PERFORMANCE EVALUATION OF PHOTOVOLTAIC MODULE-BASED SOLAR POWER PLANT AT KADIRI AND APPLICATION OF DARRIEUS WINDMILLS TO IMPROVE ITS PERFORMANCE

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ABSTRACT

Conventional energy systems made a much larger contribution to the Indian energy industry than non-conventional energy systems, but they also had a negative influence on the environment and people's health. Additionally, the world's fossil fuel reserves have substantially decreased, which has altered the global energy landscape. This unflinching fact prompted many energy sector players to investigate alternative energy sources, which led to a surge in solar Photovoltaic (PV) module-based energy systems. Although PV module-based energy systems are known to be maintenance-free, their performance is affected by a variety of variables, including the impact of shadowing, the PV module's position and tilt, the temperature of the PV module, and the weather. The current performance of the Kadiri PV module-based power system will be estimated by considering several PV module parameters, including the module's maximum power output, fill factor, and efficiency. A correlation study will be conducted between the performance of a PV module-based energy system in terms of the maximum power point, fill factor, as well as module efficiency and the different input variables (shading as well as orientation of a PV module, tilt angle, temp of a PV module, and weather conditions). Later, an estimation of the impact of Darrieus Windmills put in various configurations on the efficiency of the PV module-based power system in Kadiri will be made, and correlative research between various parameters will be conducted.

Keywords: PV module, Darrieus Windmill, Performance ratio, Efficiency, Temperature.

I. Introduction:

Today's excessive need variation, demanding energy production due to a reduction in conventional fuel sources, and the relevance of renewable power all contribute to the ongoing fluctuation of the electric power distribution system. [1] The most important sources of these types of energy resources can be Wind and Solar energies, which are the most efficient relative. Solar panels can generate this same electrical energy needed during the day, whereas wind turbines could indeed recompense and satisfy the requirements at the night through wind energy. Solar was among the renewable sources of energy, and it is incentivized due to the fast reduction in traditional non-renewable energy sources. [2-3], The world's current thermal power plants produce most of the electricity used today. To satisfy the demands, we have simply turned to certain other renewable energy like wind and solar power because the load demand also is significant. Renewable energy sources like solar and wind were both economical and the capacity of the plant often takes up more room, however in this case we have decreased the size by mounting the solar cells just on wind turbine blades. There are two different types of wind turbines, each with unique benefits of VAWT just on the horizontal axis. [3-5] To store this hybrid energy produced by solar and wind, slip rings can be used to transfer solar and wind energy into one another and an energy storage system, such as batteries.

II. Objectives:

To be novel and intriguing by being radically different from conventional electricity.

To be closely tied to concerns with industrial electricity in the actual world, such as power quality.

Utilizing non-traditional resources

To create environmentally beneficial automobiles.

Design and development of a hybrid wind-solar power producing system.

To estimate the performance and evaluate a 1000 MW grid-connected solar power plant, performance ratio weather conditions, average six-month energy generation, and some theoretical causes of losses are suggested, along with similar techniques that can be used to reduce the losses and raise the plant's overall efficiency.

III. Theoretical analysis:

The properties of photovoltaic modules, including short circuit, open-circuit voltage, maximum output power, or instant efficiency, should be measured to ascertain how well they work as a power source. [6-7]

i. Since the PV modules resistance is unlimited, the current flowing through the shunt resistance could be disregarded.

ii. The PV module's circuit for producing light has the same short circuit current as the module itself.

a) Wind Energy Conversion system:

A permanent magnet synchronous generator (PMSG) produced by the wind energy conversion makes up the proposed hybrid renewable energy generation system. With the aid of a wind generator, which would be a rotating rotor of a PSMG winds generator to produce AC electrical energy, the WECS converts the wind potential energy into kinetic energy. [8-9]

$$P_W = 1/2\ A\ C_p(\lambda, \beta) * (V_w)^3$$

Where P_w =Generated Kinetic energy
A= Swept Area
Cp =Coefficient of rotor power
λ = tip speed ratio
β = pitch angle
Vw= wind speed velocity.

