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# ANALYSIS OF THE SEASON EFFECT ON ENERGY GENERATED FROM HYBRID PV/WT IN MALANG INDONESIA

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***This research is about the effect of seasons on the energy produced by hybrid solar photovoltaic (PV) and wind turbines (WT). This study measures the amount of energy produced by the hybrid from PV/WT for 24 hours/day for a full year. The weather in Indonesia changes every day, with this change, the energy produced by PV/WT hybrids also changes. Data collection was carried out in the city of Malang, Indonesia.***

***The results showed that there are two seasons, namely the dry season and the rainy season. The dry season is from May to October and the rainy season is from November to April. Between the two seasons there is a transition period, namely May and November. Transition time is a month whose weather follows the dry season and the rainy season. The results of research using PV energy generators of 100 WP and 500 Watt WT show that there is a significant effect on the energy produced by PV/WT hybrids between the dry season and the rainy season. The total energy in the dry season is 78.296 Wh and in the rainy season it is 43,790 Wh. The energy ratio of the dry season to the rainy season is 1.7:1. Total energy every month in the dry season is between 11,242 Wh to 14,174 Wh and for the rainy season is between 5,821 Wh to 10,677 Wh. The ratio of the highest to the lowest monthly energy is 2.4:1. The total energy per day in one year is between 88 Wh to 477 Wh. The daily energy ratio from the highest to the lowest is 5.4:1.***

***This research data is very important because energy data for one year can be used as a reference and basis for designing hybrid PV/WT energy plants. This can be used as a basis for designing loads that match the generator capacity for a period of one year and also designing the capacity requirements of energy storage devices. The results of this study can also be used by other countries that have seasons such as Indonesia***

***Keywords: hybrid photovoltaic and wind turbines, photovoltaic energy wind turbines energy, dry season, rainy season***

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## 1. Introduction

The issue of global warming has prompted various countries to issue policies to look for new energy that does not damage the environment. This renewable energy in the future will play an important role in energy generation. In addition, other problems must be overcome, namely the diminishing conventional energy sources.

PV/WT hybrid energy is a renewable energy source with great potential to meet the energy crisis in the future. This energy plant is good because PV/WT can overcome the energy crisis in the future. In addition, PV/WT can complement each other to cover deficiencies in energy generation. PV/WT energy plants have complementary properties

The actual data on energy products from PV/WT hybrid plants based on environmental conditions is still very minim. Several types of environments interfere with PV/WT hybrid energy generation, such as weather, dust, wind, rain, etc. One that is very impactful and disturbing is climate. Solar cell and wind turbine resources are susceptible to weather fluctuations [1, 2]. Whereas the users highly expect stable and continuous energy with a fixed amount. If the energy source is unstable, it will affect the performance of energy consumers. The PV/WT hybrid system is connected to a network consisting of PV, WT, induction generator, controller and converter [3].

Indonesia has two climates, namely the summer and rainy seasons. Summer is about six months, and the rainy season is about six months. Seasonal shifts can usually occur forward or backward for one to two months [4].

Malang city, East Java province of Indonesia, is located at an altitude of 440 to 667 m above sea level. Its position is at 113.06° to 112.07° East Longitude and 7.06° to 8.02° South Latitude and at the intersection of the southern equator. This city can represent a large part of Indonesia for PV/WT hybrid energy sources.

It is necessary to research hybrid PV/WT energy in the dry and rainy seasons because the weather conditions are different. Researchers usually only study in the summer so that the electricity generated from the sun is large. Researchers rarely research the rainy season, which produces relatively small electrical energy by PV. Thus, in Indonesia, it is necessary to study the electrical energy produced by hybrid PV/WT throughout the year.

Researchers in Indonesia are still very few conducting experimental research on PV/WT hybrids which are carried out throughout the year covering two seasons.

Considering the influence of the seasons plays a very important role in sunlight reaching the earth and so does the wind speed which is always fluctuating. So it is very necessary to research the energy produced by hybrid PV/WT experimentally.

## 2. Literature review and problem statement

Many studies are not based on field experiments but on weather forecasts or instantaneous energy measurements. Please note that the weather changes at any time in the same month, week, day, and the amount of energy produced by PV/WT is not the same.

The feasibility study of a hybrid system using HOMER was used as a tool for technical, economic and environmental assessments. Analyze the optimal energy system to find the most feasible off-grid system. Then, this system is compared with the option of expanding to a grid system and diesel generator [5]. Analyzing solar radiation and ambient temperature data to compare the PV energy output at different locations and the best results for a 340 W module that produces 502 kWh of energy [6]. The existence of environmental influences, namely clouds that block the sun. Clouds will reduce energy by 2 to 10 %, this decrease cannot be determined when it occurs depending on the time and month [7]. Research topics in Indonesia on renewable energy technology (RET) show that they are still under-researched, especially regarding:

a) the economic potential of RET;

b) research on mapping the spatial potential of several RETs;

c) empirical data on natural resources [8], so empirical research on PV/WT hybrids is urgently needed.

