.15% of the total production in the fisheries sector which reached 260.6 million tons (Halimatussadiah et al., 2020; Sambodo et al., 2021). Shrimp cultivation is a commodity resulting from aquaculture businesses in ponds that needs to be improved both in quality and quantity. One of the main problems in shrimp farming is the environmental conditions of the pond which must be in accordance with the needs of the shrimp which requires good water quality management (Handarly & Lianda, 2018). However, the shrimp farming industry often experiences crop failures, most of which occur as a result of unequal distribution of electricity.

Equal distribution of electrical energy in Indonesia is still progressing gradually, as we know that coastal areas in Indonesia, especially the frontier, remote and underdeveloped (3T) areas, still have limited access to electricity for the range of power used, and there are even villages that have not been reached by PLN electricity. Indonesia's delay in building electricity infrastructure means that the availability of electricity in this country is insufficient to meet its level of needs (Mappa et al., 2022). As a result, electricity has not really played an optimal role as a driver of economic development. This causes uneven distribution and supply of electricity, resulting in unmet demand for electricity (Derman et al., 2019).

Responding to the problem of access to electricity and the potential for new renewable energy which is quite high in Indonesia and maximizing the utilization of ponds which are equipped with quite complex automation systems, the author has an idea, namely "Smart Cultivation System: Conceptual Innovation for Designing a Modern and Automatic Energy-Powered Pond Technology System Renewables as a solution to improve the quality of commodities produced by aquaculture businesses in ponds that have an energy independent and environmentally friendly concept. The sensor system and several Internet of Things (IoT) components make it possible to maximize pond water quality, for the system used in automatic feeding, namely by creating an electronic circuit with an automatic opening and closing system according to the time specified for feeding. The application of renewable energy itself uses an off-grid solar panel system and wind turbines that are suitable for coastal areas. Solar radiation obtained from accessing the official website of the United States Space Agency gets an average annual solar radiation of around 4.6 kWh/m. Meanwhile, the wind speed data itself has a yearly average of 4.42 m/s (Harmini & Nurhayati, 2018).

METHOD

This research was carried out by reviewing various official ministry websites in Indonesia, articles and documents related to ideal pond development. Problem identification regarding the issues to be raised has been carried out through literature studies in scientific journals, papers, essays, proceedings, mass media and electronic media. This research was carried out using data support tools such as laptops, internet networks, microphones, transportation vehicles, drones, 60D Canon cameras + kit lenses, 250D Canon cameras, Zhuyun Tech Weebil S stabilizers, tripods, microphones. Apart from that, data was collected using a direct survey by interviewing a number of technicians and field workers at the Situboondo Millenial Pond. The next step is to calculate the average energy consumption based on the data obtained. The final step is to design the Smart Cultivation System design concept: Innovation Concept Design for a Modern and Automatic Pond Technology System Powered by Renewable Energy. Figure 1 shows a flowchart of the Smart Cultivation System research flow.

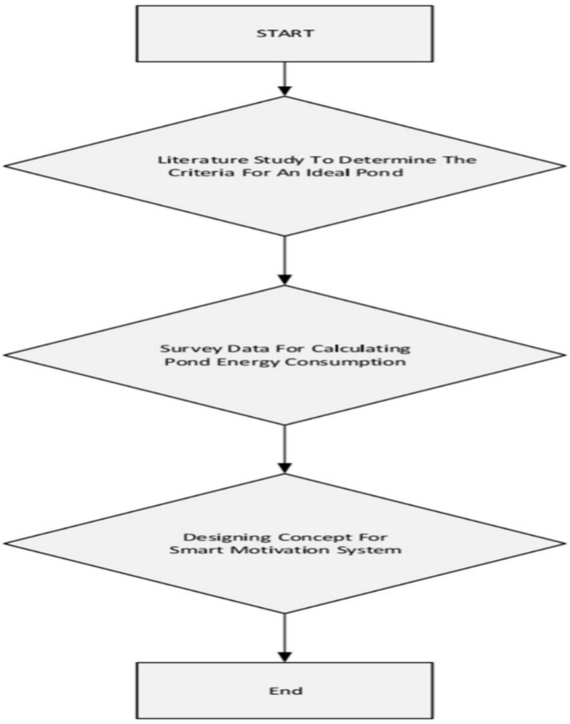

Figure 1. flowchart of smart cultivation system research flow

RESULTS AND DISCUSSION

In this research, there are several points that will be discussed, starting from calculating energy formulas and designing ideal ponds. In addition, there is a SWOT analysis of the ideal pond planning that has been designed. This will make it easier to assess the effectiveness of innovations that will be implemented in the future.

