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Solar/Wind Hybrid Electric Building Modeling for Housing Construction in Mountainous Lands Based on Homer Pro

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ABSTRACT

The rapid urbanization and population growth in the lowland regions of Semarang have led to significant increases in energy demand, necessitating the exploration of sustainable energy solutions to meet these challenges. This study addresses the critical issue of fulfilling energy requirements by implementing a hybrid renewable energy system (HRES) that integrates solar and wind energy sources. The primary objective of this research is to evaluate the feasibility, performance, and economic viability of this hybrid system in residential applications, utilizing HOMER Pro software for comprehensive modeling and optimization. The methodology involves a detailed analysis of the solar and wind energy potential specific to the region, an assessment of local energy consumption patterns, and a thorough economic evaluation, including metrics such as Net Present Cost (NPC) and Cost of Energy (CoE). The findings reveal that the HRES can generate a total annual energy output of 7,521 kWh, with a significant surplus of 2,629 kWh available for sale back to the grid. This research highlights the potential of hybrid solar and wind systems to enhance energy sustainability, reduce greenhouse gas emissions, and mitigate reliance on fossil fuels, thereby contributing to developing a more resilient energy infrastructure in lowland regions.

1. Introduction

Energy needs continue to increase along with population growth and infrastructure development, which is a big challenge in managing energy resources. In Indonesia, dependence on limited fossil energy sources and their negative impact on the environment encourages the search for renewable energy alternatives [1]. Solar and wind energy are two potential and environmentally friendly renewable energy sources [2]. It is hoped that utilizing these two types of energy in the form of a hybrid system can be an effective solution to meet energy needs, especially in residential areas [3]. Solar and wind hybrid systems can combine solar and wind energy sources to produce electricity

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in energy supply reliability because when one energy source is not available, the other energy source can be used as the primary source [4]. The implementation of this renewable energy can reduce dependence on fossil energy sources and is more environmentally friendly as it can decrease greenhouse gas emissions [5].

Residential areas in the Semarang area have great potential for implementing solar and wind hybrid energy systems. Semarang's geographical location, which is located in the tropical region, provides advantages in terms of high intensity of sunlight throughout the year, as well as significant wind potential, which can be utilized for energy production [6]. In addition to ensuring a sustainable energy supply, combining these two renewable energy sources into a hybrid system lowers greenhouse gas emissions and lessens reliance on fossil fuels [7]. Nevertheless, several obstacles must be solved before a hybrid energy system powered by solar and wind can be installed in residential sections of Semarang. The high initial investment expenses, which include buying equipment like solar panels, wind turbines, and inverters, are one of the significant obstacles [8]. For the planned Hybrid Renewable Energy System (HRES) system to be economically and energy-efficient, much study is required to determine when it will be widely implemented [9-11].

One practical way to save expenses in research on HRES that combine solar and wind power is to utilize Homer Pro software [12,13]. With the program, one can simulate different solar and wind energy combinations to find the most cost-effective and efficient designs without significant physical expenditures [14]. The program optimizes the arrangement of solar panels, wind turbines, and inverters and computes startup, operating, and long-term savings [15]. Stable energy supply is ensured by reliability analysis, and optimal design functionality is verified by performance simulations conducted in real-world settings. Sensitivity analysis also aids in comprehending how shifting certain variables affects system performance [16,17]. Homer Pro provides detailed reports to support investment and operational decisions that can help overcome HRES-related challenges and pave the way for efficient and economical deployment of hybrid energy systems [18].

Many previous studies have addressed the potential of solar and wind energy separately. However, there is still a gap in the literature regarding integrating these two energy sources in the specific context of low-lying areas, such as the city of Semarang, as per previous research by *Al Afif et al.,* [19] and Al Essa [20] Show that hybrid systems can improve energy efficiency, but no studies have specifically examined implementing hybrid systems in areas with unique geographical and climatic characteristics, such as Semarang. Therefore, this study contributes to developing new knowledge on designing and implementing hybrid systems in lowland areas.

Hybrid solar and wind energy systems offer energy supply reliability, enable more efficient land use, and reduce greenhouse gas emissions. By utilizing the high sunshine potential and significant wind speed in Semarang, this study aims to evaluate the hybrid system's performance in meeting household energy needs. However, several challenges must be overcome before hybrid energy systems can be widely deployed, including high initial investment costs and the need for further research into these systems' economic and technical viability. Using HOMER Pro software, this research will analyze the potential of solar and wind energy in Semarang and evaluate the optimal hybrid system design. The results of this study are expected to contribute significantly to the development of the renewable energy sector in Indonesia, as well as serve as a guide for the government, communities, and housing developers in reducing dependence on fossil fuels and increasing the use of environmentally friendly energy sources.