The study used Hybrid PV/WT and engines with biogas fuel. This research is good because if the PV and WT are not stable then the generator will supply energy [9], but the energy of PV and WT should be experimentally not based solely on data from sunlight strength and wind speed. Research on the effect of the dust layer on the power generated by PV was in summer. The longer the layer of dust gets thicker and what happens the power goes down. Referring to the output power when clean, dirty PV if cleaned once per week, per month, per two months and every three months lost about 2.39 %, 10.89 %, 30.16 % and 41.97 %, respectively [10]. HOMER is used to analyze energy sources to be used in Indonesia's New Capital City. The result is Solar PV generates higher capacity than other renewable technologies, hybrid renewable energy systems provide a more stable and balanced power output [11]. Simulates and analyzes the rooftop photovoltaic system on buildings. From economic aspects, the rooftops PV system has the potential to provide power at a competitive cost in comparison to other alternative options of power generation [12]. Viewed from a technological perspective and an environmental perspective, a good result for power generation is the combination of PV-WT-Bio-Gas and Battery power plants [13]. Using indicators when developing the energy supply strategy, including utilization of renewable energy will promote systemic saving of fossil fuel, reducing the harmful effects of energy systems on the environment and energy supply stabilization [14]. Indonesia also needs to map hybrid PV/WT renewable energy by region as done like by [15], with this research it is possible to start mapping in Indonesia. Indonesia has a lot of cloves, so that fluctuating PV/WT hybrid energy is well used to dry cloves in an oven, such as the oven made by [16]. Study of solar photovoltaic panels and wind turbines was carried out to obtain the optimal and efficient size of the hybrid system at the lowest cost. Solar and wind power data is carried out on hourly, daily, and monthly basis. The results show that the hybrid system can be applied efficiently and economically by utilizing renewable energy sources [17]. This has to be proven experimentally, otherwise the results will deviate considerably and please note that the cost of building a PV/WT hybrid is not cheap.

Monte Carlo method for simulating uncertain wind, sky and dust conditions based on multi-year real-world data [18], using a method the results are quite good and the cost is cheap but will still deviate if it is not proven by experiments in the field.

The choice of location for the PV/WT hybrid is very decisive, this can be caused by environmental influences. The use of diesel generators is used to support the continuity of energy supply, which can be guaranteed to be fulfilled [19]. This is good by considering the location and environmental conditions and plus other energy sources so that there is no need for large energy storage devices because energy is used directly.

Indonesia already has regulations on the use of electrical energy from solar or other sources, which can be combined with electrical energy from state-owned power plants. This merger can be carried out on a small scale, such as for households, to a large scale, such as for industry. With this rule, everyone can freely carry out in accordance with the applicable rules.

## 3. The aim and objectives of the study

The aim of the study is to analyze the effect of seasons on the energy produced by PV/WT hybrid with the experimental method.

To achieve this aim, the following objectives are accomplished:

– to know the amount of energy each season;

– to find out the amount of energy each month;

– to know the amount of energy each day;

– to find out the amount of energy comparison based on season, month and day.

## 4. Materials and methods

Research equipment consists of:

– power PV 100 WP with a maximum direct output voltage of 21.5 volts;

– power WT 500 Watt at a wind speed of 12 m/s with a generator rotation of 900 rpm, 5 blades;

– hybrid electric PV and WT for 500 Watt;

– voltage and current meter and power meter.;

– battery or battery lead type 12 Volt 40 AH.;

– change from DC to AC (inverter), maximum 500 Watts.;

– loads from 100 W to 300 W.;

– anemometer;

– hygrometer;

– thermometer.

All the equipment occupies an area of 1.5 $m^2$, but for space and others, 2 $m^2$ is made.

The city of Malang has many tall buildings, so the research is carried out on top of the building. It is carried out above the building because it is not disturbed by the shadow of trees or buildings, and free wind gusts are not hindered.

The position of the hybrid PV/WT is shown in Fig. 1, 2. Data collection is carried out 24 hours a day for one year. The data is taken based on the maximum capacity of the solar cell, namely Wp, not based on the area of the solar cell.

Fig. 1. Building and position of tools used for research

Fig. 1 shows the placement of a PV/WT hybrid generator on the roof of a 32 m high building. The building is slightly curved in shape, and the windmill appears to be placed on the edge of the front of the building.

Fig. 2. Solar cell and wind turbine

Fig. 2 is a hybrid generator that is used for data collection. The measured data is the power generated by PV/WT. The position of the PV does not change while the WT facing it can move automatically according to the direction of the wind.

Fig. 3 is a schematic of a PV/WT hybrid device circuit that records the power generated. Energy storage is carried out in the battery.

Energy from the battery and hybrid is directly supplied to the load through the inverter. The inverter functions to change the 12 V DC voltage to 220 V AC voltage. The load is an incandescent lamp, and the lamp will light up after receiving electrical energy from the inverter.

The research method and data collection were carried out as follows.

The energy from the PV and WT enters simultaneously into the electric hybrid and is then forwarded to the battery and to the load. Energy data is taken after the electric hybrid device. Data retrieval is carried out every day for 24 hours and within a full year, data is taken every hour. The energy from the hybrid goes directly to the battery and load, so that no energy from the Hybrid PV/WT is wasted.