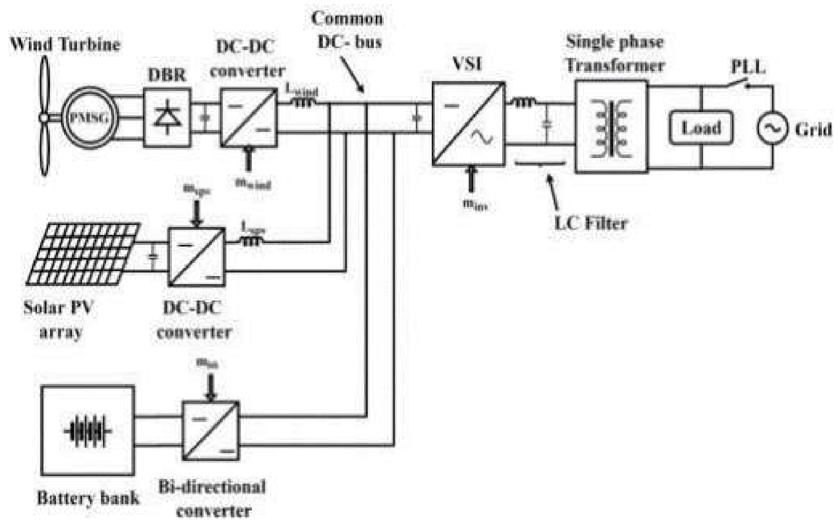

Fig.1: Block diagram of Wind hybrid solar power generation system

b) Solar PV System:

The solar PV system converts solar radiation into direct current (DC) electricity; the number of panels connected to the array determines the system's rating.

N_{series} = (Vmax DC/ Vmax) P and $N_{parallel}$ = (Imax DC / Imax P).

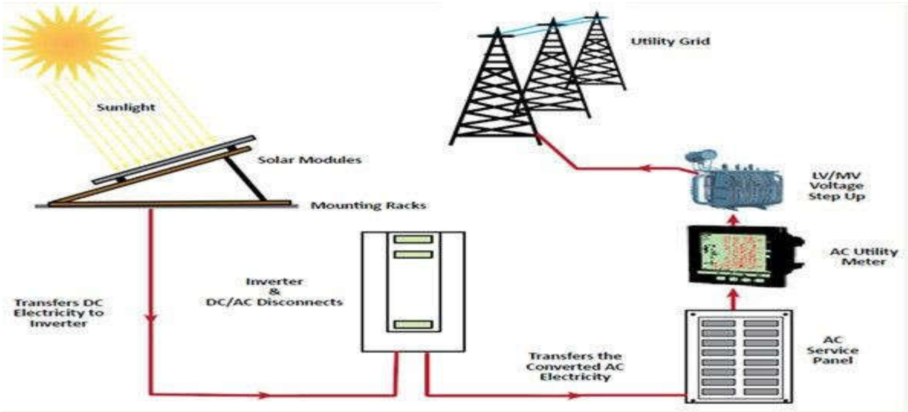

Fig.2: Grid Connected Solar PV System

Table.1: Specification of Solar Panel

Rated Values	**0.10 v, 600 mA**
Model Number	Js -2519100
Material	Polycrystalline silicon
Nominal Capacity	0.35 A
Size	52*19 mm
Thickness	200 µm
Colour	Blue
Model	Photo Voltaic cell

c) Tools:

1. Fill factor:

How much of the incident solar gets converted to usable electrical energy depends on how efficient the solar cells are

$$FF = \frac{I_{mp} * V_{mp}}{I_{sc} * V_{oc}}$$

$$\eta = \frac{I_{sc} * V_{oc} * FF}{P_s}$$

2. Performance Ratio:

The solar performance ratio shows the percentage of energy that is still available for export to a grid after accounting for energy losses. It describes the correlation and theoretical energy output of a solar PV plant besides taking environmental factors (temperature, irradiation, etc.) into consideration.

