e-ISSN 3089-1248

# Utilization of Hybrid Technology of Solar Energy and Ocean Waves for Irrigation Systems in the Coastal Area of Ujong Batee, Aceh Besar

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***Abstract*— Suboptimal irrigation is one of the main obstacles in the pond farming area in the coastal area of Ujong Batee, Aceh Besar Regency, where most of the population depends on the pond agriculture sector. Farmers often face the problem of additional costs because they use electric pumps to drain water from wells, which require electrical installation and long cables. This study aims to examine the feasibility of implementing a hybrid energy-based irrigation system, which combines solar energy and marine energy, as a solution to improve energy efficiency and reduce irrigation operational costs in the region. This research method involves measuring the intensity of solar radiation and ocean waves at the research site, as well as analyzing the power requirements to drive the water pump. The measurement results show that the lowest solar intensity for one month is 5.33 KWh/m2/day with a daily irradiation duration of up to 10 hours, producing 450 Wp of power from solar panels. Meanwhile, the speed of sea waves during the same period was 2.99 m/s, which with a turbine with a diameter of 1.5 meters can produce 186.65 watts of electrical power. By combining these two energy sources, the proposed hybrid system can provide a sustainable solution to the energy needs of irrigation systems in the coastal area of Ujong Batee, Aceh Besar Regency by reducing dependence on conventional electricity and lowering operational costs for pond farmer**

***Keywords*— *hybrid energy, solar energy, ocean wave energy, irrigation system***

## I. INTRODUCTION

The use of renewable energy as an alternative energy source has been known for a long time and continues to develop. One example is the use of biodiesel made from kepayang seeds as a biofuel. In addition, organic waste such as food waste has been processed into biogas as a form of renewable energy. The increasing cost of conventional energy has spurred research to identify potential new energy sources, including the use of wind energy, to support the agricultural and fisheries sectors, especially pond farmers.

In the coastal area of Ugong Bate, especially Ladong Village, Aceh Besar Regency, the main problem faced by pond farmers is the limited water supply for their land needs. This condition greatly affects the cultivation of aquatic animals such as shrimp, fish, and other organisms that require pond land. Farmers adjacent to settlements generally use electric power-based water pumps from PLN to irrigate pond land. However, farmers who own land far from settlements have to incur significant additional costs to install electrical installations with long enough wires for the pumps to function properly. The high cost of this installation makes the system inefficient and uneconomical for pond farmers.

To address this problem, renewable energy-based power generation technology that combines solar and wind power, otherwise known as hybrid systems, is needed. This technology is expected to improve the reliability of energy supply for water pumping, as well as increase the volume of water that can be pumped daily

## II. RESEARCH METHODS

### 1. Place and Time of Research

This research according to the level of explanatory and type of data and analysis includes research in the type of experimental research and feasibility studies. The experiment was conducted to test the performance of the hybrid energy system in supporting the operation of the water pump. A feasibility study was conducted to assess whether this technology can be applied economically and technically in the Ujong Batee area with the research location being the coastal area of Ladong Village, Aceh Besar Regency. This area was chosen because it has a significant potential for renewable energy sources, namely high solar radiation and stable sea waves. Data measurement at this location was carried out to determine the potential and challenges that exist in the application of hybrid technology with the object of

research being the pond irrigation system in the Ujong Batee area. Pond farmers who need irrigation systems are also the subject of data collection related to land conditions and energy needs.

2. Research Procedure

a. Data Collection Stage.

- Solar Intensity Measurement: Solar radiation intensity data is taken using a lux meter. Measurements were carried out daily for three months to obtain an average daily intensity. This data is needed to determine the potential energy that solar panels can generate.
- Measurement of Ocean Wave Speed and Height: The speed of ocean waves is measured using a wavebuoy device. Measurements were taken at several points around the Ujong Batee beach to get an average of the height and frequency of the waves..