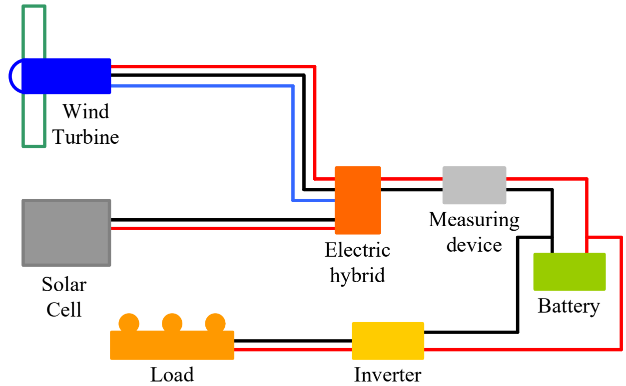


Fig. 3. Schematic of the generator circuit

The measurement results are in the form of power. Energy is obtained by multiplying power by time. The power for one hour between data collection for the first hour and the second hour fluctuates, so the power used to calculate energy is the average power of the two.

Energy yield data from hybrid PV/WT are grouped by day and month, with this data it will be possible to know the differences between one month and another and between one season and another.

## 5. Results of influence of seasons on energy generated by hybrid PV/WT

### 5. 1. Energy of the seasons

The results of the power measurement for one year by the PV/WT hybrid are shown in Fig. 4. On the graph it can be seen that there are two groups of quantities. The high power group occurs in the dry season and the low power group occurs in the rainy season.

The dry season is six months between May and October, and the rainy season is six months, from November to April. The study results are the average electric power recorded daily and every hour for a year.

Fig. 4 shows the relationship of the effect of time, month on the average power produced by the PV/WT hybrid.

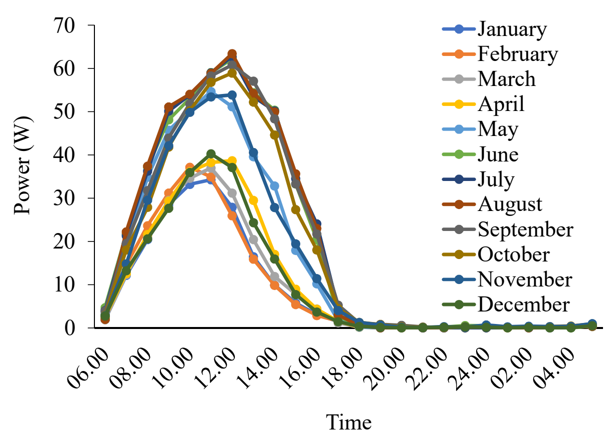


Fig. 4. Power generated for one year

The energy produced is the power multiplied by the time during which the battery is charged or use for the load. Charging time is determined at intervals of one hour. Energy can be calculated by the general formula $E=P\times t$, where $E$ – energy, Wh, $P$ – power, Watts, $t$ – time, hours.

The energy calculation results from Fig. 4 can be seen in Table 1 below. Table 1 is the average daily energy per month in one year generated from hybrid PV/WT.

Fig. 5 is the daily energy in one year made from Table 1.

Based on the amount of energy from Figure 5, the types of seasons can be grouped. It can be seen that there are two groups of energy, namely greater energy and lesser energy.

Fig. 5 can be separated by season, namely the dry season and the rainy season. The dry season starts from May to October as shown in Fig. 6.

Fig. 6 is the energy from the grouping of months including the dry season. The dry season energy grouping is based on Fig. 5. May has lower energy than other months.

