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Article

Design and analyzing a hybrid hydro and solar photovoltaic system for rural areas in Malaysia

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ABSTRACT

Some rural areas worldwide, including Malaysia, are not electrified due to geographical constraints, less infrastructure development, and isolation from the main power grid. In addition, renewable energy (RE) sources are considered alternatives to replace conventional (non-RE) sources that cause pollution. However, RE sources have limitations, such as the dependency of weather and geological conditions. To address this issue, a hybrid renewable energy system (HRES) is introduced by connecting one RE and non-RE source or more than one RE with or without non-RE sources. In this study, a stand-alone hybrid hydro and solar photovoltaic (PV) HRES was designed for Rumah Bada in Nanga Talong, Ulu Engkari. As the site has limited information on load consumption and geographical data, estimations were done based on similar studies. The available solar PV and hydro system at the site was identified with the respective parameters. The proposed system was based on the hybrid AC-DC microgrid, along with two alternatives based on the AC and DC microgrid, respectively. Technical analysis was done to find out the capability of the system by calculating the power generated during different periods and performing the load flow analysis using the PowerWorld Simulator. Apart from that, economic analysis was done to find out the most cost-efficient system by calculating the net present cost (NPC) and cost of energy (COE) using HOMER Pro.

1. Introduction

Renewable energy (RE) sources such as solar, wind, and hydro are considered alternatives for power generation. However, RE in stand-alone has limitations, such as the dependency on weather and geological conditions. Hence, a Hybrid RE System (HRES) is developed for a more reliable and sustainable energy supply with RE by combining one RE and one non-RE, or more than one RE (with or without non-RE) together as one system [1]. In Malaysia, efforts to use RE for power generation have been made in the past few years. As of December 2020, the total installed capacity of RE in Malaysia was 8,450 MW, which accounts for 23% of the total installed capacity [2]. The most installed capacity of RE is large hydro, followed by solar photovoltaic (PV), small hydro, biomass, and biogas. However, most of these RE sources are installed as individual power stations. The coverage of rural electricity supply is increased to 98% in the 11th Malaysia Plan [3] and will continue to achieve 99% in 2025 in the 12th Malaysia Plan [4]. Other efforts, such as the Sarawak Alternative Rural Electrification Scheme (SARES) and Sabah Renewable Energy Rural Electrification (RE2) Roadmap, are done to accelerate rural electrification in East Malaysia, which has some remote villages isolated by the terrain. Hence, this project aims to design and optimize a hybrid hydro and solar PV system for a selected rural area in Malaysia.

