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Optimisation of Sustainable Clean Energy for Tourist Accommodation

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Abstract: Electricity for tourism accommodation/ villas in a tourist village in Bali is mostly for air conditioning (AC), refrigerators, and swimming pool pumps. The cost of energy bills from tourism accommodation businesses is in the second position after labour costs. This study aims to obtain target of solar energy optimization which is integrated with a power source from the national grid (PLN). With this integration method, a reliable energy supply system is obtained in tourism accommodation so that the service can compete with five-star hotel accommodations. This research is an experimental study and the expected results are the percentage of renewable energy optimization in the use of building energy and the other result is energy saving achievement can be obtained. However, in this study still focus on designing a green energy model for tourist accommodation and the result obtained that the solar energy can substitute as much as 17,5% of the total energy demand from the national grid electricity (PLN). Further research will develop the solar energy and cost analysis in detail to achieve the net zero energy building in the tourist accommodation.

1 INTRODUCTION

The electricity consumption required for tourism accommodation in tourist villages is quite high. This is due to the consumption of the air conditioning system (AC). Energy in tourism accommodation is one of the main operating costs below labour costs. The COVID-19 condition which has an impact on the declining competitiveness of tourism accommodation, requires efforts for efficiency in all fields in order to increase the competitiveness of tourism accommodations that have limited networks and capital. Solar energy as Clean Energy as described in Bali Governor Regulation No. 45 (2019), emphasized on the provision and utilization of clean energy from solar energy sources including: a). large-scale PV mini-grid construction; b) small-scale PLTS development for public/communal/customary village interests; c) development of small-scale PV mini-grid for self-interest; d) installation of solar panels for government, commercial, industrial, social and household buildings; and fulfilment of Non-Electric energy needs. This energy conservation is carried out through the application of energy efficient technology and meets the standards in accordance with the provisions of conservation in the development of Green Buildings by balancing the energy consumption with the output (zero energy building). Green Building Development is carried out through, a) tropical building development in accordance with traditional Balinese architecture; b) the design or layout of the building that utilizes sunlight optimally; c) use of environmentally friendly building materials, electrical equipment and transportation in buildings that save electricity; d) Rooftop Photovoltaic system and/or other use of solar technology; e) efficiency of water resources includes: fulfilment of water sources, use of water, recycling of waste water and the use of water-saving sanitary equipment; and f) waste and wastewater treatment in accordance with procedures.

The development of a net zero energy model for buildings has been studied by many researchers from various environmental conditions, cultures and architectural models. In Bali, this concept is very

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important to apply because of the tropical environmental conditions with abundant solar sources and must be accompanied by efficiency and energy savings. In a broader sense, the concept of zero energy for buildings is one component of the development of a green building model.

The most eligible clean energy used in accordance with the potential of this island is a source of solar energy or photovoltaic (Santosa, et al., 2016). The method that has been developed is the concept of net zero energy which is applied to traditional Balinese buildings so that the Balinese Green Building concept is obtained (Santosa, et.al., 2020).

Other research on the concept of net zero energy building has been carried out using advanced methods. Lu et.al., (2021) conducted research on exploring design solutions for smart, cost-effective energy systems so that consumers can choose the optimal capacity of renewable energy systems. From the results obtained, it is recommended that socialization and campaigns about energy saving are slightly more important than the strategy for energy efficient building models that are continuously being developed, even though these two efforts are equally important to achieve net zero energy building. Further research was conducted by Huo et al., (2021) where the nearly zero-energy buildings (NZEB) model was developed. The results show that the energy saving potential of external venetian blind shading (EVBS) technology is significant. Fu et al. (2021) stated that an accurate and easy-to-apply method is needed to calculate building energy consumption for various applications. As the availability and quality of building energy data continues to improve, the methodology behind building energy calculations also evolves over time. Although relevant fields such as calibrated simulation and machine learning methods have had many recent literature reviews, statistical methods have not been reviewed in depth and it has been identified that statistical methods are rarely applied to model electricity demand, power factor, or domestic water use. Zomera et al., (2020) also conducted research on solar power systems in buildings that were combined with aesthetic factors and analysed on a monthly basis and it was found that overall it could supply 38% of the energy supply in laboratory buildings and concluded that the building integrated photovoltaic (BIPV) system very appropriate for buildings with positive energy.

