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# FIREFLY ALGORITHM FOR OPTIMAL SIZING OF STAND-ALONE PHOTOVOLTAIC SYSTEM

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**NUR IZZATI ABDUL AZIZ**

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# ABSTRACT

Although Stand-Alone Photovoltaic (SAPV) systems are frequently used as a mode of electrification in rural areas which are deprived of conventional grid electricity, a common issue of such systems is the system sizing. If the system is poorly designed, the system operation would be interrupted, thus reducing the overall reliability of the system as a power supply entity. In addition, as there are numerous models of system components in the market, selection of the optimal model for each component has always become a tedious and time consuming for system designers. Therefore, optimization methods are often used in the sizing algorithms for such systems. This study presents the development of Firefly Algorithm-based Sizing Algorithm, known as FASA for sizing optimization of SAPV systems. The sizing algorithm utilized Firefly Algorithm (FA) to optimally select the model of each system component such that a system technical performance indicator is consequently optimized. FA was incorporated in two sizing approaches, i.e. the intuitive method and the hybrid intuitive-deterministic method with the technical performance indicator set as Performance Ratio (PR) and Loss of Power Supply Probability (LPSP) respectively. Besides that, two design cases of PV-battery system, i.e. system with standard charge controller and system with MPPT-based charge controller were investigated. Apart from that, Iterative-based Sizing Algorithms (ISA) for each design case with the two sizing approaches were developed to determine the optimal solutions which were used as benchmark for FASA. The results showed that FASA had successfully found the optimal PR and LPSP in all design cases using both intuitive and hybrid intuitive-deterministic methods. In addition, sizing algorithm with FA was also discovered to outperform sizing algorithm with selected computational intelligence, i.e. Genetic Algorithm, Evolutionary Programming and Particle Swarm Optimization in producing the lowest computation time in the sizing optimization.

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# CHAPTER ONE
# INTRODUCTION

## 1.1 BACKGROUND

Electricity plays an important role in the development of a civilization. It is used to power up residential and office buildings, industries, information and communication equipment as well as vehicles and transportation. Electricity in a conventional power system is generated using several types of energy resources such as fossil fuels, nuclear energy and renewable energy (RE). Besides that, a recent statistics in [1] revealed that the world electricity generation is currently dominated by the usage of fossil fuels, followed by renewable energy and nuclear energy. However, fossil fuels are basically a finite energy resource which is depleting with respect to time. In addition, the burning of fossil fuels results in greenhouse gases (GHG) emission [2]. As a result, the quality of the surrounding environment is compromised when using fossil fuels. Due to the drawback of the fossil fuels, nuclear energy offers a more attractive solution towards a cleaner mode of electricity generation as it does not release GHG to the environment. Nevertheless, there are other issues related to the implementation of nuclear power plant such as safety and disposal of nuclear waste [3]. Therefore, renewable energy is introduced as its energy resource is inexhaustible and environmentally benign [4].

RE can be defined as a continuous natural resource that can be replenished without failure and will not be depleted throughout time [5]. RE technologies are developed using several types of energy resource such as solar, wind, hydro, biomass and geothermal. Solar energy is one of the most popular REs as the sunshine is ample and available in wider region as compared to other RE resources. In electricity generation, solar energy is converted to electricity via photovoltaic (PV) effect. Therefore, a solar energy- based electricity generation system is known as PV system. A recent global market report in [6, 7] showed that PV system has the fastest market growth worldwide when compared with other RE technologies. The PV systems can be implemented using either Grid-Connected Photovoltaic (GCPV) systems or Stand-Alone Photovoltaic (SAPV) systems. A GCPV system is a PV system which injects