2. Literature review

There are numerous configurations for hybrid hydro and solar PV systems in Malaysia and other countries. These models are dependent on the RE resources available and the price of components for the system. In short, the configurations of HRES can be classified into two categories: stand-alone (off-grid) and grid-connected (on-grid). Off-grid HRES is a system that generates power and supplies the loads connected without relying on the grid. As the primary energy source (which is RE) is stochastic in nature, energy storage technologies (for example, battery energy storage systems (BESS), supercapacitors, and flywheels) are normally connected to the system to store energy during the absence of RE [5]. In on-grid HRES, the system is connected to the grid, which enables the buying and selling of power from the grid to compensate for the variability of RE systems [5, 6]. A feasibility study of a stand-alone hybrid PV-hydrokinetic turbine (HKT) system was conducted for a rural village, Kampung Git, in Sarawak, Malaysia [7], which was compared with a PV-battery system and diesel generator (DG) system. It was found that the proposed system had the lowest levelized cost of energy (LCOE) and net present cost (NPC) of RM1.21/kWh and RM1,431,000, respectively. Based on the renewable energy fraction (RF), PV contributes 66% of energy due to the larger size of 89.9 kW, as compared to the 7 kW HKT system at the remaining 34%. Another study conducted for Mboke, Ihiagwa, Nigeria [8] proposed a stand-alone PV-hydro-DG battery system due to the unstable grid supply. The system was compared with PV-hydro-battery, PV-DG-battery, and PV-DG system and was found to be the most optimized system with NPC of US$963,431 and COE of US$0.112/kWh. Although the PV-hydro-battery system is more environmentally friendly, it is not economically friendly as the NPC and COE are 125% and 127% more than that of the optimized system. Grid-connected hybrid hydro and solar PV systems were studied in ref [9] and ref [10]. Sabudin et al. [9] designed and simulated a grid-connected PV-hydro-battery system for Kampung Lepok, Kuala Selangor, Malaysia. The system was compared with PV-hydro (without battery) and hydro-battery systems, both grid-connected. The feasibility is based on RF and NPC, and it was concluded that the PV-hydro fulfilled the criteria with 9.12% RF and NPC of RM4.83 million. By comparing the battery-hydro-grid and PV-battery-hydro-grid systems, it was found that the largest RE contributor is hydro at 7.7%, followed by PV at 1.5%. The main supply of the system relies on the grid at 90.8%. Syahputra, and Soesanti [10] investigated the potential of a grid-connected PV-hydro-battery system in Banjarharjo Village, Yogyakarta, Indonesia. The comparison was made between similar systems with different capacities of solar PV from 0 to 40 kW, and the system with 0 kW solar PV (without PV) is the most optimal system due to the cost saved from not using a PV system, and the 622 kW micro-hydro system being sustainable, thanks to the strong flow rate of 6,500 L/s. To simulate and analyze the HRES design, several software has been used in various studies. One of the software is HOMER. Developed for both on-grid and off-grid systems by the National Renewable Energy Laboratory (NREL) in 1993 [11], HOMER is commonly used for the design and techno-economic analysis of HRES. Another software is the PowerWorld Simulator, commonly used for power system applications. It is more popular than other simulation tools as it can display power flow, voltage, and other parameters in real-time animation, which helps users visualize the situation in a complex power system [12]. HRES functions in the form of a microgrid, which is defined as a self-sufficient energy system formed with local power generating units along with energy storage devices and controllable consumer load within clearly considered electrical borders [13]. Generally, HRES microgrids are classified into three types: AC (alternating current), DC (direct current), and hybrid AC-DC microgrids. AC microgrids can be further classified as centralized and decentralized AC microgrids. These configurations are different in terms of the bus involved and the number of components used.

3. Methodology

The research was done in several stages. Initially, the site was decided, and the geographical data (solar irradiance and flow rate) was obtained based on databases and similar studies. Next, the load demand of the site was estimated, and the specifications were identified. After that, the calculation of power generated by the different stand-alone systems at the site was done with the geographical data. Finally, optimization and simulation of the HRES design were done in PowerWorld Simulator and HOMER Pro, followed by techno-economic analysis and comparison with alternative systems.

3.1 Location details

The proposed site for this project is Rumah Bada, which is located in Nanga Talong, Ulu Engkari (coordinates: 1°23'22.69"N, 111°59'6.63"E). The nearest towns are Sri Aman and Lubok Antu. Figure 1 shows the aerial view of Rumah Bada. It is an Iban settlement with 30 households. The daily activities of the community are fishing, farming, and being a part-time National Park ranger.

Figure 1. Aerial view of Rumah Bada

3.2 Geographical data

3.2.1 Solar-related data

The monthly average solar global horizontal irradiance (GHI) is obtained from NREL and is shown in Figure 2. The daily radiation and clearness index was the lowest in January, with 4.552 kWh/m^2/day and 0.459, respectively. The two values have a peak at different months, at 4.934 kWh/m^2/day in March and 0.492 in August. The average values are 4.767 kWh/m2/day and 0.4765, respectively.