Skandalos and Karamanis, (2021) built a window-focused integrated photovoltaic system (BIPV), such as semi-transparent photovoltaic (STPV) or PV shielding devices, proposed as an efficient approach for electricity production and energy performance improvement of buildings. The findings clearly show that BIPV can substantially contribute to the transition to energy-free buildings due to its passive energy benefits. Arif et al., (2021) conducted a special study on BIPV for two different countries and in general it was found that the hybrid system can save energy up to 9%, this is a good result for the development of the use of photovoltaic systems for building. Meanwhile, Ardrubali and Grazieschi (2020) examined the life cycle of renewable energy, and found that the most beneficial thing was the potential for global warming of up to 89% for energy and 88% on the emission side. For this energy development, incentives are still needed because the indirect benefits are very beneficial for green development. Zhang et al., (2020) promote energy saving potentials in buildings in the Asia Pacific (APEC) region, considering the potential for economic development in this region to develop very rapidly, it must be accompanied by excellent building energy saving efforts. The building sector has the potential to be the largest contributor to achieving APEC's energy goals and thus to climate change goals.

Chen et al., (2021) examined the occupant's behaviour towards energy saving and found that behavioural efficiency has been identified as an efficient and economical method compared to the technology of the equipment itself. There are many examples of energy-saving behaviour in this research, for example, opening windows, opening doors, setting air conditioners and others. Nagaoka, (2021) and Hassan and Raves (2021) examine efforts to lead to energy reduction in the future. At the extreme they develop Zero Energy Building (ZEB). And innovate to install photovoltaic on building walls and map the location of photovoltaic placement on walls with a validated model. So that the energy reduction can be targeted up to 80%. And modelled the most dominant crushing innovations in the building.

2 METHODOLOGY

The planned photovoltaic system is a hybrid system where the photovoltaic operates in an integrated manner with the PLN electricity network. This was chosen because tourism accommodations already have an adequate electricity network and the solar system uses batteries to store energy which data is used at night or in other conditions where there is no sunlight. The installation of this solar power system is carried out on tourism accommodation / villas in the Ubud -Bali area. The overall system design is shown in Figure 1 below.

Renewable energy will be able to supply the main energy from air conditioning operations, refrigerator pumps for swimming pools (pool), as well as some lights for the time of day. This is based on an assessment in previous research, it was found that most of the energy from tourism accommodation is consumed by these equipment and peak energy consumption during the day.

Figure 1: Design of hybrid energy system photovoltaic and national grid (PLN).

In the design model designed for testing using 4 monocrystalline solar panels arranged in parallel in order to obtain a larger current. Solar Charge Controller (SCC) where the Solar Charge Controller is used to regulate the electric current coming out of the solar panel and the current used, the Solar Charge Controller works to keep the battery from overcharging and using excessive battery energy. This SCC also uses the Internet of Thing (IoT) system to monitor and also as a measuring tool for the performance of the solar power system. After the electric current enters the SCC, it is then flowed into the battery for energy storage which will be used at night to operate the load from the battery to the inverter to convert DC current into AC current which will be used for the operation of air conditioning, pool pumps, refrigerators and etc.

The integration system with the National grid (PLN) uses an automatic transfer switch (ATS) system that works automatically to transfer electrical energy sources to the national grid (PLN) electricity if the solar power condition has decreased its performance as indicated by battery charging drops to below 30% or equivalent. with the voltage dropping to 10V. This system was chosen because the Building Integrated Photovoltaic system that uses a dual meter as a controller has not yet been regulated that data values excess solar energy and vice versa.

The data is taken using an IoT data retrieval system based on Android which consists of current (I), voltage (V), power (W) and daily energy generated (Wh). Data retrieval system with IoT with *Epever Tracer* equipped with *Epever eBox-WiFi*, shown in the following Figure 2.

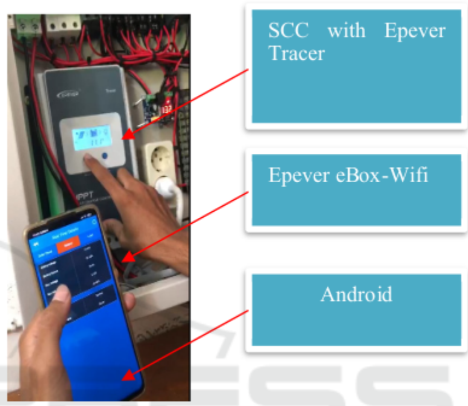

Figure 2: Internet of Thing of measurements.

As for the survey and analysis of energy demand from villa accommodation in detail, it is carried out with precision measuring instruments. Measurements were made of all utilities available at the Villa . where the minimum standard of Villa accommodation utilities consists of: air conditioning, refrigerator, water heater, pool circulation pump, clean water circulation pump, microwave, lighting.

In general, data collection is done with a valid measurement system and instrumentation and combined with data acquisition based on internet of thing. Meanwhile, secondary data were obtained from other previously published journals and references.

The data analysis method is carried out with statistics that can be shown by pictures, graphs or tables. The results of the analysis will be used as a reference for planning the optimization and efficiency of the use of solar power for the electricity consumption needs of tourism accommodation. Data analysis will use the help of several computer programs, namely: @cool pack, @PVSys, and @spread sheet.