Table 1

Average daily energy (Wh) produced by hybrid PV/WT in one year

| Time | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06.00 | 1.35 | 1.5 | 1.19 | 1.48 | 1.92 | 2.55 | 2.26 | 1.19 | 2.35 | 1.97 | 1.95 | 1.95 |
| 07.00 | 7.11 | 8.59 | 7.15 | 7.6 | 10.87 | 13.2 | 12.7 | 12.11 | 11.73 | 10.53 | 8.85 | 8.85 |
| 08.00 | 16.32 | 19.13 | 16.82 | 17.12 | 26.55 | 29.48 | 28.79 | 29.82 | 25.65 | 23.00 | 22.2 | 22.2 |
| 09.00 | 24.5 | 27.43 | 25.4 | 25.5 | 40.29 | 42.72 | 43.19 | 44.27 | 37.87 | 34.89 | 35.85 | 35.85 |
| 10.00 | 30.89 | 34.2 | 32.06 | 32.75 | 47.94 | 50.63 | 52 | 52.6 | 47.88 | 46.03 | 46 | 46 |
| 11.00 | 33.74 | 36.07 | 35.81 | 37.22 | 52.4 | 56.1 | 56.44 | 56.47 | 55.07 | 53.52 | 51.65 | 51.65 |
| 12.00 | 31.08 | 30.46 | 34.11 | 38.48 | 52.92 | 60.67 | 60.87 | 61.16 | 59.55 | 57.89 | 53.67 | 53.67 |
| 13.00 | 22.21 | 20.95 | 25.84 | 34.08 | 45.39 | 58.33 | 58.11 | 58.84 | 58.95 | 55.61 | 47.25 | 47.25 |
| 14.00 | 13.23 | 12.89 | 16.19 | 23.27 | 36.24 | 52.4 | 51.84 | 52.1 | 52.73 | 48.45 | 34.23 | 34.23 |
| 15.00 | 7.85 | 7.64 | 9.85 | 13.00 | 25.42 | 41.83 | 42.37 | 42.82 | 40.85 | 36.02 | 23.67 | 23.67 |
| 16.00 | 4.44 | 4.16 | 6.10 | 6.67 | 14.1 | 26.88 | 29.32 | 29.35 | 27.53 | 22.71 | 15.45 | 15.45 |
| 17.00 | 2.29 | 2.25 | 2.82 | 2.95 | 5.95 | 11.6 | 14.26 | 13.05 | 13.52 | 11.26 | 7.75 | 7.75 |
| 18.00 | 0.89 | 1.13 | 0.71 | 0.87 | 0.95 | 1.63 | 2.5 | 1.77 | 3.22 | 2.89 | 2.68 | 2.68 |
| 19.00 | 0.19 | 0.36 | 0.11 | 0.17 | 0.15 | 0.37 | 0.53 | 0.26 | 1.00 | 1.05 | 1.00 | 1.00 |
| 20.00 | 0.11 | 0.05 | 0.03 | 0.13 | 0.16 | 0.22 | 0.50 | 0.06 | 0.75 | 0.56 | 0.45 | 0.45 |
| 21.00 | 0.10 | 0.07 | 0.03 | 0.13 | 0.19 | 0.15 | 0.27 | 0.08 | 0.43 | 0.26 | 0.15 | 0.15 |
| 22.00 | 0.13 | 0.07 | 0.05 | 0.13 | 0.15 | 0.13 | 0.03 | 0.08 | 0.15 | 0.16 | 0.20 | 0.20 |
| 23.00 | 0.18 | 0.05 | 0.08 | 0.10 | 0.19 | 0.38 | 0.03 | 0.18 | 0.17 | 0.16 | 0.25 | 0.25 |
| 24.00 | 0.15 | 0.16 | 0.15 | 0.07 | 0.19 | 0.55 | 0.05 | 0.26 | 0.32 | 0.23 | 0.45 | 0.45 |
| 01.00 | 0.15 | 0.18 | 0.16 | 0.07 | 0.16 | 0.33 | 0.08 | 0.18 | 0.25 | 0.23 | 0.48 | 0.48 |
| 02.00 | 0.11 | 0.11 | 0.11 | 0.12 | 0.11 | 0.18 | 0.1 | 0.06 | 0.15 | 0.19 | 0.33 | 0.33 |
| 03.00 | 0.05 | 0.07 | 0.1 | 0.13 | 0.06 | 0.17 | 0.15 | 0.08 | 0.17 | 0.26 | 0.35 | 0.35 |
| 04.00 | 0.10 | 0.09 | 0.11 | 0.15 | 0.1 | 0.07 | 0.18 | 0.15 | 0.22 | 0.39 | 0.33 | 0.33 |
| 05.00 | 0.42 | 0.29 | 0.29 | 0.28 | 0.24 | 0.22 | 0.31 | 0.27 | 0.5 | 0.69 | 0.7 | 0.7 |
| TOTAL | 197.59 | 207.9 | 215.27 | 242.47 | 362.64 | 450.79 | 456.87 | 457.21 | 441.01 | 408.95 | 355.89 | 355.89 |

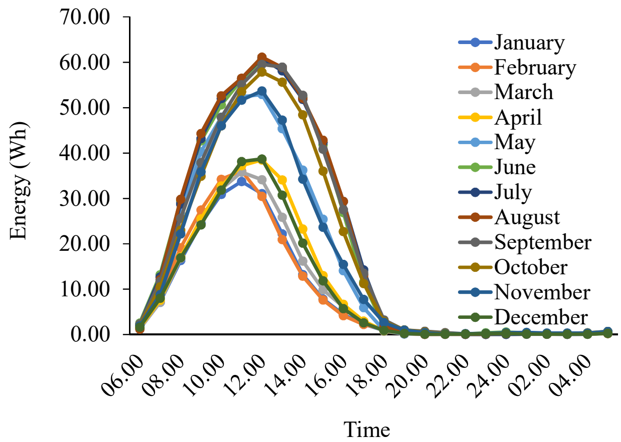


Fig. 5. Average daily energy according to the month

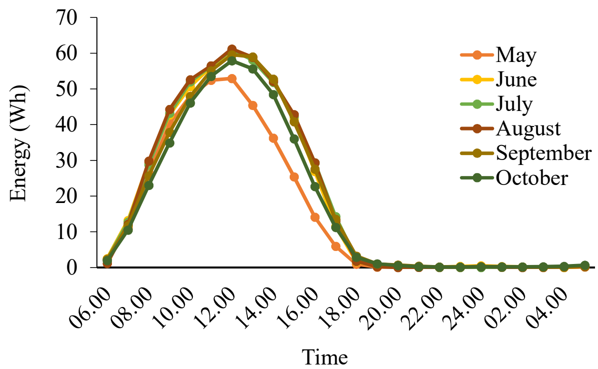


Fig. 6. Energy generated during the dry season

The rainy season starts from November to April, the graph is as shown in Fig. 7.