2. Methodology
2.1 HOMER Modelling

The Cost of Energy (COE) of a hybrid power generating system comprising solar panels photovoltaic (PV) and wind turbines may be easily computed using the HOMER program. HOMER simulations incorporate several critical variables, including the amount of solar and wind energy that can be generated at the study site, load profiles for energy consumption, technical details of individual system components (PV module and wind turbines), and economic analysis to ascertain the costs associated with producing energy [21]. Figure 1 shows the HOMER simulation framework involving necessary energy system design and evaluation steps.

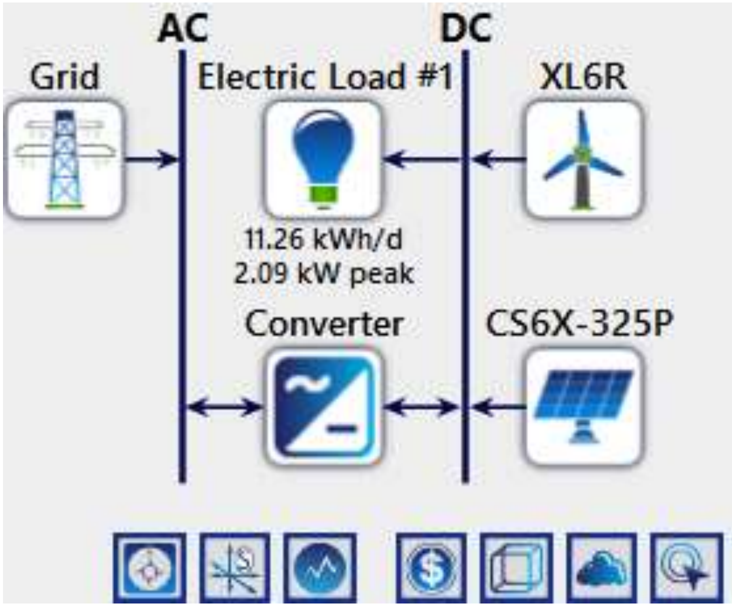

Fig. 1. Homer system configuration

HOMER is a comprehensive analytical tool for collecting and evaluating data on the characteristics of solar radiation and wind speed at a particular location. This data is essential for determining the potential energy that can be generated by PV systems and wind turbines. This study's main components include a 0.325 kW solar panel (Canadian Solar 6X-325P) and a 6kW horizontal wind turbine (Bergey Excel 6R), accompanied by an AC-DC inverter. Daily or weekly load profile analysis will be conducted to determine the optimal size of each system component to ensure consistent and efficient energy availability. Figure 2 shows the characteristics of solar radiation or radiation that often occurs in the Semarang area, while Figure 3 illustrates the wind speed data.