3 RESULTS AND DISCUSSIONS

From the results of the design and tests that have been carried out, it is found that the array system is more profitable if arranged in parallel rather than in series because it will produce larger currents and losses on the network can be smaller so that the battery charging speed can be faster and larger, but to get reliability The current and voltage of the photovoltaic are then connected in parallel and in series.

From the results of observations on the utility of the villa as an object, energy demand is obtained from each of the main utilities to support guest services at the villa. From the survey results, it is found that the proportion of energy from villa utilities is that the dominant energy is consumed by air conditioning (35%), followed by swimming pool circulation pumps and pumps for clean water supply 17.5% and 10%, respectively. The overall energy demand proportion is shown in Figure 3 below.

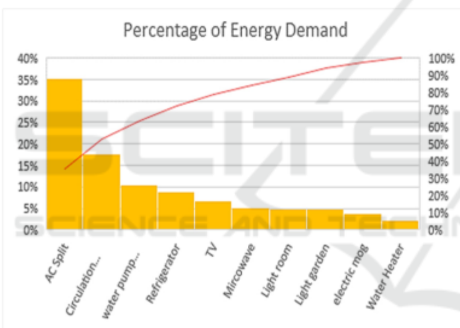

Figure 3: Proportion of energy demand of the villa's utilities.

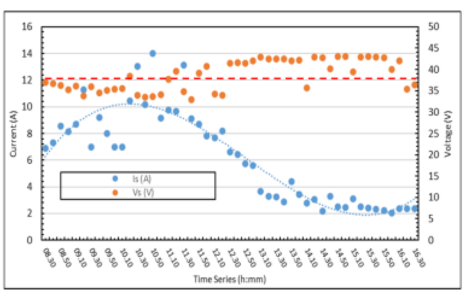

Figure 4: Variation of daily Current (I) and Voltage (V) of the photovoltaic array.

From the results of the solar energy supply is designed at a voltage of 12 V . and the results vary slightly due to variations in the recording of the instrument and measuring instrument. While the resulting current varies according to the intensity of daily sunlight. Figure 4 shows the output voltage (V) and current (I) of photovoltaic with the data obtained is the daily average from June to August.

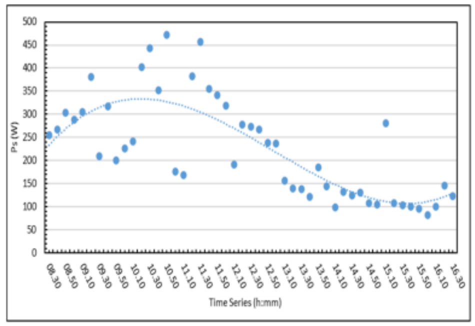

Figure 5: Variation of daily power output of photovoltaic.

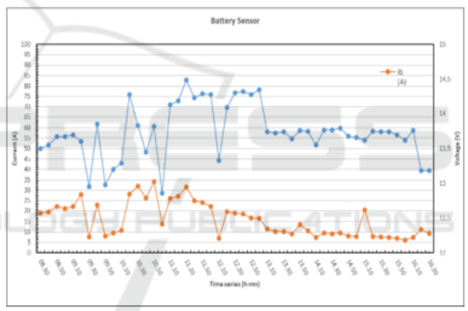

Figure 6: Batterie sensor of Voltage (V) and Current (I).

The power generated from the photovoltaic is shown in Figure 5. While the condition of the current sensor battery (I) and voltage (V) is shown in Figure 6. From the daily power produced, the average is 225 W and the battery current and voltage is 13.7 V and 15.9 A , respectively. So to adjust this condition, it was chosen to drive the swimming pool circulation pump, where this load is the dominant energy demand after air conditioning, so it has contributed significantly to the implementation of "Nearly Zero Energy Building (NZEB)" in tourism accommodation in Bali.

4 CONCLUSIONS

From the discussion and analysis that has been carried out, it can be concluded that the use of solar power for tourism accommodation / villa applications is very appropriate to support the Bali Governor's Regulation towards the use of clean energy in supporting sustainable tourism. From the results of experiments conducted at one of the villas in the Ubud-Bali area, that the installed photovoltaic capacity uses parallel and series circuits to get the current and voltage reliability of the photovoltaic. From the analysis of the suitability of daily power and energy generated from solar power, it is chosen to drive the swimming pool circulation pump and can substitutes National Grid energy (PLN) as much as 17,5%. For further research will be continued to develop solar power capacity and energy demand efficiency to achieve "Net Zero Energy Building" towards green-based tourism, and will investigated deeply toward operational cost analysis.

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