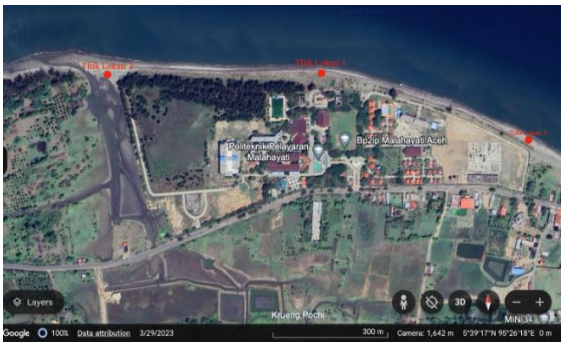


Fig 1. Research location in Gampong Durung, Aceh Besar Regency (Source : Google Earth Pro, 2024).

3. Research framework

The research framework used in this study is as follows:

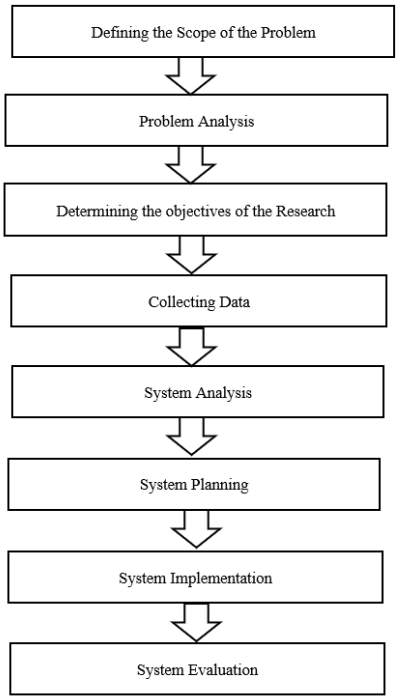


Fig 2 research framework

## III. RESEARCH RESULT

1. Solar Energy Potential Analysis The average solar intensity data in April 2024 can be seen in the tables below:

TABLE I. SOLAR INTENSITY IN APRIL 2024 (AVERAGE PER DAY)

| Date | Average Lux | W/m² | kW/m² | kWh/m²/day |
|---|---|---|---|---|
| 01-Apr-24 | 53745,40 | 537,45 | 0,54 | 5,37 |
| 02-Apr-24 | 59507,14 | 595,07 | 0,60 | 5,95 |
| 03-Apr-24 | 57319,94 | 573,20 | 0,57 | 5,73 |
| 04-Apr-24 | 55986,58 | 559,87 | 0,56 | 5,60 |
| 05-Apr-24 | 51560,19 | 515,60 | 0,52 | 5,16 |
| 06-Apr-24 | 51559,95 | 515,60 | 0,52 | 5,16 |
| 07-Apr-24 | 50580,84 | 505,81 | 0,51 | 5,06 |
| 08-Apr-24 | 58661,76 | 586,62 | 0,59 | 5,87 |
| 09-Apr-24 | 56011,15 | 560,11 | 0,56 | 5,60 |
| 10-Apr-24 | 57080,73 | 570,81 | 0,57 | 5,71 |
| 11-Apr-24 | 50205,84 | 502,06 | 0,50 | 5,02 |
| 12-Apr-24 | 59699,10 | 596,99 | 0,60 | 5,97 |
| 13-Apr-24 | 58324,43 | 583,24 | 0,58 | 5,83 |
| 14-Apr-24 | 52123,39 | 521,23 | 0,52 | 5,21 |
| 15-Apr-24 | 51818,25 | 518,18 | 0,52 | 5,18 |
| 16-Apr-24 | 51834,05 | 518,34 | 0,52 | 5,18 |
| 17-Apr-24 | 53042,42 | 530,42 | 0,53 | 5,30 |
| 18-Apr-24 | 55247,56 | 552,48 | 0,55 | 5,52 |
| 19-Apr-24 | 54319,45 | 543,19 | 0,54 | 5,43 |
| 20-Apr-24 | 52912,29 | 529,12 | 0,53 | 5,29 |
| 21-Apr-24 | 56118,53 | 561,19 | 0,56 | 5,61 |
| 22-Apr-24 | 51394,94 | 513,95 | 0,51 | 5,14 |
| 23-Apr-24 | 52921,45 | 529,21 | 0,53 | 5,29 |
| 24-Apr-24 | 53663,62 | 536,64 | 0,54 | 5,37 |
| 25-Apr-24 | 54560,70 | 545,61 | 0,55 | 5,46 |
| 26-Apr-24 | 57851,76 | 578,52 | 0,58 | 5,79 |
| 27-Apr-24 | 51996,74 | 519,97 | 0,52 | 5,20 |
| 28-Apr-24 | 55142,34 | 551,42 | 0,55 | 5,51 |
| 29-Apr-24 | 55924,15 | 559,24 | 0,56 | 5,59 |
| 30-Apr-24 | 50464,50 | 504,65 | 0,50 | 5,05 |