$$PR = \frac{\text{Energy Measured (KWh)}}{\textit{Energy Modeled (kwh)}} = \frac{Y_f}{Y_r}$$

$$= \sum P_{ac} \Big/ \sum \left(P_o * \frac{G_{poA,t}}{G_{ref,t}}\right)$$

Were

T= Point in time

P_{ac} = Measured AC Electricity Generation

P_o = Name plate DC power

G_{poA}, t = Measured P_{oA} irradiance

$G_{ref,t}$ = Irradiance at standard test conditions (1000 w/m^2).

3. Weather Corrected performance ratio (PR_{corr}):

Since the power varies with the variation in module temperature, it is crucial to consider the impact on PV module output performance, which is not considered in PR. More significantly, the losses comprise terms that translate power to the total operating module temperature, which is the difference between the ordinary PR and the weather-corrected PR. [13]

$$PR_{corr} = \frac{\sum P_{ac}}{\sum((P_o * (\frac{G_{poA,t}}{G_{ref,t}})(1 - \frac{y}{100(25 - Tmod)}))}$$

IV. RESULTS AND DISCUSSION:

The 1000 MW Grid Connected Solar PV System was built in Kadiri, Sri Sathya Sai district, which covers an area of 25.88 km2 and has an elevation of 504 m. The plant was completed in 2015, and its location is 738 meters above sea level. The plant has a total installed capacity of 1000 MWP. It is made up of parts A and B, each of which can produce 625 MW and 383 MW, respectively. Each polycrystalline-type PV module utilized in this system has a 285 WP rating, and there are 20 of them in total. These 20 modules are connected to make one string.

Table.2: Solar PV System

Kadiri, Andhra Pradesh, Latitude -14.1138○N, Longitude – 78.1611○ E			
S.N.O	V(v)	I(mA)	P(w)
1.	8	0	0
2.	8.6	68	0.5848

3.	9	122	1.098
4.	8.8	141	1.2408
5.	8	156	1.248
6.	7.4	176	1.3024
7.	6.3	196	1.2348
8.	4.2	210	0.882
9.	2.8	236	0.6608
10	0	252	0

Using a load connected across the maximum current and voltage indicated in the below table, we recorded the data with a multimeter and plotted the graph for both current and voltage as well as for power and voltage. By placing a load over it during the peak of the day's irradiance, which is midday, the maximum voltage and current are obtained.

Table.3: Maximum and Minimum Voltage and Current of Solar Panel

S.No	Time	Voc (v)	Vmp (v)	Isc (mA)	Imp (mA)
1	6:05	4.4	3	100	90
2	7:10	5.1	4	200	180
3	8:15	5.9	5	230	195
4	9:20	6.8	6	260	210
5	10:25	7.2	7.4	320	190
6	11:30	7.8	7.8	340	160
7	12:35	8.4	8.2	290	180
8	13:40	8	7.4	230	156
9	14:45	7.2	6.9	180	144
10	15:50	6.8	5	120	90
11	16:55	3.75	3	55	51
12	18:00	2	1.72	22	19

a) **Wind Output Parameters:**

The design parameters are considered

Length=100cm,Radius=32cm,Density=1.18kg/cm3,Circumference=25cm, Speed=3. The wind speed controls the amount of wind output. The estimated the wind speed by browsing the internet, and it is good between 2 and 6 o'clock. Varying wind speeds produce different amounts of wind production.