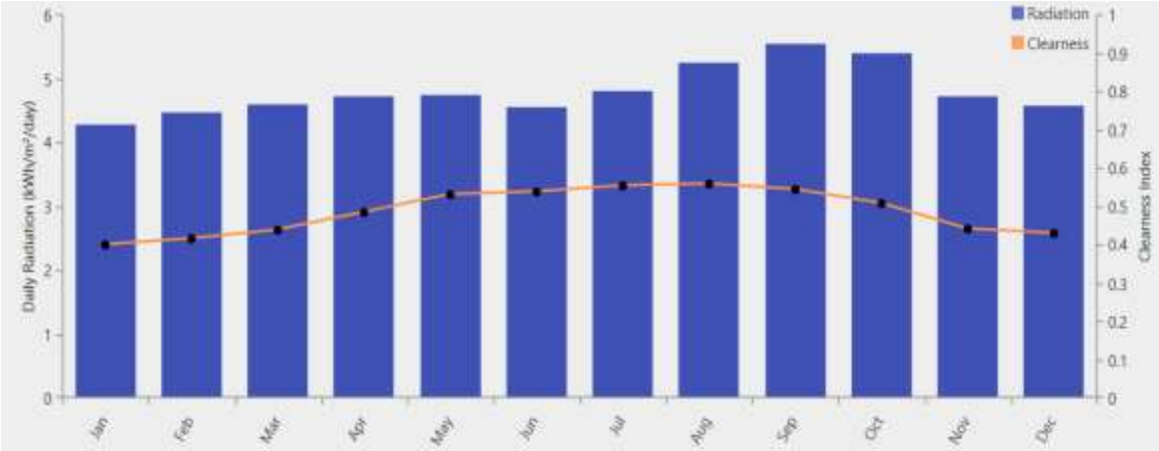

Fig. 2. Average of solar intensity in Semarang

Fig. 3. Average of wind speed in Semarang

Utilizing the collected data, HOMER software conducts simulations aimed at optimizing the capacity of the integrated PV and wind turbine system. A comprehensive technical analysis ensures the hybrid system can generate sufficient energy to meet the anticipated consumer load requirements. Concurrently, an economic analysis is performed to evaluate the costs associated with the initial investment, ongoing maintenance, and the overall cost of energy production over the system's operational lifespan. The analysis reveals that, with a maximum load of 2.09 kW, the daily power consumption in residential areas is estimated to be 11.26 kWh. Furthermore, Table 1 presents the investment values for various components utilized in this HRES, providing a detailed overview of the financial implications of deploying this integrated energy solution. This dual approach of technical and economic assessments facilitates informed decision-making regarding the feasibility and sustainability of the proposed energy system.

Table 1
HRES system components [22,23]

Parameter	PV	Wind Turbines	Converter
Name	Canadian Solar 6X-325P	Bergey Excel 6R	Generic Inverter
Rate Capacity	0.325 kw	6 kw	1 kw
Capital (IDR)	2,000,000.00	38,500,000.00	Rp. 10,700,800.00
Replacement (IDR)	2,000,000.00	38,500,000.00	Rp. 8,534,000.00
O&M (IDR/year)	200,000.00/year	3,550,000.00	Rp. 320,580.00
Life Time	25 years	30 years	10 years

This entire simulation process helps in determining the CoE, namely the cost of energy production, which is a critical parameter in assessing the economics of the HRES PV-Wind system [24]. This tool provides critical insights that support innovative and sustainable investment strategies, enabling stakeholders to evaluate the feasibility, performance, and economic viability of various renewable energy systems.

2.2 Energy Analysis

The simulation results from HOMER produce an economic analysis of two main aspects: output power analysis and cost analysis. Output power analysis measures a hybrid system's energy production capacity, consisting of energy produced by solar panels PV and wind turbines [25]. Solar panels convert solar energy into electricity, while wind turbines harness the wind's kinetic energy to produce electricity. These two energy sources complement each other in providing stable and sustainable power, depending on weather conditions and energy needs at the study location [26]. This analysis is essential for evaluating the performance and efficiency of renewable energy systems in an economic context and determining the sustainability and return on investment in the long term [27]. The following Eq. (1) is used to calculate the output power of the PV panel.

$$P_{PV} = Y_{PV} \times f_{PV} \times \left(\frac{G_T}{G_{T,STC}}\right) \times \left[1 + \alpha_P\left(T_c - T_{c,STC}\right)\right] \tag{1}$$

Where, Y_{PV} is the nominal capacity of the PV panel, f_{PV} is the reduction factor of the PV panel, G_T is the solar radiation received by the PV panel at the current time, $G_{T,STC}$ does the PV panel receive the radiation under standard conditions, is the power temperature coefficient, T_c is the temperature of the PV panel at the current time, and $T_{c,STC}$ is the temperature of the PV panel at standard test conditions [28].The following Eq. (2) is used to calculate the output power of the wind turbine.

$$P_{WTG} = P_{WTG,STP} \times \left(\frac{\rho}{\rho_0}\right) \tag{2}$$

Where, P_{WTG}does the wind turbine produce the power, $P_{WTG,STP}$does the wind turbine produce the power under standard conditions, ρ is the actual density of air, and ρ_0 is the density of air under standard conditions [29].