Energy Formula Calculation

Smart cultivation system pond energy calculations assume that there are several components that are the daily burden of the shrimp pond, such as: lights, waterwheels and water pumps. Determination of daily loads is based on the results of direct interviews with pond technicians and field workers. From the interview results, the results were obtained, namely the specific name plate for each component and the time to use the components per day. so the results were obtained in table 1. This table will function as a reference in determining components in shrimp pond.

Table 1. Daily load of shrimp ponds

Load Name	ower (W)	Quantity (Items)	Time (hours) Time (hours)	Energy Consumption (Wh)
Lights	20	10	12	2.400
Waterwheel	750	2	16	24.000
Water Pump	750	1	1	750
Total Number	1.520	13	29	27.150

Total power = 1520 W
Total Energy Consumption = 27150 Wh
Estimated Loss = 15%
Total Overall Energy = 27150 + (Total Energy Consumption x Losses)
= 27150 + (27150 x 15%)
= 31.222,5 Wh

1. Inverter Capacity
   Total Power = 27150
   Inverter Power = Total Power + (Total Power x Power Tolerance)
   = 27150 + (27150 x 20%)
   = 32.580
2. Battery Capacity Calculation
   $C = \frac{N \, x \, Ed}{Vs \, x \, DOD \, x \, eFF}$
   $C = \frac{2 \, x \, 633{,}05}{12 \, x \, 0{,}8 \, x \, 0{,}9}$
   C = 1.465,98 Ah/Day
   Battery Energy = Battery Voltage x C
   = 12 x 1.465,98
   = 17.591,8 Wh
   Battery Specifications = 12 v 200 Ah = 2.400 Wh
   Battery Capacity $= \frac{\text{Battery Energy}}{\text{Battery Spec}}$
   Battery Capacity $= \frac{17.591{,}9}{2.400}$
   Battery Capacity = 7,33 = 8 battery units

3. Battery Charging Time Analysis (accu)
   The length of time for charging a battery can be calculated using the following formula.
   $h = \left(\frac{\text{Ah}}{\text{A}}\right)$
   $h = \left(\frac{100}{16}\right)$
   h = 6,25 hours= 7 hours 30 minutes
   So, the time required to fully charge the battery is 7 hours 30 minutes
4. Solar Panel Capacity Calculation
   Effective Radiation Time = 5 jam
   Solar Panel Power Requirement $= \frac{\text{Battery Energy}}{\text{Effective Time}}$

   Solar Panel Power Requirement $= \frac{17.591{,}8}{5}$
   Solar Panel Power Requirement = 3.519,36 Wp
   Number of Solar Panels = 450 Wp
   Solar Panel Specifications = 450 Wp

Number of Solar Panels $= \frac{3.518,36}{450}$
Number of Solar Panels = 7,81 = 8 solar panel units

Planning SMART CULTIVATION SYSTEM
Application of Power Plants that Utilize Renewable Energy Power

The implementation of renewable energy power plants is designed with a hybrid system. Wind and solar energy have high efficiency, high reliability, and do not cause pollution to the surrounding environment (Muliadi & Hadi, 2023; Silitonga & Ibrahim, 2020). In this case, the Hybrid Power Plant that is applied to the Smart Cultivation System concept is the application of the Solar Power Plant (PLTS) and the Application of the Wind Power Plant (PLTB). The implementation of PLTH aims to be a supplier of shrimp pond electricity systems, so that electricity in the Smart Cultivation System concept can be independent and environmentally friendly. The Smart Cultivation System concept is also equipped with IoT (internet of things) based technology to optimize energy savings in shrimp ponds (Arifin et al., 2023; Intyas et al., 2022). Measuring electrical power usage is usually carried out using simple measuring instruments and recording is still manual so that the data obtained cannot be done all the time and the results take too long to obtain. With an IoT-based electrical power monitoring system, it can be checked in real time with access via the internet network. To connect to the internet this tool uses an ethernet shield, and for monitoring displays on the internet it uses Ubidot. So the existence of IoT technology is very helpful in saving energy in shrimp ponds which can be accessed on mobile phones.