Table.4: Wind output Parameters

S.NO	Wind speed (m/sec)	RPM	V(v)	I(A)	P(w)
1.	5	165	1.8	0.89	0.712
2.	3.2	138	1.14	0.49	0.5586
3.	Manual	120	3.22	1.85	5.95

b) **The total output of the Gird Connected Wind and Solar System:**

Following the connection of the solar and wind inputs to the appropriate converters and then to the charge controller, are getting the results shown below. In this configuration, are using two separate boost converters, one for the PV unit and one for the wind system (their outputs are shown above).

Table.5: Total output of Wind Solar Power generation

S.No	V(v)	I (mA)	P(w)
1.	9.6	0	0
2.	11.2	0.9	10.8
3.	13.4	1.1	14.74
4.	14.1	1.9	26.79

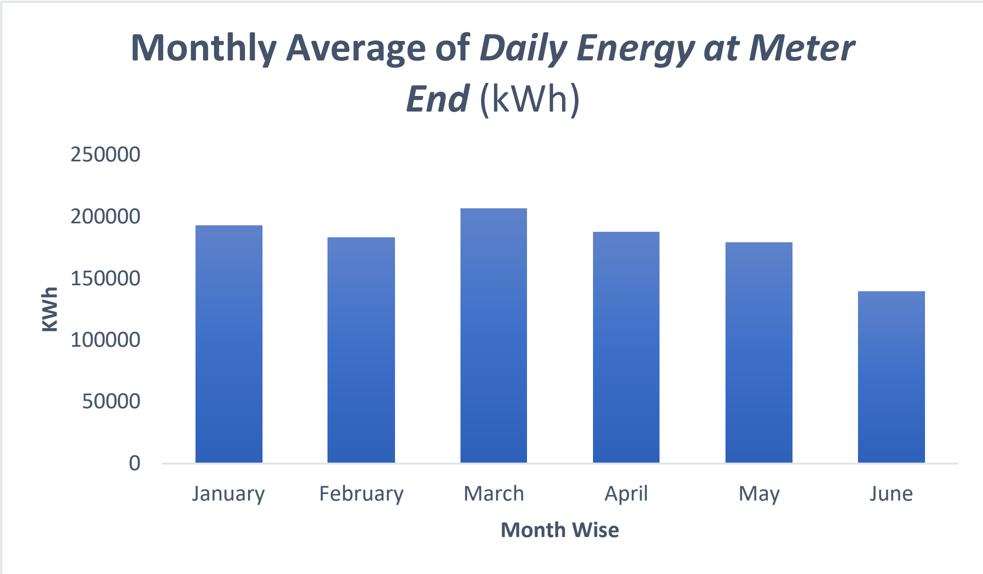

Fig.4: Monthly Average of Generated Energy

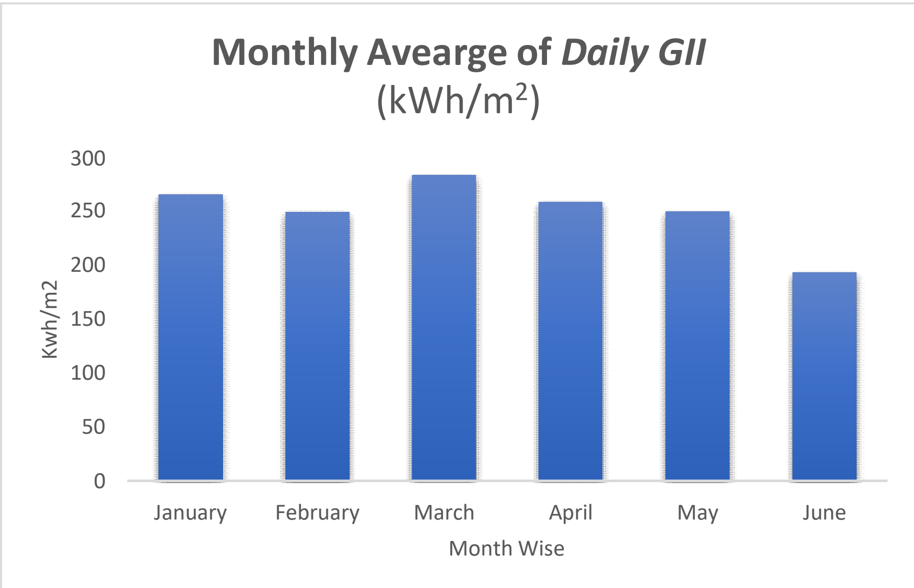

Fig.5: Monthly Average of Daily GII (kWh/m^2) Irradiation.