2.3 Cost Analysis

Determining the economic cost of a HRES involves analyzing two key financial metrics: Net Present Cost (NPC) and CoE [30].The NPC value can be determined using Eq. (3) below.

$$NPC\ (Rp) = \frac{TAC}{CRF} \tag{3}$$

Where, TAC is the total annual cost and CRF. The capital return factor is calculated using Eq. (4).

$$CRF\ (Rp) = \frac{i(1+i)^N}{[(1+i)^N - 1]} \tag{4}$$

Where, N is the number of years and i is the annual accurate interest range (%). CoE energy costs are the average unit cost of energy produced (IDR/kWh) [13], which is calculated using Eq. (5).

$$COE\ (Rp/kWh\ ) = \frac{C_{tot.ann}}{E} \tag{5}$$

Where, $C_{tot.ann}$ is the total annual cost, and E is the total energy consumption per year. Then, return on Investment (ROI) is calculated by dividing the difference in the cost of capital by the difference in the annual average nominal cash flows over the life of the project [31]. The return on investment is calculated using the following Eq. (6).

$$ROI = \frac{C_{i,ref} - C_i}{R_{proj}\ (C_{cap} - C_{cap,ref})} \tag{6}$$

Where, $C_{i,ref}$ represents the nominal annual cash flow for the base (reference) system, C_i denotes the nominal annual cash flow for the current system, R_{proj} indicates the project lifetime in years, C_{cap} refers to the capital cost of the current system and $C_{cap,ref}$ Signifies the capital cost of the base system. The last economic parametric is a simple payback period (SSP). This is a financial metric used to determine the time it takes for an investment to generate enough cash flow to recover its initial cost—the formula for calculating the simple payback period on Eq. (7).

$$SSP = \frac{Initial\ Investment}{Annual\ Cash\ Flow} \tag{7}$$

According to the Central Statistics Agency Indonesia, Semarang has a BI discount rate of 6.25% in 2024 [32]. This HRES system has projections for up to 25 years, considering the value of inflation each year.

Fig. 4. Annual inflation

3. Results

3.1 Homer Simulation Result

In this research, simulations were carried out using HOMER PRO software to help model a hybrid power generation system that combines solar and wind power. For housing in mountainous areas. Homer Pro is an abbreviation for Hybrid Optimization Model of Electrical Renewables, which functions as a tool for creating system designs from Renewable Energy [33]. This software can simulate and optimize power generation systems that are either stand-alone or connected to a combination of EBT such as PLTS, PLTB, PLTMH, and PLT Bio, which are combined with generators (diesel/gasoline) to serve the electricity load [34]. Table 2 shows the total annual energy production.

Table 2
Total annual energy production

Production	Kwh/Year	Percent (%)
Canadian Solar MaxPower CS6X-325P	471	6.27
Bergey Excel-6R	5,396	71.7
Grid Purchases	1,655	22.0
Total	7,521	100

The simulation results establish that the Canadian Solar MaxPower CS6X-325P solar plate panels have an energy output of 471 kWh every year, roughly 6.27% of the energy produced by the system. On the other hand, The Bergey Excel-6R wind turbine stands out as the most significant energy producer, with an energy output of 5,396 kWh per annum; this constitutes 71.7% of the total energy produced in the year. This enormous output emphasizes the role of wind energy in the hybrid renewable energy system. Moreover, the grid's energy purchase is also incorporated as part of the energy utilized in the system; these purchases add up to 1,655 kWh/year, which is 22.0% of the total energy supplied. These results also indicate that all energy demands can be met by grid and renewable sources, showing the significance of the variety of energy generation methods on the reliability and sustainability of the system. The results can encourage optimizing hybrid energy systems during forthcoming projects to boost renewable energy.

Overall, the total annual production from this system reaches 7,521 kWh. The data in Table 3 shows that although this hybrid system can produce most of the energy needed, purchasing power from the electricity grid is still required to meet total energy needs. These results emphasize the importance of combining various energy sources in a hybrid system to increase the reliability and stability of energy supplies, especially in mountainous areas with varying weather conditions.

Table 3
Total annual energy use

Consumption	Kwh/Year	Percent (%)
DC Primary Load	4,108	61.0
Sales Grid	2,629	39.0
Total	6,737	100

Simulations conducted using HOMER PRO indicate that the primary fuel cell (FC) load necessitates an annual energy consumption of 4,108 kWh, which accounts for 61.0% of the total yearly energy usage of the system. This substantial demand highlights the fuel cell's critical role in meeting the facility's energy requirements. In addition to fulfilling its internal energy needs, the system can generate a considerable energy surplus of 2,629 kWh per year. This surplus represents 39.0% of the total energy production and can be sold back to the electricity grid, thereby contributing to the overall economic viability of the system. The ability to produce excess energy enhances the operation's sustainability and provides an additional revenue stream, reinforcing the importance of integrating renewable energy technologies into modern energy systems.

