Priority based Energy Distribution for Off-grid Rural Electrification

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***Abstract*—Rural off-grid electrification is always very challenging due to mostly using limited output renewable energy source such as solar power system. Owing to its nature of power generation that depends on weather condition, the reliability in power provision is often affected by uncontrolled overwhelming usage or bad weather condition. Total power system blackout that frequently happens not only disturb the night activity routine but also can be life threatening if the rural community is unable to initiate telephony communication with the outside world during state of emergency due to power outage. In order to reduce the frequency of total system blackout caused by the reasons mentioned, we proposed a priority-based energy distribution scheme to assist the off-grid standalone solar power system to improve the overall operating hours of the critical appliances in rural areas. The scheme takes into consideration of criticality of the home appliances as defined by the rural users, so that the system would distribute power supply based on the current state of the system with an objective to prolong the service availability of the critical appliances that matter the most to the users. The scheme has been evaluated under simulated scenario and has shown a 100% operation availability of the critical appliance is achievable even during bad weather season that has very low solar input.**

***Keywords*—PI (Panel Input); BP (Battery Power); critical appliances; non-critical appliances; prioritization; operating hour**

I. Introduction

In this modern world, electrical power supply has become so commonly available and it has been a necessity in daily living. Most people living in the urban never have to worry about power provision as there are plenty and cheap. While more energy has been provision to support more applications, the increasing release of greenhouse gases that cause global warming has risen the attention to adopt greener renewable energy sources that have minimal deleterious on nature [1, 2]. On the other hand, while the urban is thinking hard on how to embrace greener renewable energy sources, the rural areas have long been depending on renewable energy power source. The adoption of renewable energy sources such as solar power in rural areas because they are usually not part of the nationwide power grid network hence standalone renewable energy sources are the better option compared to using the highly polluted diesel power generator. The standalone solar power systems have limited power capacity and not very reliable. Many factors such as weather conditions, unpredictable usage load and battery cells deterioration can easily interrupt power availability. In the case of Malaysia especially in the states of Sarawak and Sabah, many of the rural living still rely heavily on standalone power generators powered by diesel fuel but slowly migrating towards renewable energy sources. Rural electrification programs have been initiated by the government to provision off-grid power supply to small villages but owing to rural populations are very scattered and in large quantity, many villages are still waiting for the electrification program to reach them. The wait could be another 5 to 10 years subject to the planning and priority to implement. The standalone off-grid power systems are usually powered through solar diesel hybrid system due to Malaysia located in a region with plenty of sunlight throughout the year and the diesel generators are used as backup during rainy seasons. Renewable energy source such as solar power is an excellent renewable energy source but since it can be easily affected by bad weather or overwhelming usage, there is a need to look into how to strike a balance between the power generated and its usage. Our research works have been investigating the possibility to make optimum use of the amount of power generated in order to improve the overall sustainability of power supply in a more intelligent way. Upgrading and up-scaling the solar power system may solve the power supply issues in short term with an expense of higher cost, but that is not the direction we are looking at. Our approach is to maintain the same solar power system and introduce a new power distribution scheme to prevent total power blackout which happened every time the system running out of power. Our proposed priority-based energy distribution scheme shall ensure critical appliances and emergency communication equipment will still operational at all time without being affected by overwhelming power usage by other non-critical appliances.

This paper has been structured into five sections. Section II explains the background information that leads to the problem that this research is trying to solve. The nature of the solar power system and its importance role in serving the rural areas are also being described. Section III highlights the existing works on power management and schemes by other researchers. Unfortunately, none of the existing works taking rural daily living needs as the main consideration for solution formulation. Section IV describes the design philosophy of the proposed priority-based energy distribution scheme and how it works in ensuring the continuous operation of the critical appliances. Section V presents the simulation results that compare the proposed scheme to standard solar system under different power input and load scenario. The comparison has shown that under simulated environment, total power blackout can be prevented with the adoption of the new scheme.

Section VI concludes the paper by highlighting the impact of the new scheme to rural living.

II. Background

Since solar power is a more convincing energy source in Malaysia owing to its location is closer to the equator and