The figure 4 and 5 show that the Monthly average of both irradiation and generated energy of solar and wind energy comparing the results the month of March got maximum and minimum in June.

Table.6: Overall output of Generation Hybrid Connected Solar and Wind energy

Month	Irradiation in Inclined Plane (GII) (kWh/m2)	Generated Energy (KWh)
January	264.6795	192624.4736
February	248.8784	183091.9636
March	282.8512	206297.7497
April	258.1423	187463.8179
May	249.2125	178762.5244
June	192.7369	139451.6551
Half-yearly	1496.5008	1087692.184

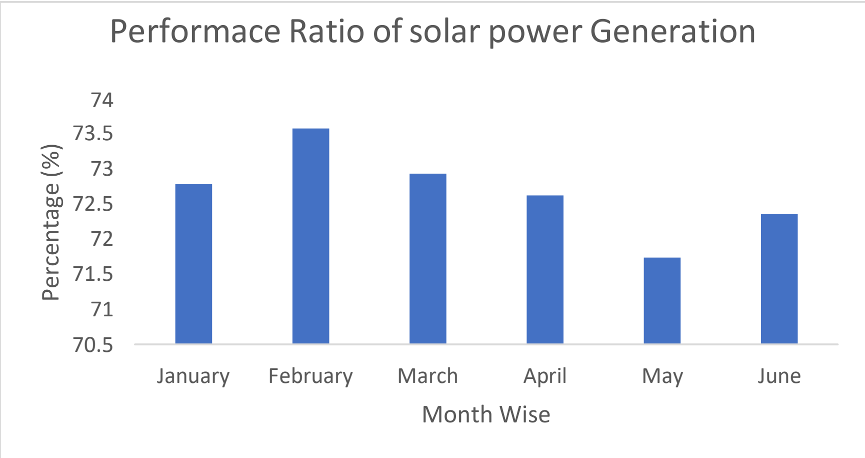

Fig.6: Monthly Average of Performance Ratio of Hybrid Power Generation of Solar and Wind energy

The Monthly average performance ratio of solar and wind energy-based hybrid power generation is shown in the Fig 6. It is common to refer to the indicator of a plant's quality as a quality factor because it is location independent. It considers the gird's accessibility, the amount of radiation required to produce the electrical energy, as well as the radiation levels at a specific time. The ideal analysis timeframe is typically one year. The month of February has the highest performance ratio.