The total annual energy consumption of the hybrid power generation system reached 6,737 kWh, demonstrating its effectiveness in meeting the energy needs of households located in mountainous regions. This system satisfies internal energy requirements and showcases its efficiency in generating surplus energy, which can be sold, thereby enhancing its economic viability. The ability to produce excess energy underscores the financial potential of hybrid solar and wind power systems, particularly in challenging geographic conditions such as highland areas. Furthermore, this capability supports energy sustainability by providing a reliable and renewable energy source that can reduce dependence on conventional energy supplies. The findings highlight the advantages of integrating diverse renewable energy technologies, emphasizing their role in promoting energy independence and economic benefits in regions characterized by unique topographical challenges. Overall, this hybrid system represents a promising solution for enhancing energy access and sustainability in mountainous environments.

3.2 Cost Projection

Cost Projection in this research aims to evaluate the costs associated with constructing and operating solar/wind hybrid electric buildings for residential construction in mountainous areas. The methodology includes collecting data and costs from various sources, such as supplier component prices, installation costs, and operational costs, which are then analyzed using Homer Pro software to simulate system configurations. The components analyzed include initial investment, installation, operational, and maintenance costs. Cost data was collected through market surveys, interviews with suppliers and contractors, and secondary data from literature and industry reports, which were then input into Homer Pro for further analysis. The analysis includes calculating the total initial investment costs, simulating various system configuration scenarios in Homer Pro to determine the most economical combination, analyzing operational costs, and combining initial and operational costs to obtain total costs over the system's life.

The potential energy produced from developing solar/wind hybrid electricity for housing construction in the mountains is an economical and sustainable solution. Carrying out simulations using the Homer Pro application is hoped to help develop better decisions regarding investment in solar/wind hybrid electricity systems for housing in mountainous areas. The cost summary was stated in Table 4 below.

Table 4
Cost summary

Type	Base case	Lowest cost system
Npcs	Rp. 212,875,000,000.00	Rp. 191,780,000,000.00
Initial Capital	Rp. 19,700,000,000.00	Rp. 43,200,000,000.00
O & M	Rp. 9,630,000.00 / year	Rp. 7,400,000.00 / year
LCOE	Rp. 2,584.00 /kwh	Rp. 2,158 /kwh

3.3 Monthly Electric Production

Monthly electricity production is generated by a solar/wind hybrid system implemented in mountainous areas. Simulations using Homer Pro are used to detail the total amount of electricity produced each month, identify production trends based on seasonal variations, and analyze system performance from various points of view, including efficiency and emissions. Figure 5 presents the Homer system simulation results regarding estimated monthly electricity production of around 0.87 Megawatts. This peak production correlates with the high intensity of sunlight in that month. In addition, the most significant wind speeds were recorded in August, significantly contributing to energy production, especially in mountainous areas. This combination of solar and wind energy potential means the airport has optimal conditions to utilize renewable energy sources effectively throughout the year.

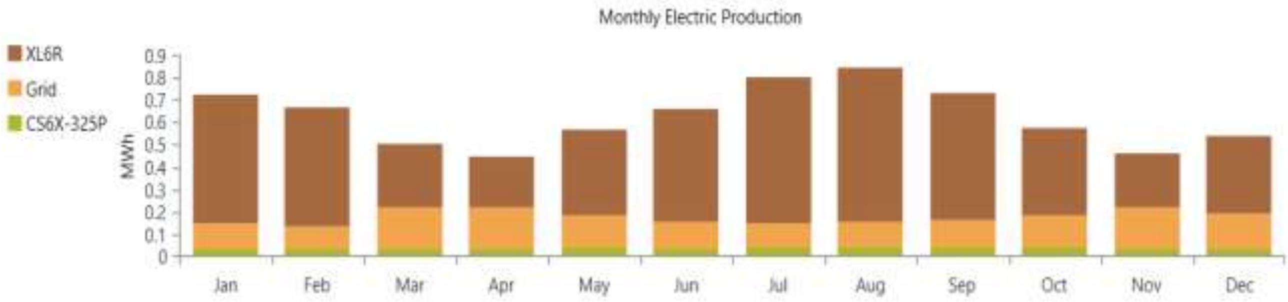

Fig. 5. Monthly production

Based on the graph above, it is known that monthly electricity production is divided based on three sources, namely XL6R (wind turbine), Grid, and CS6X-325P (Solar panels), which are marked with the sequential colors brown, orange, and green. Regional factors and wind speed greatly influence electricity production from wind turbines, resulting in variations in electricity production. On the other hand, the contribution from the leading electricity network or grid, marked in orange, is relatively constant throughout the year with slight variation. Meanwhile, the CS6X-325P source, marked in green, provides a minor contribution compared to the other two sources and is also relatively constant throughout the year. Total monthly electricity production, measured in MWh (megawatt-hours), is the sum of the contributions of these three sources. This graph shows that electricity production tends to be higher during summer (June, July, August) and lower during winter (December, January, February).