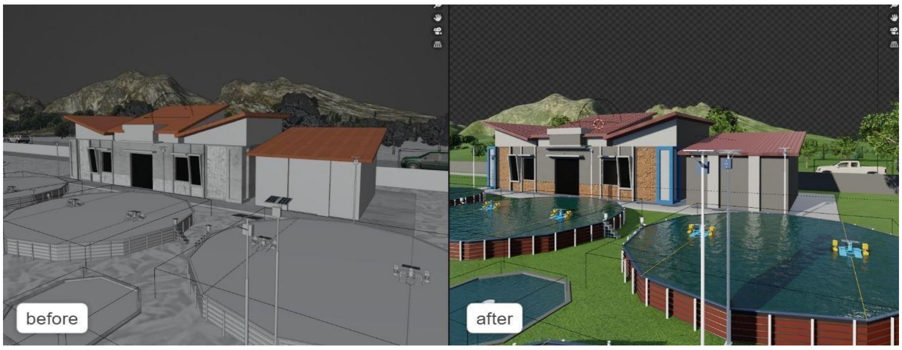

Figure 1. View of the Main Millennial Shrimp Farm building

Application of Water Filtration

Pond water quality is a very important factor for the survival and productivity of shrimp farming. Water quality is expressed by several physical parameters such as temperature, salinity, water turbidity, dissolved solids and so on (Arif Mustofa, 2020; Hamidah et al., 2019). To reduce the impact that occurs due to poor water quality, a monitoring and control system is needed so that a new idea emerged, namely the application of a microcontroller-based water circulation filtration system in ponds. The filtration system in this shrimp pond uses a microcontroller which functions as a filter and regulates the entry and exit of sea water which is used to replace pond water which is dirty and does not meet the quality of sea water used for shrimp cultivation. This microcontroller-based water circulation filtration is equipped with a filter, LM35DZ temperature sensor, water turbidity sensor, salinity sensor, L298 motor driver, DC water pump and NI myRIO microcontroller. So that changes in water circulation in shrimp ponds will change automatically.

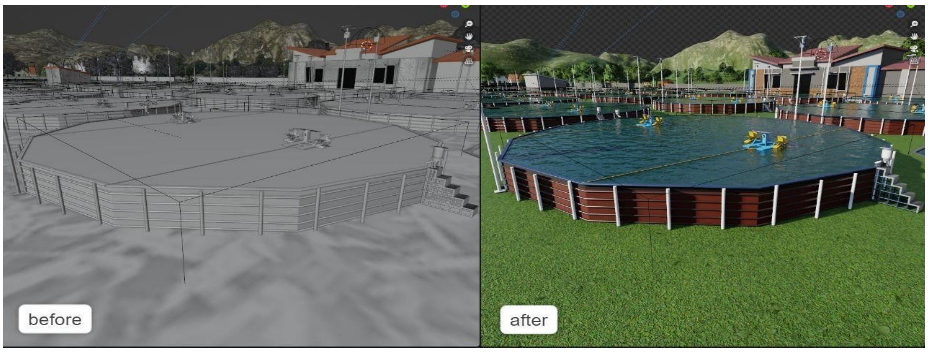

Figure 2. View of a shrimp pond with an Off-Grid PLTS powered aerator

Use of IoT-based Solar Powered Automatic Shrimp Feeder

Feeding for shrimp cultivation must also be in accordance with their needs in order to obtain optimal growth results (Prama et al., 2023; Renitasari et al., 2021). In this new idea, the use of automatic feeders in shrimp cultivation uses solar panel power. This tool is used to overcome the problem of feeding shrimp farmers who still use manual methods to become automatic, has a programmed scheduling system and is useful for many people, especially shrimp farmers. The tool designed is a tool that is programmed via a PLC equipped with a solar panel. PLCs can be programmed, controlled and operated by operators. Meanwhile, solar panels can directly transfer solar radiation or light energy into electrical energy. With the support of a charge controller and battery as the main power to turn on the PLC and a DC motor which is used to distribute shrimp feed. So this tool can provide a solution for effective feeding for shrimp farmers.3.2.4 Pengaplikasian Penerangan Jalan Umum Tenaga Surya (PJU-TS) Berbasis Mikrokontroller.