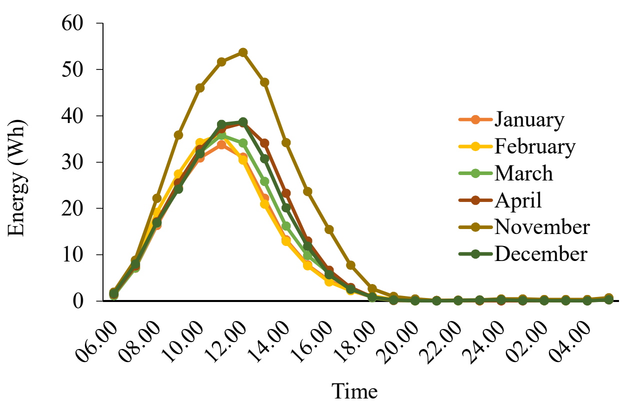


Fig. 7. Energy generated in the rainy season

Fig. 7 is the energy group for the month that includes the rainy season. This rainy season energy grouping is based on Fig. 5. The highest energy is seen in November.

Table 1 and Fig. 6, 7 can be made bar graphs based on seasons. The dry season and the rainy season are depicted in Fig. 8.

Fig. 8 shows the amount of energy produced by hybrid PV/WT in two seasons. Dry season energy is the sum of energy from May to October. The energy of the rainy season is the result of the sum of the energy from November to April. The energy of the dry season is much greater than the rainy season. The dry season produces energy of 78,296 Wh and the rainy season of 43,790 Wh.

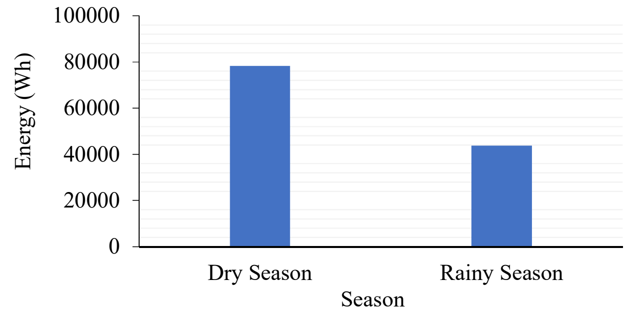


Fig. 8. Energy by season

### 5. 2. Energy every month

Energy per month for one year can be seen in Table 2. Energy per month is the total energy per day for one month.

Table 2

Total energy (Wh) per month generated by hybrid PV/WT

| Month | Jan | Feb | Mar | April | May | June |
|---|---|---|---|---|---|---|
| Energy | 6122.19 | 5821.2 | 6673.37 | 7274.1 | 11241.84 | 13523.7 |
| Month | July | Aug | Sept | Oct | Nov | Dec |
| Energy | 12550.97 | 14173.51 | 13230.3 | 11964.45 | 10676.7 | 6974.69 |

Table 2 can be drawn as a bar chart as shown in Fig. 9. The total energy of each month in one year can be seen in the Fig. 9

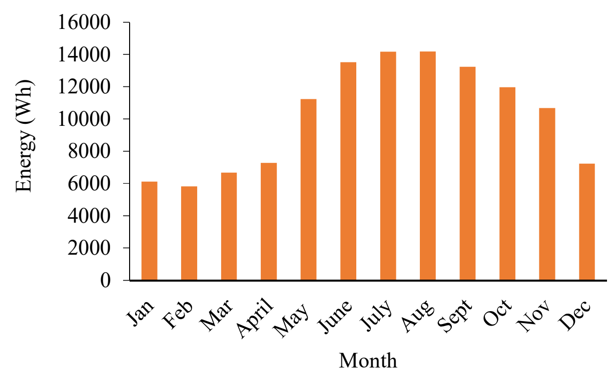


Fig. 9. Total energy every month

The lowest energy is in February because the number of days is only 28 days other than that this month is included in the rainy season and the highest energy is in August.

All months of energy are influenced by the seasons. In the rainy season, the energy value of each month is relatively lower when compared to months in the dry season.

Energy every month in the dry season is between 11,242 Wh to 14,174 Wh and energy every month in the rainy season is between 5,821 Wh to 10,677 Wh.

### 5. 3. The energy produced every day

The average daily energy per month can be seen in Table 1 and/or Fig. 5. The Figure shows that no day is the same even though it is in the same month.

The lowest daily average energy is in January at 197 Wh and the highest energy is on a day in August at 457 Wh. From Fig. 13 the lowest energy of 88 Wh occurred on one of the days in January and Fig. 11 in August shows the highest energy of 477 Wh. To find out the energy produced every day can be represented by one month in the dry season and one month in the rainy season.

For the dry season represented in August, this month was chosen because the energy produced is the largest when compared to other months. The daily energy generated in August shown in Fig. 10.