4. Conclusions

The simulation results indicate that integrating renewable energy sources can fulfill approximately 61.0% of the total energy requirements for residential areas in Semarang. This finding underscores the significant potential of renewable energy adoption, as it demonstrates the capability to meet more than half of the region's energy demands. The proposed hybrid energy system, which comprises photovoltaic solar panels, wind turbines, and power converters, exemplifies an effective strategy for reducing reliance on conventional energy sources. Furthermore, this system contributes to substantially decreasing carbon emissions, promoting environmental sustainability. The results highlight the viability of hybrid renewable energy systems to enhance energy security and support the transition towards a more sustainable energy future in urban settings.

The projected return of capital or simple payback will occur in the 13th year of running the system. This shows that despite the relatively high initial investment costs, this system has the potential to be a profitable investment in the long term. The projected return on capital in year 13 reflects a balance between operational costs and the economic benefits derived from the use of renewable energy. It also shows that with the proper policy support and appropriate technology, implementing renewable energy systems can be a financially attractive option, besides the significant environmental benefits derived from reduced greenhouse gas emissions and air pollution.

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References

[1] Al Afif, Rafat, Yasmine Ayed, and Omer Nawaf Maaitah. "Feasibility and optimal sizing analysis of hybrid renewable energy systems: A case study of Al-Karak, Jordan." Renewable Energy 204 (2023): 229-249. https://doi.org/10.1016/j.renene.2022.12.109

[2] Alhousni, Fadhil Khadoum, Firas Basim Ismail Alnaimi, Paul C Okonkwo, Ikram Ben Belgacem, Hassan Mohamed, and El Manaa Barhoumi. "Photovoltaic Power Prediction Using Analytical Models and Homer-pro: Investigation of Results Reliability." Sustainability 15, no. 11 (2023): 8904. https://doi.org/10.3390/su15118904

[3] Allouhi, A., and S. A. M. A. Rehman. "Grid-connected hybrid renewable energy systems for supermarkets with electric vehicle charging platforms: Optimization and sensitivity analyses." Energy Reports 9 (2023): 3305-3318. https://doi.org/10.1016/j.egyr.2023.02.005

[4] Arifin, Zainal, Suyitno, Dominicus Danardono Dwi Prija Tjahjana, Mohamad Muqoffa, Singgih Dwi Prasetyo, Noval Fattah Alfaiz, and Arifin Sanusi. "Grid-Connected Hybrid PV-Wind System Simulation in Urban Java." Journal Europeen Des Systemes Automatises 55, no. 4 (2022): 477–83. https://doi.org/10.18280/jesa.550406

[5] Aziz, Ali Saleh, Mohammad Faridun Naim Tajuddin, Mohd Rafi Adzman, Mohd Fayzul Mohammed, and Makbul A.M. Ramli. "Feasibility Analysis of Grid-Connected and Islanded Operation of a Solar PV Microgrid System: A Case Study of Iraq." Energy 191, no. xxxx (2020). https://doi.org/10.1016/j.energy.2019.116591

[6] Babu, Manish Ku, and Papia Ray. "Sensitivity Analysis, Optimal Design, Cost and Energy Efficiency Study of a Hybrid Forecast Model Using HOMER Pro." Journal of Engineering Research 11, no. 2 (2023): 100033.

[7] Badan Pusat Statistik (BPS - Statistics Indonesia). "Bank Indonesia Rate 2024," 2024.

[8] Essa, Mohammed Jasim M Al. "Energy Assessments of a Photovoltaic-Wind-Battery System for Residential Appliances in Iraq." Journal of Energy Storage 59 (2023): 106514.

