Proceedings of the 2nd Faculty of Industrial Technology International Congress
International Conference
Bandung, Indonesia, January 28-30, 2020
ISBN 978-623-7525-37-0

Ratio Optimization of Wind-Solar Hybrid System

Muhammad Haekal[1*], Dani Rusirawan[2], and Istvan Farkas[3]

[1] Graduate Student of Mechanical Engineering, Szent Istvan University, Godollo – HUNGARY

[2] Department of Mechanical Engineering, Institut Teknologi Nasional (Itenas), Bandung – INDONESIA

[3] Department of Physics and Process Control, Szent István University, Godollo – HUNGARY

* Corresponding author e-mail: mhaekalt@gmail.com

Abstract

Indonesia is located in equator line which mean it has a constant period of solar radiation period throughout the year, as identified about 4.80 kWh/m2/day. The potential of wind energy is about 60,647 MW which only 0.01% is used. Therefore, in order to meets the target by 2025 and 2030 Indonesia needs to utilize renewable energy sources. Wind and solar energy appears to a prospective solution mentioned that the fast growing of both technology resulting in the decrease of its total system cost. Moreover, couple both sources energy somehow lowered the cost as well as tackle the issue of their intermittent sources. In this study, simulation of wind-solar hybrid system will be done with various capacities and will be compared with a system with 100% solar and 100% solar.

Keywords: Hybrid, Solar, Wind, Renewable Energy

1. Introduction

Traditionally, fossil fuels are used as primary sources of energy. However, harmful gas emission due to the burning of fossil fuels has challenged the future viability of the human civilization that is depending on conventional energy sources.

Moreover, under the Paris Agreement in 2015, member countries have to meet the proposed target by 2025 or 2030. Utilizing renewable energy sources come as one of the solutions to encourage the substitution for fossil fuel energy which likely result in reducing greenhouse gas (GHG) emission in the atmosphere and meet each countries target. As for Indonesia, the country sets its target to increase 23% of electricity are generated from renewable energy resources by 2025 and reduce GHG emission to 29% by 2030

Indonesia is located in the equator line, and therefore it has a constant period of solar radiation period throughout the year, as identified is about 4.80 kWh/m2/day. The potential of wind energy is about 60,647 MW, and presently only 0.01% is used. Based on this fact, it can be predicted that a hybrid renewable energy system between wind and solar energy is a potential solution to have a contribution to meet the national strategy.

Table 1: Renewable Energy Resource Potential in Indonesia (Source: Rencana Umum Energi Nasional, 2017)

No	Energy Sources (MW)	Potency (MW)	Installed Capacity (MW)
1	Geothermal	29,544	1,439
2	Hydro	75,091	4,827
3	Micro-Hydro	19,385	197
4	Bio Energy	32,654	1,671
5	Solar	207,898	79
6	Wind	60,647	31
7	Ocean	17,989	0
Total		443,208	

The sequences of the simulation process are as follow: fully of the photovoltaic (100% PV), fully of the wind turbine (100% WECS = wind energy conversion system), and varying of the ratio between solar and wind, as a hybrid system. The expected outcome of this study is try to find the optimal ratio between photovoltaic and wind turbine in hybrid system, in the certain area, for the predetermined of the capacity.

2. Hybrid Resources Energy System

(Mita Bhattacharya et al.) in their study about the effect of renewable energy on economic growth found that wind, solar PV, and hydropower are the sources having significant growth in the electricity sector. Besides, the rapid development of wind and solar has a significant contribution to the position of renewables as a vital part of the global power mix and resulting in the technical maturity and their cost.

(Mehdi Ben Jebli et al.) mentioned with the rapid reduction in the cost of the main system components including PV panels, wind turbines, and batteries, the total system cost is considerably decreased. As the result of today fast-growing rate of renewable power production based on wind and photovoltaic systems.

(Jeffy Johnson, et al) studied the feasibility of a 200 kW solar wind hybrid system in the Dehradun district (Uttarakhand, India). The study is using Homer for simulation with the model as shown in Fig. 1.

Fig. 1: Hybrid System Model (Source ….)

The model consists of solar PV system (100 kW), Wind turbine generator (100 kW), DC/AC converter (100 kW). Lead-acid battery storage, 100 kW h (1 kW h, 100 strings) and Electrical Load (193.80 kW h/day). By assuming the load profile, operation and maintenance cost, lifetime and derating factor, it was found that the yearly average electricity production was 55.56% by wind energy and 44.44%. The total net present cost or life-cycle cost (NPC) of the system is about $1,774,269. The operating cost of the project during its entire lifetime is obtained at $3,277 — comparison with a generator only system (considering a 200 kW diesel generator costing $15,000). The total net present cost of a generator only system is $7,062,077. The total operating cost will be $267,807.