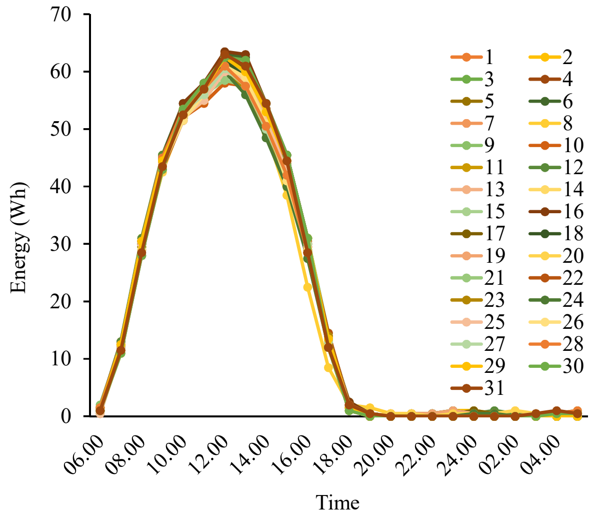


Fig. 10. Daily energy generated in August

The average daily energy produced by the hybrid PV/WT in August is shown in Fig. 10.

August energy influenced by date is shown in Fig. 11. It can be seen that in addition to the date there is an influence of the hour.

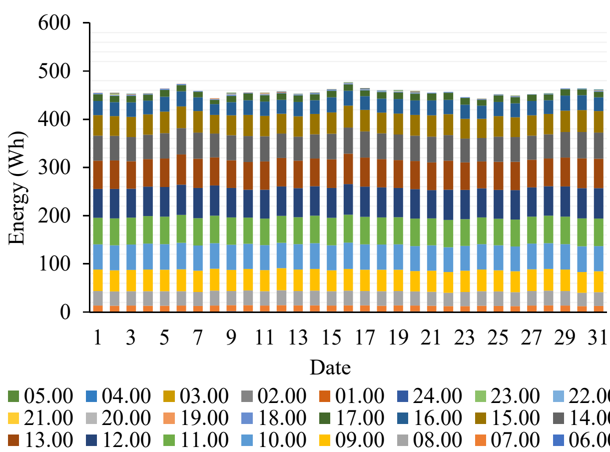


Fig. 11. August daily energy

The difference between Fig. 10, 11 is in the amount of energy. The dominant Fig. 10 shows the amount of energy every day and every hour. The dominant Fig. 11 shows the amount of energy each day. Different dates have almost the same energy, as well as at the same time on different dates. There is a difference but not significant. This also occurs in the months of dry season.

For the rainy season represented in January, this month was chosen because the energy produced is the least when compared to other months. The daily energy generated in January by time in Fig. 12.

The average daily energy produced by the hybrid PV/WT in January is shown in Fig. 12. The graph shows that every day at the same hour, the energy is very different and the difference is quite big.

January energy influenced by date is shown in Fig. 13. It can be seen that in addition to the date there is an influence of the hour.

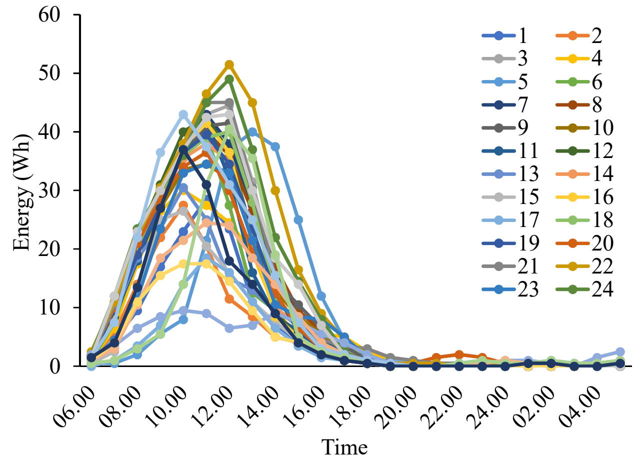


Fig. 12. Daily energy generated in January

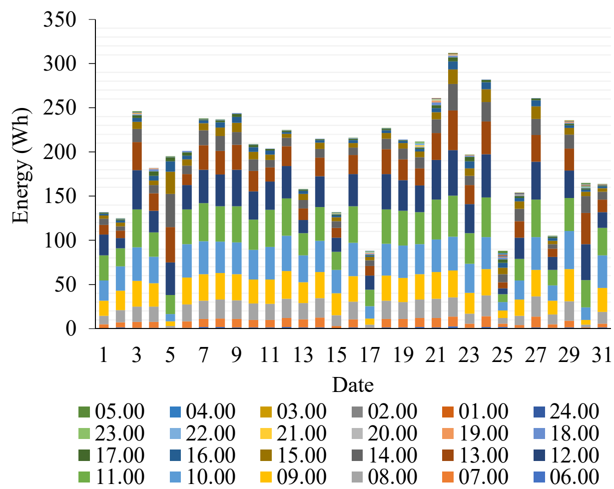


Fig. 13. January daily energy

The difference between Fig. 12, 13 is in the amount of energy. The dominant Fig. 12 shows the amount of energy every day and every hour. The dominant Fig. 13 shows the amount of energy each day. Different dates have different energies, so at the same time on the same date the energy is different. This difference is very significant and it can occur in the months of the rainy season.