[9] Hasan, Sayeed, Mohammad Zeyad, S. M.Masum Ahmed, and Md Sadik Tasrif Anubhove. "Optimization and Planning of Renewable Energy Sources Based Microgrid for a Residential Complex." Environmental Progress and Sustainable Energy, no. March (2023): 1–11. https://doi.org/10.1002/ep.14124

[10] Hemeida, A. M., M. H. El-Ahmar, A. M. El-Sayed, Hany M. Hasanien, Salem Alkhalaf, M. F.C. Esmail, and T. Senjyu. "Optimum Design of Hybrid Wind/PV Energy System for Remote Area." Ain Shams Engineering Journal 11, no. 1 (2020): 11–23. https://doi.org/10.1016/j.asej.2019.08.005

[11] Khosravani, Ali, Elaheh Safaei, Michael Reynolds, Kerry E Kelly, and Kody M Powell. "Challenges of Reaching High Renewable Fractions in Hybrid Renewable Energy Systems." Energy Reports 9 (2023): 1000–1017.

[12] Mauludin, Mochamad Subchan, Singgih Dwi Prasetyo, Noval Fattah Alfaiz, and Zainal Arifin. "Techno-Economic Modeling of Hybrid PV-Hydroelectric Generator Systems in Semarang." Mathematical Modelling of Engineering Problems 11, no. 3 (2024): 783–91. https://doi.org/10.18280/mmep.110323

[13] Mbasso, Wulfran Fendzi, Serge Raoul Dzonde Naoussi, Reagan Jean Jacques Molu, Kenfack Tsobze Saatong, and Salah Kamel. "Technical Assessment of a Stand-Alone Hybrid Renewable System for Energy and Oxygen Optimal Production for Fishes Farming in a Residential Building Using HOMER Pro." Cleaner Engineering and Technology 17 (2023): 100688.

[14] Menesy, Ahmed S., Hamdy M. Sultan, Ibrahim O. Habiballah, Hasan Masrur, Kaisar R. Khan, and Muhammad Khalid. "Optimal Configuration of a Hybrid Photovoltaic/Wind Turbine/Biomass/Hydro-Pumped Storage-Based Energy System Using a Heap-Based Optimization Algorithm." Energies 16, no. 9 (2023). https://doi.org/10.3390/en16093648

[15] Nassar, Yasser F., Mohammad J. Abdunnabi, Mohamed N. Sbeta, Ahmad A. Hafez, Khaled A. Amer, Abdulaziz Y. Ahmed, and Basim Belgasim. "Dynamic Analysis and Sizing Optimization of a Pumped Hydroelectric Storage-Integrated Hybrid PV/Wind System: A Case Study." Energy Conversion and Management 229, no. December 2020 (2021): 113744. https://doi.org/10.1016/j.enconman.2020.113744

[16] Pérez Uc, Daniel Alejandro, Susana Estefany de León Aldaco, and Jesús Aguayo Alquicira. "Trends in Hybrid Renewable Energy System (HRES) Applications: A Review." Energies 17, no. 11 (2024): 2578.

[17] Prasetyo, Singgih D., Alvyan N. Rizandy, Anom R. Birawa, Farrel J. Regannanta, Zainal Arifin, Mochamad S. Mauludin, and Sukarman. "Design and Economic Analysis of a Solar-Powered Charging Station for Personal Electric Vehicles in Indonesia." Journal of Sustainability for Energy 3, no. 2 (2024): 65–74. https://doi.org/10.56578/jse030201

[18] Prasetyo, Singgih Dwi, Farrel Julio Regannanta, Anom Respati Birawa, and Muhammad Salman Alfaridzi. "Techno-Economic Evaluation of Hybrid Photovoltaic-Wind Energy Systems for Indonesian Government Buildings." Journal of Sustainability for Energy 2, no. 3 (2023): 132–44. https://doi.org/10.56578/jse020303

[19] Prasetyo, Singgih Dwi, Farrel Julio Regannanta, Mochamad Subchan Mauludin, and Zainal Arifin. "Economic Feasibility of Solar-Powered Electric Vehicle Charging Stations: A Case Study in Ngawi, Indonesia." Mechatronics and Intelligent Transportation Systems 2, no. 4 (2023): 201–10. https://doi.org/10.56578/mits020402

[20] Rahmat, Muhammad Aqil Afham, Ag Sufiyan Abd Hamid, Yuanshen Lu, Muhammad Amir Aziat Ishak, Shaikh Zishan Suheel, Ahmad Fazlizan, and Adnan Ibrahim. “An Analysis of Renewable Energy Technology Integration Investments in Malaysia Using HOMER Pro.” Sustainability (Switzerland) 14, no. 20 (2022). https://doi.org/10.3390/su142013684

[21] Rana, Aqsa, and Gyula Gróf. “Prosumer Potential Assessment and Techno-Economic Feasibility Analysis of Rural Electrification.” Energy Conversion and Management: X 22 (2024): 100542.