(I.A. Adejumobi et al.) studied a hybrid solar-wind power in Information Communication Center (ICT) infrastructure and communities in rural areas. The calculation of estimated load in ICT, Bank, and Hospital was done in this research. Furthermore, the model mainly consists of photovoltaic that produced direct current (DC) electricity and wind turbine system was transported to DC Disconnect before entering Mix Controller (Fig. 2)

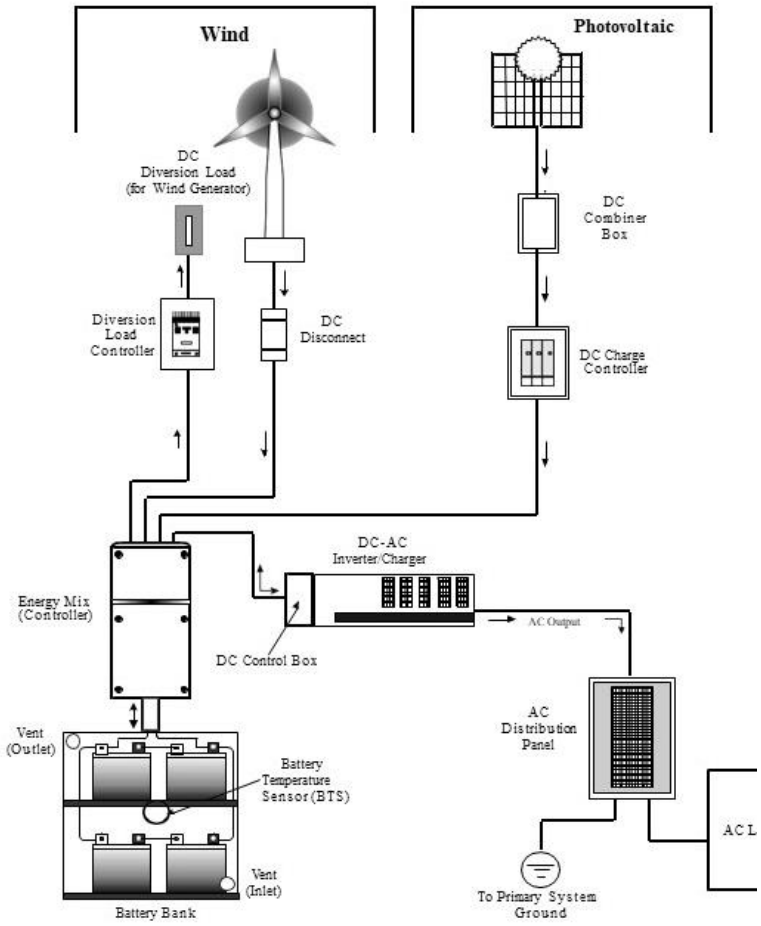

Fig. 2: Schematic Diagram of Hybrid System (Source ….)

The off-grid (stand-alone) system are suggested since there is no utility grid service in a rural area. Moreover, the off-grid system is considered economical in providing electricity at remote locations especially rural banking, hospital and ICT (Information Communication Technology) in rural environments.

3. Input Data

Cipatujah (West Java, Indonesia) is selected as the location of the study. Solar and wind data were obtained for the location through NASA (National Aeronautics and Space Administration) database through its site. As the latitude and longitude of which was assumed to be the same as that of Cipatujah, West Java, Indonesia.

- Latitude: -7.7294
- Longitude: 107.9152

As Figure 3 and 4 show, the simple average of the data was obtained. Direct normal irradiation is found to be 4.21 kW h/m^2/day, while the average wind speed at 10 meters and 50 meters are 4.68 m/s and 5.55 m/s respectively.