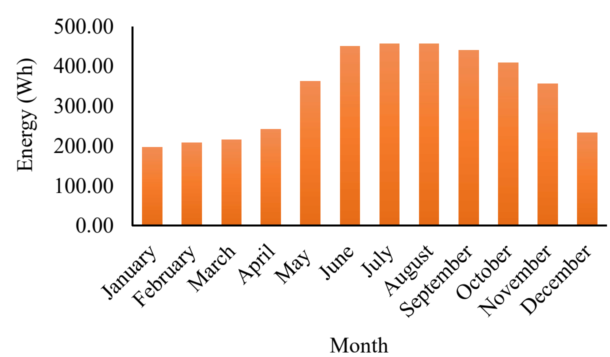


Fig. 14. Average daily energy by month for a year

The total average energy per day according to the month is the total energy in each day for 24 hours and in the average in one month. The energy for each day of the month is considered the same, as shown in Fig. 14.

### 5. 4. Energy comparison by season, month and day

The energy value by season has been calculated in subchapter 5.1. The comparison of dry season energy with the rainy season is 78.296 Wh compared to 43.790 Wh or 1.7 : 1.

The energy value by month has been calculated in subchapter 5 .2. Energy comparison every month regardless of season, January : February : March : April : May : June : July : August : September : October : November : December = 1 : 0.95 : 1.09 : 1.19 : 1.84 : 2.21 : 2.31 : 2.32 : 2.16 : 1.95 : 1.74 : 1.18.

Energy value on a daily basis has been calculated in sub chapter 5. 3. The daily energy comparison is taken on the highest daily basis, namely August with the lowest being January = 477 : 88 = 5.4 : 1.

## 6. Discussion of results influence of seasons on energy generated by hybrid Photo Voltaic and Wind Turbine

Indonesia has two seasons, namely the dry season and the rainy season. Based on the power and energy from the study results shown in Fig. 4, 5, there is another season, namely the transition season. The transitional season produces energy outside of the rainy and dry seasons. The transition season occurs in May and November.

Energy products from the dry season and the rainy season can be separated according to the month. The dry season starts from May to October and the rainy season starts from November to April.

The dry season does not rain much, even in certain months there is no rain at all. May is the month of transition between the rainy season to dry season. From the data graph, Fig. 6 shows that the lowest energy in the dry season is in May. The energy produced in May cannot be high because it still rains but it is rare and the clouds don't often cover the sun and the wind still blows often.

From June to October, there is almost no rain and in this month the wind blows relatively slowly, and the clouds rarely cover the sun. During this dry season, a lot of energy is produced from solar energy, while wind energy is very small and often goes to zero because there is no wind blowing.

The highest energy is produced in August while the lowest is in May. For other months it is almost the same. The highest energy occurs on average at 12.00. Energy in August was 61 Wh, while May was 53 Wh. This energy is dominated by solar energy, while wind energy is very small. Wind energy at midday is very small or often non-existent. Total energy during the dry season is 78,296 Wh.

The rainy season occurs around November to April. November is the month of transition between dry and the rainy season. Fig. 7 shows that the highest power in the rainy season is November. November's energy is highest because it has been raining but not every day, the sun still shines brightly, and the wind often blows.

From December to April, it often rains and in this month the wind is blowing relatively fast and the clouds often cover the sun's rays. Solar energy decreases a lot during this rainy season while wind energy increases slightly compared to the dry season.

The highest energy occurred in November while the lowest was in January. For other months, it is almost the same as January. The highest energy on average occurs at 12.00. In November the highest energy is 53 Wh, while in January the maximum energy at 11.00 is only 33 Wh. Total energy during the rainy season is 43,790 Wh. In the rainy season, the sun is often covered by clouds, but the wind frequently blows so that energy is still produced daily.

The comparison of dry season energy product with the rainy season is the total dry season energy divided by the total rainy season energy equal to 1.7. With this data, it shows that the season greatly influences the yield of PV/WT hybrid energy. This effect cannot be ignored when planning energy generation with hybrid PV/WT. With this influence, it is better if this plant is combined with other generators so that the energy supply to users can be stable.

This is an important notification and a warning for PV/WT hybrid energy designers, especially in Indonesia, to be careful in determining the load in one year.

The results of this study can be used as input for designers and practitioners in the field of PV/WT hybrid energy. Please note that the energy produced by a PV/WT hybrid power plant is strongly influenced by the seasons.

The data from the PV/WT hybrid energy study affected by this season is expected to be used as a reference and consideration for building solar-wind power plants throughout Indonesia and ASEAN. This data can also be used to calculate battery requirements and regulate the use of electrical energy in one year.

The monthly energy produced by the PV/WT hybrid does not depend on the season but depends on the weather conditions. If the weather is sunny there are no clouds covering the sun, then the energy absorbed by the PV is large. Likewise, when the wind blows hard, the energy produced by WT is large.