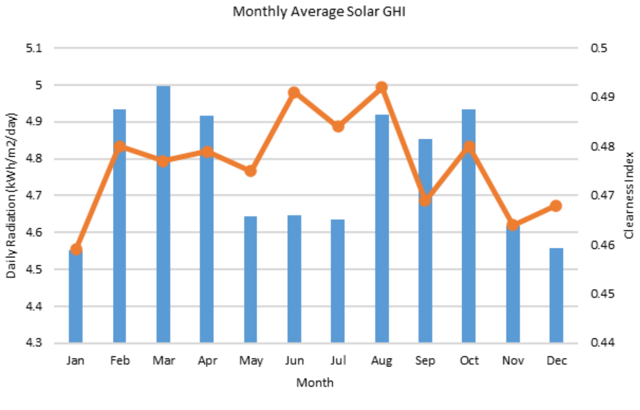

Figure 2. Monthly average solar global horizontal irradiance (GHI)

3.2.2 Hydro-related data

The river near Rumah Bada is the Engkari River, which is one of the tributaries of Batang Lupar, a downstream river of Batang Ai dam. Due to the remoteness of the area, it is not possible to obtain direct data on the Engkari River. Hence, the hydro data of the river is reasonably estimated based on a case study analysing the potential of rural sustainable energy supply in the Baram River Basin, Sarawak [14]. Based on Figure 3, the monthly average flow rate has a maximum of 23 L/s in April and a minimum of 11 L/s in July and October. The annual average flow rate is 17 L/s.

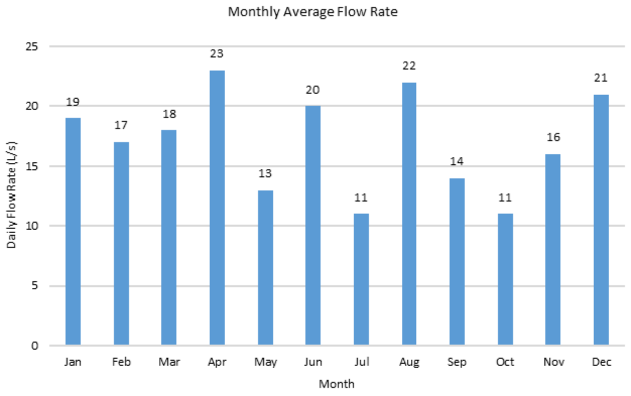

Figure 3. Assumed monthly flow rate

3.3 Load demand

Due to the unavailability of site data related to the load demand in Rumah Bada, estimations will be done based on a study on the electricity consumption of rural villages that benefit from SARES [15]. Since all 30 households live in the same longhouse, it is expected that each household uses the same electrical appliances with a similar pattern of load demand. It is also assumed that the room for each household has one living room, two bedrooms, one kitchen, and one toilet. The load demand estimation is done for a typical day, and all appliances are assumed to be used. Table 1 shows the load estimation of one household in Rumah Bada. The daily load demand per household is estimated to be 2915 Wh (2.915 kWh). Based on this value, the daily load demand of Rumah Bada is 87.450 kWh. The load profile for the entire longhouse is illustrated in Figure 4.

Table 1. Load estimation of one household in Rumah Bada

Appliance	Power Rating (W)	Quantity	Duration (hour)	Load (W)	Energy (Wh)
Lamp	10	5	4	50	200
TV	60	1	2	60	120
Radio	20	1	1	20	20
Table Fan	35	3	5	105	525
Refrigerator	75	1	24	75	1800
Rice Cooker	500	1	0.5	500	250
			Total	810	2915

3.4 Components of hybrid hydro and solar PV system

The proposed HRES for Rumah Bada is a stand-alone PV-hydro-battery system. This is because the site has an independent PV system and hydro system under the initiative of SARES. It is worth noting that the capital cost, replacement cost, and operational and maintenance (O&M) cost are based on reasonable estimations from other studies due to the customization nature. The entire project is projected to have a lifetime of 25 years.