[22] Rekioua, Djamila, Toufik Rekioua, Ahmed Elsanabary, and Saad Mekhilef. “Power Management Control of an Autonomous Photovoltaic/Wind Turbine/Battery System.” Energies 16, no. 5 (2023). https://doi.org/10.3390/en16052286

[23] Renjith, A, and P Selvam. “Efficient Maximum Power Tracking Technique in Grid Connected PV-Wind System.” Electric Power Systems Research 214 (2023): 108955.

[24] Riayatsyah, T. M.I., T. A. Geumpana, I. M. Rizwanul Fattah, Samsul Rizal, and T. M. Indra Mahlia. “Techno-Economic Analysis and Optimisation of Campus Grid-Connected Hybrid Renewable Energy System Using HOMER Grid.” Sustainability (Switzerland) 14, no. 13 (2022). https://doi.org/10.3390/su14137735

[25] Saranya, M., and G. Giftson Samuel. “Energy Management in Hybrid Photovoltaic–Wind System Using Optimized Neural Network.” Electrical Engineering, 2023. https://doi.org/10.1007/s00202-023-01991-4

[26] Singh, G. K. “Solar Power Generation by PV (Photovoltaic) Technology: A Review.” Energy 53 (2013): 1–13. https://doi.org/10.1016/j.energy.2013.02.057

[27] Sri Anggoro Prahastono, Ahmad Agus Setiawan, Wahyu Wilopo. “The Design of Hybrid Renewable Energies Utilization To Increase” 02, no. 02 (2023): 18–29.

[28] Sukimin, Nur Syazani, Ahmad Fateh, Mohamad Nor, Nur Hanis, Mohammad Radzi, and Naji Ammar. “Prediction of Bifacial Photovoltaic Panel Performance Using Temperature and Irradiance Data at Johor, Malaysia” 1, no. 1 (2024): 9–21.

[29] Tjahjana, Dominicus Danardono Dwi Prija, Suyitno, Rendy Adhi Rachmanto, Wibawa Endra Juwana, Yudin Joko Prasojo, Singgih Dwi Prasetyo, and Zainal Arifin. “Economic Feasibility of a PV-Wind Hybrid Microgrid System for Off-Grid Electrification in Papua, Indonesia.” International Journal of Design and Nature and Ecodynamics 18, no. 4 (2023): 811–18. https://doi.org/10.18280/ijdne.180407

[30] Turkdogan, Sunay. “Design and Optimization of a Solely Renewable Based Hybrid Energy System for Residential Electrical Load and Fuel Cell Electric Vehicle.” Engineering Science and Technology, an International Journal 24, no. 2 (2021): 397–404. https://doi.org/10.1016/j.jestch.2020.08.017

[31] Ubaidillah, Zainal Arifin, Farrel J. Regannanta, Rendy A. Rachmanto, Denny Widhiyanuriyawan, Eflita Yohana, Moch S. Mauludin, and Singgih D. Prasetyo. “An Examination of Hybrid PV-Biogas Power Plants for Electric Vehicle Charging Station Development in Indonesia.” International Journal of Design and Nature and Ecodynamics 19, no. 1 (2024): 201–9. https://doi.org/10.18280/ijdne.190122

[32] Wahedi, Abdulla Al, and Yusuf Bicer. “Techno-Economic Optimization of Novel Stand-Alone Renewables-Based Electric Vehicle Charging Stations in Qatar.” Energy 243 (2022): 123008. https://doi.org/10.1016/j.energy.2021.123008

[33] Xiao, Yulong, Chongzhe Zou, Mingqi Dong, Hetian Chi, Yulin Yan, and Shulan Jiang. “Feasibility Study: Economic and Technical Analysis of Optimal Configuration and Operation of a Hybrid CSP/PV/Wind Power Cogeneration System with Energy Storage.” Renewable Energy 225 (2024): 120273. https://doi.org/10.1016/j.renene.2024.120273

[34] Yohana, Eflita, Moch S. Mauludin, and Singgih D. Prasetyo. "An examination of hybrid PV-biogas power plants for electric vehicle charging station development in Indonesia." International Journal of Design & Nature and Ecodynamics 19, no. 1 (2024): 201-209. http://dx.doi.org/10.18280/ijdne.190122