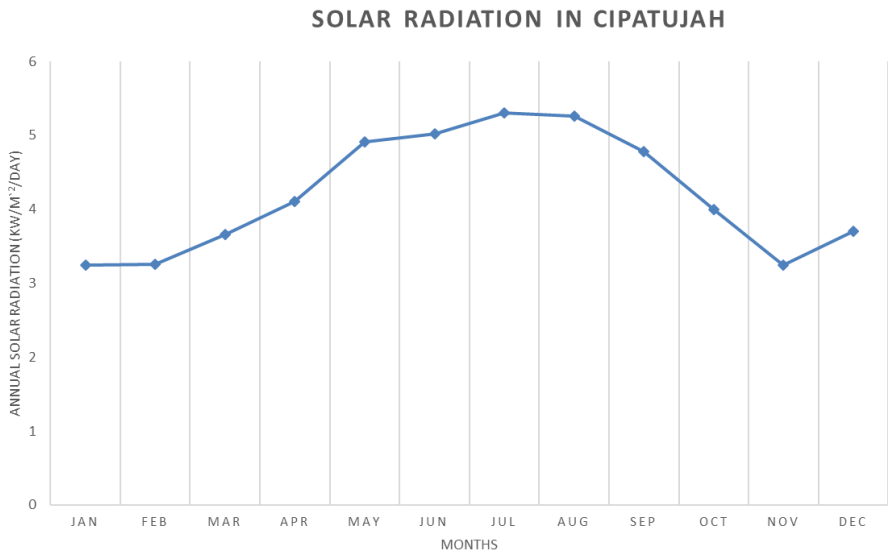

Fig. 3: Solar radiation in Cipatujah (Source: NASA Database)

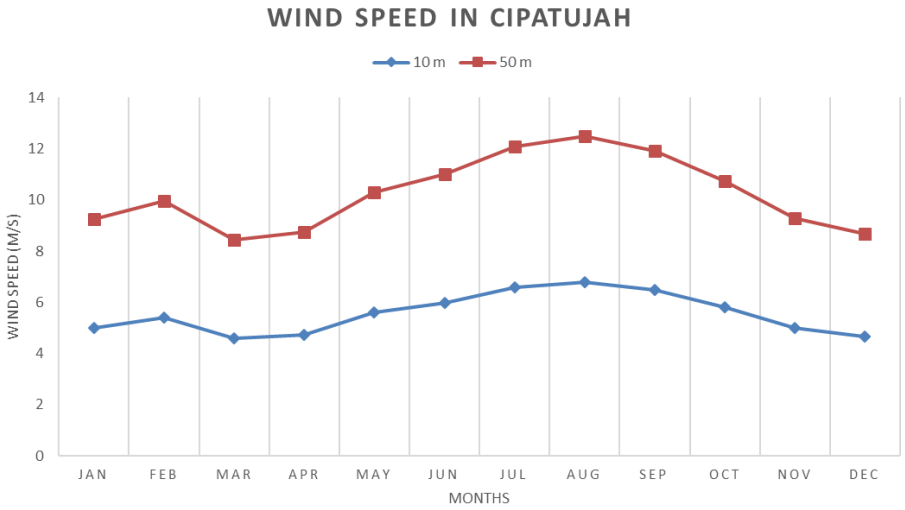

Fig. 4: Wind speed in Cipatujah (Source: NASA Database)

4. Simulation

In this study, the simulation will be done using HOMER (Hybrid Optimization Model for Electric Renewables) and RetScreen. HOMER simulations are performed by analyzing energy balance calculations and show all possible configurations arranged by net present cost which can be useful for comparison of system design. It also facilitates us to carry out sensitivity and optimization analysis. On the other hand, RET Screen can perform technical, financial, and economic analysis and risk and sensitivity evaluations. The proposed case is comparable with the best case to understand the plus-points.

5. Expected Result

The proposed study's primary goal is acquiring the optimal ratio between photovoltaic and wind turbines through. At first, the simulation will be done for fully photovoltaic, fully wind turbines, and various ratios between solar and wind hybrid systems, which the capacities of 10 KW, 50 KW, and 250 KW. Also, the long-term target is providing a method for optimized the hybrid system will be proposed as well as the differences between the existing and suggested method will be found.

6. References

ArcGIS Web Application, available at https://power.larc.nasa.gov/data-access-viewer/, accessed on January 2, 2020.

Ben Jebli, M., & Ben Youssef, S. (2015). Output, renewable and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable Energy*, *83*, 799-808. doi: 10.1016/j.renene.2015.04.061

Bhattacharya, M., Paramati, S., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy*, *162*, 733-741. doi: 10.1016/j.apenergy.2015.10.104

Datta, U., Kalam, A., & Shi, J. (2018). Hybrid PV–wind renewable energy sources for microgrid application: an overview. *Hybrid-Renewable Energy Systems In Microgrids*, 1-22. doi: 10.1016/b978-0-08-102493-5.00001-7

I.A., A., S.G., O., F. G., A., & M.B., O. (2011). Hybrid Solar and Wind Power: An Essential for Information Communication Technology Infrastructure and People In Rural Communities. *IJRRAS*, *9*(1), 130-138.

Johnson, J., Mondal, S., Mondal, A., Rana, S., & Pandey, J. (2018). Feasibility Study of a 200 kW Solar Wind Hybrid System. *Applied Solar Energy*, *54*(5), 376-383. doi: 10.3103/s0003701x18050080

Rencana Umum Energi Nasional, available at https://www.esdm.go.id/assets/media/content/content-rencana-umum-energi-nasional-ruen.pdf, accessed on December 20, 2019.