3.4.1 Solar PV system

The existing solar PV system in Rumah Bada was launched for operation in June 2019. The system consists of 270 Wp polycrystalline PV panels connected in 6 strings with 20 panels each in series. With a peak power of 32.4 kW, it is the main electricity source for the local community. The system has a capital cost of RM5015/kW; the same goes for the replacement cost. O&M cost is negligible, as minimal maintenance is required besides cleaning and dusting. The efficiency is estimated to be around 15% to 22%, and the lifetime of this system is 25 years.

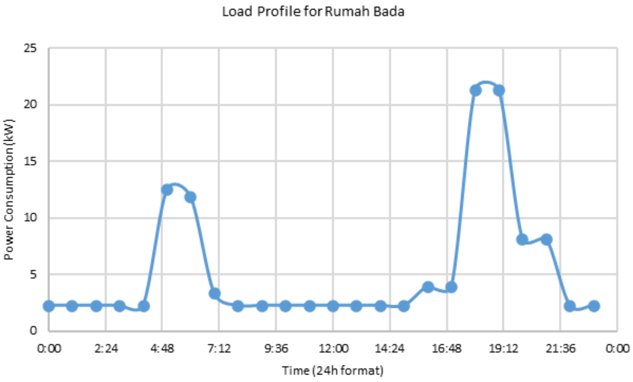

Figure 4. Load demand of a typical day for all households in Rumah Bada

3.4.2 Hydro system

The existing hydro system in Rumah Bada is a pico-hydro system and was launched for operation in May 2018. The pico-hydro system acts as a supporting system and has a power capacity of 10 kW. The system is commonly used for lighting purposes whenever necessary. Both the capital cost and replacement cost are RM5000/kW. The O&M cost is RM250, mainly used for the maintenance of moving parts in the hydro turbine. The designed flow rate for the pico-hydro system is 25 L/s. The efficiency is 80%, and the lifetime is 25 years.

3.4.3 Battery

For the PV system in Rumah Bada, a lithium-ion (Li-ion) battery system with a capacity of 165 kWh is used. The capital cost is RM555/kWh, and the same goes for the replacement cost. Similar to solar PV systems, the O&M cost is negligible as the battery will be replaced immediately once it malfunctions. Depth of discharge (DoD) is 85%, and the lifetime is five years.

3.4.4 Inverter

In Rumah Bada, the PowerCube 5000 MicroGrid Inverter by Huawei Corporation is used to convert the DC power of solar PV systems and batteries into AC power for distribution. The specifications of the components in the system are given in Table 2.

Table 2. Specifications of components in the system

Parameter	**PV**	**Hydro**	**Battery**	**Inverter**
Capital Cost	RM5015/kWp	RM5000/kW	RM555/kWh	RM1635/kW
Replacement Cost	RM5015/kWp	RM5000/kW	RM555/kWh	RM1635/kW
O&M Cost	-	RM250	-	RM50
Lifetime	25 years	25 years	Five years	15 years
Efficiency	15 – 22%	80%	-	96%
Power Capacity	32.4 kWp	10 kW	165 kWh	33 kW

The system has six strings, with five batteries in each string. Both the capital cost and replacement cost are RM1635/kW. The O&M cost is RM50. The inverter has an efficiency of 96% and a lifetime of 15 years.

3.5 Relevant equations

In HRES design, technical and economic calculations are done to ensure the system will be able to fulfill the load demand and benefit the community economically.

3.5.1 Technical calculations

The generated solar PV power, PPV, can be obtained with Equation 1 [5].

$$P_{PV} = \frac{1}{1000}\sum_{t=1}^{24} GHI(t) \times A_{PV} \times N_{PV} \times \eta_{\mathrm{PV}}\ (kW) \qquad (1)$$

Where GHI is the global horizontal irradiance (in kWh/m²/day), A_{PV} is the surface area of solar PV panels (in m²), N_{PV} is the number of solar PV panels, h_{PV} is the solar PV panel efficiency (in %) (generally between 15% and 22%), and t is time of the day (in hours).