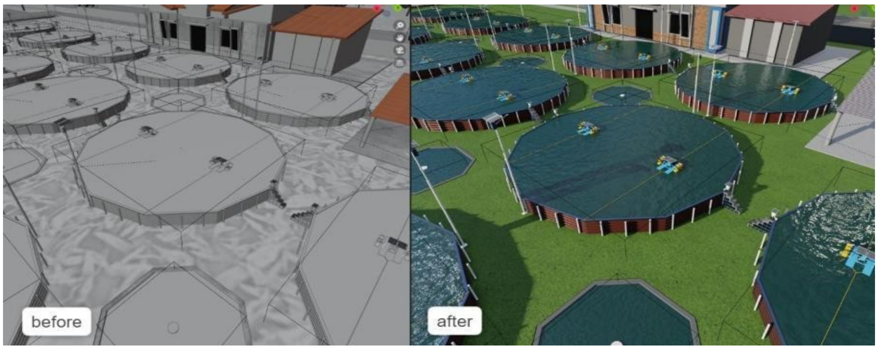

Figure 3. Pond view part 2 for placing shrimp seeds

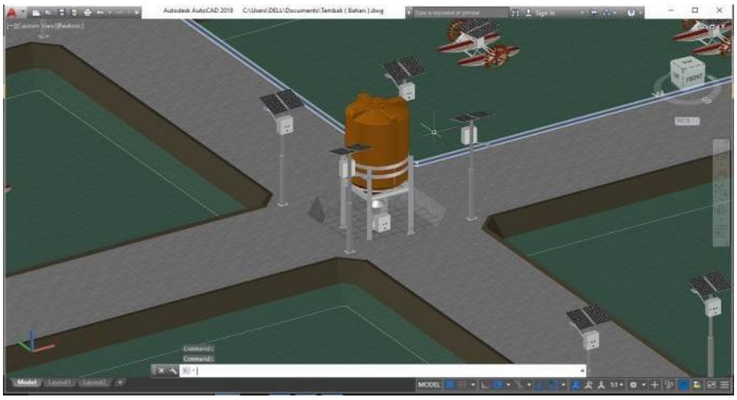

Figure 4. Design of automatic feeding equipment

Application of Microcontroller Based Solar Public Street Lighting (PJU-TS)

Application of microcontroller-based Solar Public Street Lighting (PJU-TS). The use of PJU-TS in shrimp ponds provides many benefits in terms of energy savings and easy and efficient maintenance for many years. The microcontroller-based PJU-TS can automatically start up in the afternoon and turn off in the morning and can turn on when there is fog/smoke even during the day because the microcontroller-based PJU- TS is equipped with an Arduino Uno, LDR sensor, lithium ion battery, MQ sensor -2. With a fast and easy installation system, PJU-TS can be a quick solution to overcome the need for public street lighting in shrimp ponds.

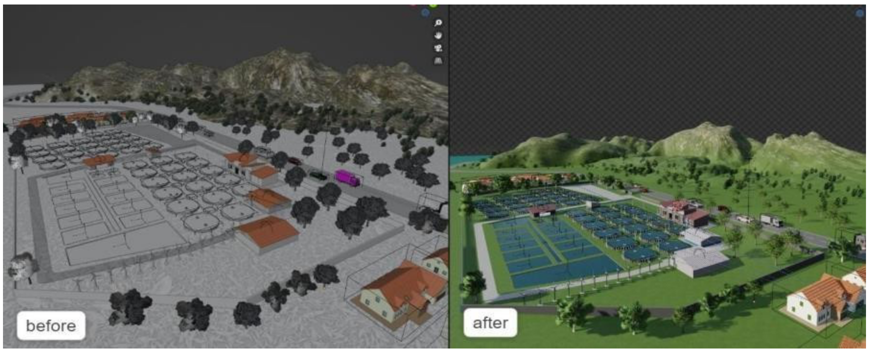

Figure 5. View of the use of Off-Grid PLTS for lighting in ponds

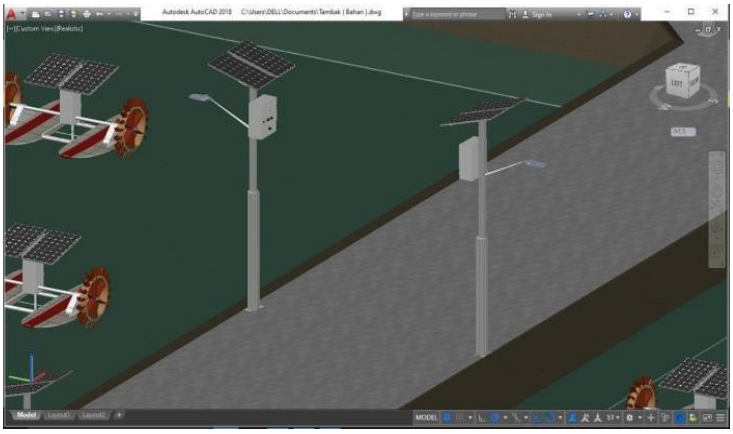

Figure 6. Design of solar powered public street lighting

SWOT Analysis

A detailed review of an innovation work is required before it is actually implemented. Below, we attach a SWOT analysis on "Smart Cultivation System": Innovation Concept for Designing a Modern and Automatic Pond Technology System Powered by Renewable Energy and Environmentally Friendly.

Table 2. SWOT Analysis

Strengths	Weakness	Opportunities	Threads
Abundant Energy Sources	Ordering Fees Are Quite High	Intensive and Government Support	Competition with Conventional Energy Sources
Environmentally friendly	Dependence On Weather Conditions	Increased Use of Renewable Energy	Technological Limitations
Long Term Cost Savings	-	-	-
Hybrid PLTS system with thermoelectric	-	-	-

CONCLUSION

The research presents a comprehensive exploration of energy calculations and pond design for smart cultivation systems, with a focus on shrimp ponds. Through interviews and analysis, the energy consumption of various components such as lights, waterwheels, and pumps was determined, leading to the calculation of total power consumption and the specification of necessary equipment like inverters, batteries, and solar panels.

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