Based on available data, it can be seen that the highest solar intensity was recorded on April 12, 2024, with an average value of 5.97 KWh/m²/day. This is due to the sunlight reaching 100% unobstructed by clouds and the high temperature recorded on that day reaching 34°C. In addition, the data also shows that the average intensity of the sun in.

April 2024 is 5.16 KWh/m²/day and 5.18 KWh/m²/day, respectively, with an irradiation duration of 10 hours per day and an average temperature of 32.7°C. Another study also stated that the solar intensity for Banda Aceh City is in the range of 1677 KWh/m²/year.

2. Analysis of the Energy Potential of Sea Waves.
The average sea wave energy data in April 2024 can be seen in the tables below:

TABLE II. TABLE 1. SEA WAVE INTENSITY IN APRIL 2024 (AVERAGE PER DAY)

| Date | The Significant Wave Height (Hs) [m] | Wave Period (T) [Detik] | Wind Speed [m/s] | Wave Energy (kW/m) |
|---|---|---|---|---|
| 01-Apr-24 | 1,56 | 9,6 | 6,2 | 11,46 |
| 02-Apr-24 | 2,43 | 7,0 | 5,8 | 20,28 |
| 03-Apr-24 | 2,10 | 6,4 | 7,5 | 13.85 |
| 04-Apr-24 | 1,90 | 11,7 | 6,1 | 20,72 |
| 05-Apr-24 | 1,23 | 11,8 | 5,8 | 8,76 |
| 06-Apr-24 | 1,23 | 10,9 | 6,6 | 8,09 |
| 07-Apr-24 | 1,09 | 7,8 | 5,4 | 4,55 |
| 08-Apr-24 | 2,30 | 6,6 | 7,4 | 17,13 |
| 09-Apr-24 | 1,90 | 10,1 | 5,2 | 17,9 |
| 10-Apr-24 | 2,06 | 8,6 | 8,0 | 5,71 |
| 11-Apr-24 | 1,72 | 7,6 | 5,1 | 5,53 |
| 12-Apr-24 | 2,30 | 6,6 | 7,4 | 17,13 |
| 13-Apr-24 | 1,90 | 10,1 | 5,2 | 17,9 |
| 14-Apr-24 | 2,06 | 8,6 | 8,0 | 5,71 |
| 15-Apr-24 | 1,09 | 7,8 | 5,4 | 4,55 |
| 16-Apr-24 | 2,30 | 6,6 | 7,4 | 17,13 |
| 17-Apr-24 | 1,90 | 10,1 | 5,2 | 17,9 |
| 18-Apr-24 | 2,06 | 8,6 | 8,0 | 5,71 |
| 19-Apr-24 | 1,09 | 7,8 | 5,4 | 4,55 |
| 20-Apr-24 | 2,30 | 6,6 | 7,4 | 17,13 |
| 21-Apr-24 | 1,90 | 10,1 | 5,2 | 17,9 |
| 22-Apr-24 | 2,06 | 8,6 | 8,0 | 5,71 |
| 23-Apr-24 | 1,09 | 7,8 | 5,4 | 4,55 |
| 24-Apr-24 | 2,30 | 6,6 | 7,4 | 17,13 |
| 25-Apr-24 | 1,90 | 10,1 | 5,2 | 17,9 |
| 26-Apr-24 | 2,06 | 8,6 | 8,0 | 5,71 |
| 27-Apr-24 | 1,90 | 10,1 | 5,2 | 17,9 |
| 28-Apr-24 | 2,06 | 8,6 | 8,0 | 5,71 |
| 29-Apr-24 | 1,09 | 7,8 | 5,4 | 4,55 |
| 30-Apr-24 | 1,07 | 8,0 | 6,4 | 4,49 |