By assuming the daily energy produced is constant throughout the year, the annual hourly energy generation, AEP_{PV} can be obtained with Equation 2**Error! Reference source not found.**.

$$AEP_{PV} = P_{PV} \times 8760\ (kWh) \qquad (2)$$

The power from falling water, $P_{HY,avg}$ can be obtained with Equation 3 [5].

$$P_{HY,avg} = \frac{m \times g \times h_n \times \eta}{1000}\ (kW) \qquad (3)$$

Where m is the mass flow rate (in L/s), g is the gravity acceleration (= 9.81 m/s²), h_n is the net head (in m) and h is the efficiency (generally between 75% and 95%).

From here, with the power available for one year (365 days in hours), the annual energy produced from the hydro turbine, AEP_{HY} is obtained with Equation 4.

$$AEP_{HY} = CF \times \sum_{d=1}^{365} P_{HY,avg,d}\ (kWh) \qquad (4)$$

Where CF represents the capacity factor, which is the ratio of the annual energy produced by a hydro system to the theoretical maximum if the system operates 24/7 at maximum output power.

The required battery size, C_{req} in ampere-hour (Ah), is computed with Equation 5 [16].

$$C_{req} = \frac{\frac{W_{demand(DC)}}{V_{DC}} \times N_{storage}}{DOD \times DF_{batt}} (Ah) \qquad (5)$$

Where $W_{demand(DC)}$ is the average daily DC load demand during critical months, V_{DC} is the system bus DC voltage, $N_{storage}$ is the design autonomy period (in days), DOD is the depth of discharge, and DF_{batt} is the derating factor (including temperature and wiring losses).

The battery capacity in kWh is expressed in Equation 6.

$$C_{req} = \frac{W_{demand(DC)} \times N_{storage}}{DOD \times DF_{batt}} (kWh) \qquad (6)$$

Load flow analysis is important in the power system study and is calculated by equation 7 & 8. The analysis is aimed to calculate and evaluate the important parameters of a test system, which are the sinusoidal steady state of system voltage, generated (P) and reactive (Q) power, and transmission losses. Single-line diagrams and per-unit systems are commonly used in this analysis [17]. Based on Kirchhoff's current law, the current at ith bus is:

$$I_i = y_{i0}V_i + y_{i1}(V_i - V_1) + y_{i2}(V_i - V_2) + \cdots + y_{in}(V_i - V_n) = (y_{i0} + y_{i1} + \cdots + y_{in})V_i - y_{i1}V_1 - y_{i2}V_2 - \cdots - y_{in}V_n \qquad (7)$$

$$I_i = V_i \sum_{j=0}^{n} y_{ij} - \sum_{j=0}^{n} y_{ij} V_j \quad (j \neq i) \qquad (8)$$

The complex power at ith bus is calculated based on the equation 9 & 10:

$$S_i = P_i + jQ_i = V_i I_i^* \qquad (9)$$

$$I_i = \frac{P_i - jQ_i}{V_i^*} \qquad (10)$$

From Equations 8 and 10,

$$I_i = \frac{P_i - jQ_i}{V_i^*} = V_i \sum_{j=0}^{n} y_{ij} - \sum_{j=0}^{n} y_{ij} V_j \quad (j \neq i) \qquad (11)$$

3.5.2 Operational and economical calculations

LCOE is a standardized method used for the evaluation of the cost of an energy source to produce a unit of energy (RM/kWh) across the lifespan of the project. This approach helps to determine the most suitable energy source at a specific location in the economic comparative analysis [5]. In HOMER, COE is formulated as such in Equation 12.

$$COE = \frac{C_{ann,tot} - c_{boiler} H_{served}}{E_{served}}\ (RM/kWh) \qquad (12)$$

Where $C_{ann,tot}$ is the total annualized cost of HRES, c_{boiler} is the marginal cost of the boiler, while H_{served} and E_{served} represent the total thermal and electrical load served, respectively.