The weather is unstable, so the energy that can be produced by PV/WT hybrids is not the same every month and can even differ greatly if the seasons are not the same.

Energy, every month for one year, is not the same. The six-month rainy season has almost the same energy for five months. November has greater energy because of the transition from dry to rainy seasons.

The dry season for six months has almost the same energy as five months. The month of May has the least energy due to the transition period between the rainy season to the dry season.

The ratio of the energy produced in the highest to the lowest month is August with January. From Table 2, the total energy produced in August is 14173 Wh and the total energy in February is 5821Wh. so that the magnitude of the comparison between August and February is 2.4.

When build a power plant with hybrid PV/WT on a monthly basis, care must be taken. To determine the energy supply to the user must be good and not fluctuating. Given the average energy produced each month is not the same. The range of energy produced each month varies from a ratio of 1 to 2.4 this shows that the energy difference each month is very significant. Energy supply is stabilized using energy storage with a larger capacity. Let's recommend that the energy supply to the user is equal to the average energy product. If there is an oversupply, energy will go into energy stores and if there is a shortage it will be taken from energy stores.

The energy produced every day cannot be the same because the weather changes all the time. Different days at the same hour and the same month different energy products occur, especially during one season. This is due to different weather conditions so that the energy produced is also different. For one year there is never the same energy produced.

The daily energy ratio varies widely, taken from the lowest energy product in January which was only 88 Wh. The highest energy produced in August in one day is 477 Wh. So the comparison value is very large up to 5.4 times. It could be that the energy is low because black clouds cover the sun most of the day and the wind is not blowing hard. The energy product can be high because that day there is no clouds to cover the sun even though the wind is blowing slowly.

With the data from this daily energy research, it can be used to predict the load that will be carried out every day. Daily energy data is also important to know the ups and downs of energy every day. Daily load usage is highly dependent on the amount of energy generated by the PV/WT hybrid. The comparison of the value of daily energy products is very large, so if you want to build this plant, you must prepare a large energy storage device. Likewise, if the loading is only carried out at night, it requires a large energy storage device.

PV and WT energy are good to use because they complement each other so that they can be used as a source of electrical energy. Future hope can use 100 % PV and WT for electrical energy sources [20]. This statement can be true if it is equipped with large energy storage or combined with other generators, considering the energy produced by PV/WT is not constant.

The heat energy generated is used to heat the greenhouse, and the electrical energy obtained from the operation of the hybrid power system from a gas turbine can be used not only for lighting the premises, but can also be used for greenhouse needs [21]. This system can be combined with a PV/WT hybrid so that the energy supply can be fulfilled, properly considering the limited supply of bio gas.

Optimizing a hybrid renewable energy system consisting of WT/PV and battery, this device is big to meet the needs of just only one house [22]. This research is good because it takes into account the unstable weather changes so that it requires a fairly large device.

The same area as before will produce more energy [23]. If the PV performance can be increased then the energy produced will increase and the influence of the season can be reduced slightly.

The novelty of this research is the energy value of the PV/WT hybrid experiment every season, every month, every day and the comparison value of season, month and day energy.

The scientific problem that prompted this research was carried out. If the research on energy produced by hybrid PV/WT is only based on the strength of solar light and wind speed, it does not guarantee the results are correct, in fact the results will be far from the truth.

The results of this study can be used as a basis for planning a PV/WT hybrid power plant. The product of electrical energy can be calculated using the formula below:

$$n = Af/Ae,\ Et = n \times Ee,$$

where $n$ – the number of equipment units; $Af$ – area of land to be installed hybrid PV/WT; $Ae$ – unit area of equipment (2 $m^2$); $Et$ – total energy produced; $Ee$ – equipment energy can be taken from Table 1 or Table 2.

This PV/WT hybrid power plant is good if the load is used during the day according to the data from Fig. 5 and Table 1. With a large load during the day it does not require a large battery, so battery investment is reduced.

Energy from PV/WT hybrid power plants can be used 100 % by combining it with other power plants. That way, the energy from the PV/WT hybrid, no matter how small, can still enter other plants. This combination can also make energy supply to users uninterrupted at all because if the supply of hybrid PV/WT drops, the power plant will supply it.

The first weakness is that this research is only conducted in one place, so it is necessary to conduct research in other areas. The second weakness is that the direction of the solar cell (PV) cannot be changed and is only to one point of the sun during the day, so it is necessary to do further research using a controller to direct the solar cell according to the position of the sun.

## 7. Conclusions

1. Energy in the dry season is 78.296 Wh and in the rainy season it is 43,790 Wh.

2. Energy every month in a year is not the same, the energy produced every month ranges from 5,821 Wh to 14,174 Wh.

3. The average daily energy in the dry season is between 362 Wh to 457 Wh and in the rainy season between 197 Wh to 355 Wh. The lowest daily energy is 88 Wh and the highest is 477 Wh.

4. The ratio of energy in the dry season to the rainy season is 1.7 : 1. The ratio of the highest to the lowest monthly energy is 2.4 : 1. The ratio of the highest to the lowest average daily energy is 2.3 : 1 and the ratio of the highest to the lowest daily energy is 5.4 : 1.

## Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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