Based on existing data, it can be seen that the highest significant wave height (Hs) was recorded on April 2, 2024, with the average significant wave height ranging from 1.23 meters to 2.43 meters with larger waves tending to be at the beginning of the month and fluctuations occurring throughout the month which are influenced by weather factors and the wind season. In addition, the data also shows that the longest wave period recorded on April 5, 2024 varies between 6.4 seconds to 11.8 seconds with waves that have a longer period tending to carry more energy according to the correlation between the wave period and the energy produced. Meanwhile, the highest wind speed ranges from 5.8 m/s to 7.8 m/s with the highest value on April 3, 2024, which is 7.5 m/s.

Steady wind speeds during April show consistent potential to support wave energy. Strong winds affect the formation of larger waves and potentially produce higher energy. As for the wave energy generated during April 2024 varies between 8.76 kW/m to 20.72 kW/m, with the highest peak on April 4 of 20.72 kW/m with the energy value generated showing good potential for wave conversion in Ujong Batee, Aceh Besar for electricity generation opportunities and the average daily wave energy of around 15 kW/m shows a decent potential to utilize wave energy consistently throughout the month.

## IV. CONCLUSION

Based on the results of research on irrigation systems in the coastal area of Ujong Batee, Aceh Besar Regency, it can be concluded that suboptimal irrigation is a significant problem for pond farmers who are highly dependent on the pond agriculture sector. Mainly, the reliance on electric pumps that require electrical installations and long cables results in high additional costs. This study evaluates the feasibility of implementing a hybrid energy-based irrigation system, which integrates solar energy and marine energy, as an alternative to improve energy efficiency and reduce irrigation operational costs.

The results of solar radiation intensity measurements showed the lowest value of 5.33 KWh/m²/day for one month, with a daily irradiation duration of 10 hours. With this intensity, the solar panel is capable of generating a power of 450 Wp. On the other hand, the speed of sea waves in the same period was recorded at 2.99 m/s, which allows a turbine with a diameter of 1.5 meters to generate 186.65 watts of electrical power. Relatively stable wave height conditions and supportive wind speeds provide opportunities for sustainable energy conversion. The combination of these two energy sources shows significant potential to be applied in irrigation systems.

Further research is needed to develop a hybrid energy-based irrigation system in more detail, including large-scale evaluation and field trials to ensure its reliability in various weather conditions and solar radiation intensity.

Pond farmers in Ujong Batee need to be given training and education on renewable energy technology and how to operate hybrid systems. This is important so that they can make optimal use of the system and understand the maintenance required. Local governments and related institutions need to provide policy support and funding for the implementation of hybrid energy systems. Incentives or subsidies for the installation of this technology can accelerate adoption and make it easier for farmers to switch from conventional irrigation systems.

Further research is needed to identify the potential for more efficient and low-cost technology development, further studies to identify the optimal point of placement of power generation equipment as well as an economic feasibility analysis for the implementation of this technology as well as to explore the possibility of integrating additional energy sources such as biomass or wind. It is important to regularly monitor and evaluate the performance of the hybrid system implemented. The data obtained can be used for system improvement as well as to identify best practices in the application of this technology in various pond farming areas

By implementing this hybrid system, it is hoped that it can reduce dependence on conventional energy sources and reduce irrigation operational costs for pond farmers in the region. This hybrid energy-based irrigation system not only offers a more sustainable solution, but can also increase the energy independence of farmers and support the sustainability of the pond agriculture sector on the coast of Ujong Batee

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