Since there is no boiler in the system, COE is formulated as such in Equation 12 and expressed in Equation 13.

$$COE = \frac{C_{ann,tot}}{E_{served}}\ (RM/kWh) \qquad (13)$$

In general, NPC is the total cost throughout the project lifespan, which includes installation, replacement, and O&M costs. When the total project cost is analyzed, the difference between the present revenue generated and the cost spent during the project lifetime is calculated. NPC is formulated as such in Equation 14 [7].

$$NPC = \frac{C_{ann,tot}}{CRF} \times I \times R \qquad (14)$$

Where CRF is the capital recovery factor, I is the annual interest rate, and R is the project lifetime.

4. Results and discussion

The proposed design of the system will be based on the hybrid AC-DC HRES microgrid. In this configuration, the pico-hydro system is connected to the AC bus, while the solar PV and battery systems are connected to the DC bus. As the HRES provides electricity to an AC load, the DC bus is connected to the AC bus via the Huawei PowerCube 5000 Microgrid Inverter. Figure 5 shows a schematic of the proposed design. For comparison purposes, two alternative designs are proposed based on the centralized AC and DC HRES microgrid, respectively. In short, the components will be collected to a common bus, and the component that operates differently from the bus will be connected to a power converter. After performing the necessary calculations and simulation, the results and techno-economic analysis are presented in this section.

4.1 Technical analysis

The technical analysis is done by calculating the power generated by each component during different periods and performing the load flow analysis for the proposed and alternative configurations.

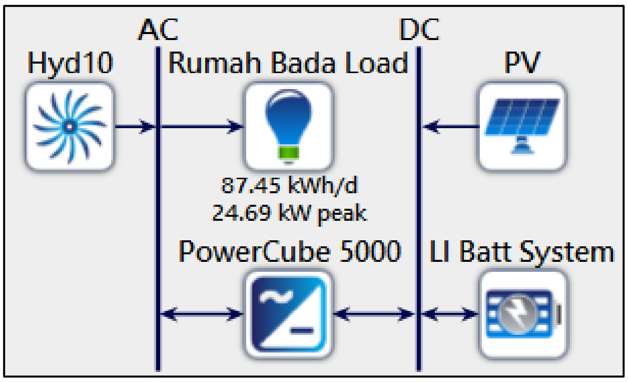

Figure 5. Simple schematic of the proposed design

4.1.1 Power calculation during different periods

The average daily radiation of 4.767 kWh/m²/day is used for the calculation of power generated by solar PV systems. The efficiency of the solar PV panels is assumed to be 20%. The power and energy generated by the system are computed by using Equation 1 and multiplying the equation together with 12 hours, respectively. Table 3 represents the calculation of the average daily power and energy generated by solar PV systems.

Table 3. Calculated average daily power and energy generated by a solar PV system

Daily radiation (kWh/m²/day)	4.767
Average daily power generated (kW)	22.4716
Average daily energy generated (kWh)	269.6592

The power supplied by the pico hydro system is assumed for two scenarios: low and high flow rates. The average low and high flow rates are taken as 14 L/s and 21 L/s, respectively. CF is taken as 0.771. The power and energy generated by the system are computed by using Equation 1 and Equation 2 divided by 365 days. Table 4 shows the calculations of the average daily power and energy generated by the Pico hydro system.

Table 4. Calculated average daily power and energy generated by the pico hydro system

	Average low	Average High
Flow rate (L/s)	14	21
Average daily power generated (kW)	4.9442	7.4164
Average daily energy generated (kWh)	91.4875	137.2331

4.1.2 Load flow analysis

The load flow analysis is done for the proposed and alternative configurations on the PowerWorld Simulator and is shown in Figure 6. The respective circuits are constructed, followed by the input of power capacity for each component. Due to the varying nature of output power during charging and discharging, the battery is set as the slack bus for each system. The simulation results for the three systems are obtained and summarised in Table 5.