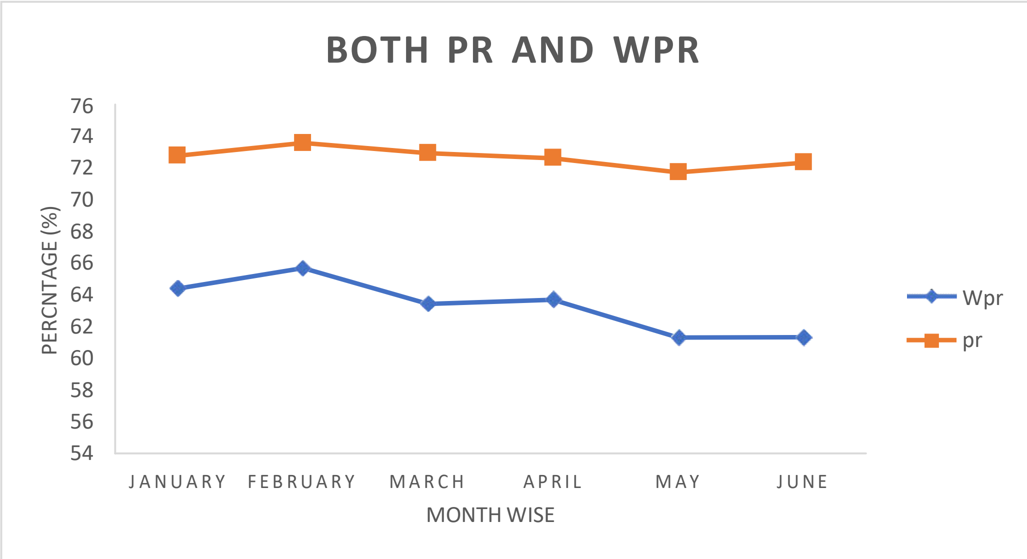

Fig.7: Monthly Average of Both Performance and Weather Corrected Performance ratios.

In the figure 7 performance and weather-corrected performance ratios were observed as a monthly average. When the weather is ideal in April and the sun orientation is at its highest, the percentage of energy produced is at its highest.

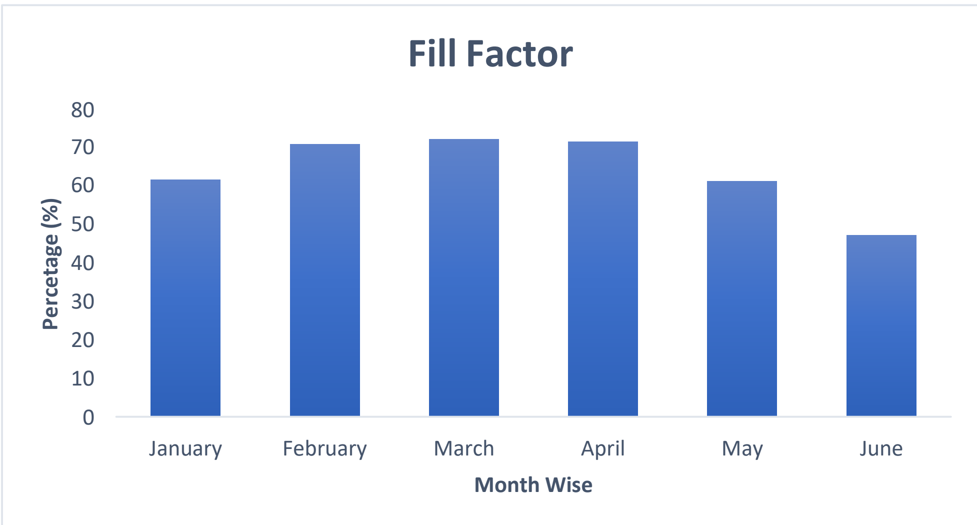

Fig.8: Monthly Average of Fill factor of Hybrid Power Generation of Solar and Wind energy

The Figure 8 shows the monthly average fill factor for solar and wind energy hybrid power generation. The term "fill factor" refers to the relationship between the maximum power that can be used and the sum of the open-circuit voltage and short circuit current. the proportion of an image sensor's pixels total area to their light-sensitive area. It is a crucial factor in determining how effectively an organic solar cell converts sunlight into power. In March, solar cells have a high fill factor.

V. CONCLUSION:

In Kadri, Andhra Pradesh, the solar PV generation from January to June of 2021 was evaluated. The coordinates are 14.1138 N and 78.1611 E. In the modern world, where new technologies are constantly being developed, maintaining an uninterrupted power supply is a major problem. Additionally, the amount of area needed to install renewable energy sources is important. The hybrid technology overcomes the space issue while ensuring a steady supply of power. The performance ratio is maximum at 73.5% in February and Minimum at May 71.73%, the weather performance ratio is maximum in February and Minimum in at May 61.12%. The fill factor is Maximum at 71% in March and Minimum in at June 47%.

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