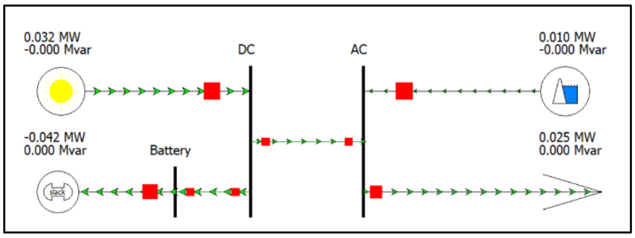

Figure 6. Load flow simulation for hybrid AC-DC microgrid

Table 5. power of each component in different HRES design

Design		**Hybrid AC-DC**	**AC**	**DC**
Solar PV	Real (kW)	32	32	32
	Reactive (kVAR)	0	32	10
Pico Hydro	Real (kW)	10	10	10
	Reactive (kVAR)	0	32	10
Battery	Real (kW)	-42	-17	-48
	Reactive (kVAR)	0	0	0
Load	Real (kW)	25	25	25
	Reactive (kVAR)	0	0	0

It was found that the solar PV and pico hydro systems are able to generate the specified real power (32 kW and 10 kW, respectively). In terms of reactive power, the two systems in the hybrid AC-DC microgrid have zero reactive power. In comparison, the reactive powers of the AC and DC microgrid are 32 kVAR and ten kVAR, respectively, which is contributed by the power converter connected to the components. Table 5 shows the power values of each component in different HRES designs. The battery in each configuration is charged with different amounts of power. The battery is charged the most in the DC microgrid with 48 kW and the lowest in the AC microgrid with 17 kW. Nonetheless, no reactive power is supplied to the battery for each case. Also, the load demand of 25 kW can be fulfilled by each configuration without reactive power. Another simulation shown in Figure 7 is done on the proposed design to identify the capability to supply power at night or when the solar PV system is unable to fulfil the load demand.

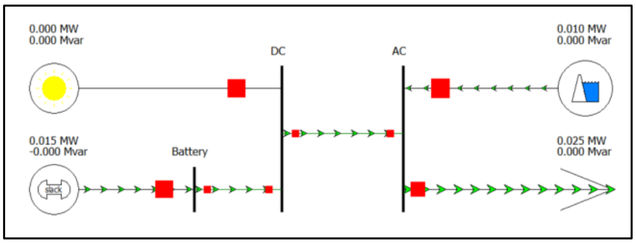

Figure 7. Load flow simulation for hybrid AC-DC microgrid (without solar PV)

This simulation is done by setting the solar PV power to 0 kW while maintaining the parameters of other components.

4.2 Economic analysis

The economic analysis is done by inserting the necessary inputs of each component for the proposed and alternative configurations and performing the simulation using HOMER (Table 6).

Table 6. Economical results for the different HRES design

Design	Hybrid AC-DC	AC	DC
NPC (RM)	568,887	618,156	629,484
COE (RM/kWh)	1.38	1.50	1.53
Operating Cost (RM/yr)	16,313	16,256	17,094
Initial Capital (RM)	358,000	408,000	408,500
Replacement (RM)	211,321.21	209,624.11	222,564.47
O&M Cost (RM)	3,878.25	4,524.63	4,847.82
Salvage (RM)	-4,312.04	-3,992.63	-6,428.14

The main economic parameters used to compare the different HRES designs are the NPC and COE. Based on Table 6, the most economical HRES design is the proposed hybrid AC-DC microgrid with an NPC of RM568,887 and COE of RM1.38/kWh. In comparison, the AC and DC microgrids have slightly higher NPC and COE, at about 110% of the proposed design. From Figure 8, the initial capital contributes the most to the NPC due to the budget spent on installation. However, the capital cost is not a major concern, as most components are installed beforehand. The replacement cost also contributes significantly to the NPC, as the batteries are replaced once every five years. It is worth noting that the RE sources are only replaced after the project lifetime, thus not contributing to the replacement cost. The O&M cost takes up a small portion of NPC, as it only comprises the maintenance for the pico hydro turbine and converter.

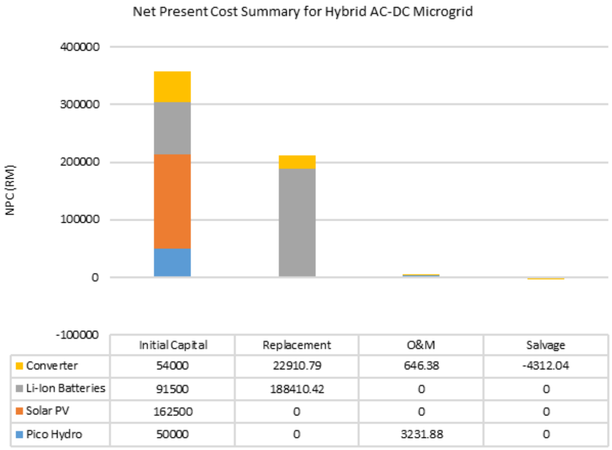

Figure 8. NPC summary for hybrid AC-DC microgrid

4.3 Discussion

From the power calculation for HRES components at different periods, the solar PV and pico hydro systems are unable to reach the maximum power capacity with the geographical data. However, the generated power is sufficient to fulfill the load demand of Rumah Bada. From a technical perspective, the optimal system should have minimal reactive power in each component, as reactive power causes additional load, overheating, and power loss on the cables and system equipment. Based on the technical analysis, the proposed system is the most feasible system with the least reactive power. In terms of battery charging, the DC microgrid is more favorable as the system provides the most power to charge the battery. Despite that, the battery in the proposed system only requires to supply 15 kW when the solar PV system is unable to supply to Rumah Bada. From an economic perspective, the proposed hybrid AC-DC microgrid is also proven to be the most feasible system with the lowest COE and NPC. Although the proposed system will require a complex control system to facilitate the power flow, the proper utilization of components helps to reduce the overall cost. In comparison, the alternative systems have a simpler control system but will require more converters and power correction equipment, which contributes to the higher overall cost.

5. Conclusion

In conclusion, an HRES is proposed and designed for Rumah Bada, a longhouse located in Nanga Talong, Ulu Engkari. Due to the remoteness of the location, the geographical data was obtained based on databases and relevant studies. The load demand of Rumah Bada was estimated with an average consumption pattern based on relevant studies. The specifications of HRES components were identified. With that, the HRES design is proposed based on a hybrid AC-DC microgrid along with alternatives based on AC and DC microgrids. Technical analysis was done by performing calculations on the power generated by the HRES components during different periods. It was found that the generated power is sufficient for the load demand in Rumah Bada despite not achieving the intended power capacity. Besides that, load flow analysis was done for the proposed and alternative designs using the PowerWorld Simulator. From the analysis, all three systems were able to supply sufficient power to the load in Rumah Bada. However, the AC and DC microgrids produce reactive power of 32 kVAR and ten kVAR, respectively, which would result in drawbacks such as additional load, overheating, and power loss on the cables and equipment of the system. From there, the proposed hybrid AC-DC microgrid is preferred as the system produces zero reactive power. Economic analysis was done with HOMER, and the proposed system is the most feasible system with the lowest COE of RM1.38/kWh and NPC of RM568,887. Overall, the proposed hybrid AC-DC microgrid system is the most optimal system. Further investigations can be done on the microgrid control system design to facilitate power flow and investigation on the transmission system. Thus, it is hoped that this project will contribute to the research of implementing HRES in Malaysia.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflict of interest

The authors declare no potential conflict of interest.

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