UNIVERSITI TEKNOLOGI MARA

SIZING OPTIMIZATION OF LARGE-SCALE GRID-CONNECTED PHOTOVOLTAIC SYSTEM USING DOLPHIN ECHOLOCATION ALGORITHM

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ABSTRACT

Despite being used as large-scale power plant, a common issue of Grid-Connected Photovoltaic (GCPV) system is the system sizing. As numerous models of system components are commercially available, the selection of optimal components has frequently become tedious and time consuming for system designers. Hence, optimization methods are regularly incorporated in the sizing algorithm for such system. This study presents the development of Dolphin Echolocation Algorithm (DEA)-based sizing algorithm for sizing optimization of large-scale GCPV systems. DEA was used to select the optimal combination of the system components which are PV module and inverter such that either the Performance Ratio (PR) or Net Present Value (NPV) is correspondingly optimized. Before incorporating the optimization methods, a sizing algorithm for large-scale GCPV systems was developed. Later, an Iterative-based Sizing Algorithm (ISA) was developed to determine the optimal sizing solution which was later used as benchmark for sizing algorithms using optimization methods. Besides DEA, Evolutionary Programming (EP), Firefly Algorithm (FA) and Cuckoo Search Algorithm (CS) were also incorporated in the sizing algorithm for performance comparison. For each sizing algorithm using these optimization methods, the optimal population size and the number of iterations for convergence were investigated. The results showed that the DEA-based sizing algorithm had successfully found the optimal PR and NPV for the system. Apart from that, sizing algorithm with DEA was also discovered to outperform sizing algorithms with selected computational intelligence, i.e. EP, FA and CS in producing the lowest computation time in finding the optimal sizing solution. Besides having more than 200 times faster than ISA, DEA was found to be approximately 2, 2, 13 times faster than EP, FA and CS respectively. Moreover, DEA was the only Computational Intelligence that is capable of finding the optimal PR and NPV as suggested by the benchmarked algorithm ISA.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Electricity supply plays an important role in our daily life activities. It is used to power up residential and office buildings, industries, appliances, information and communication equipment as well as vehicles and transportation. Commonly, the main sources of electrification originate from conventional fuel resources such as natural gas, coal and oil. However, these conventional resources are basically finite which are depleting with respect to time [1]. Therefore, as alternative of the conventional energy resources, renewable energy (RE)-based electricity generation is used to support continuous electricity supply.

In past decades, RE seems to be the most reliable alternative energy resources to replace the conventional fuel resources. RE is a continuous natural resource that can be replenished without failure and will not be depleted throughout time [2]. There are a few types of RE resources such as wind energy, hydroelectric energy, thermal energy, wave energy, tidal energy, geothermal energy and solar energy. Recently, solar energy-based technology such as photovoltaic (PV) has become one of the fastest growing RE technologies [3]. It is estimated that the installed PV capacity worldwide had exceeded 140,000 MW by 2030 [4]. Most of these capacities come from Grid-Connected Photovoltaic (GCPV) systems.

A GCPV system typically consists of PV array and inverters. The PV array contains parallel PV strings and each string consists of PV modules connected in series. The PV modules contain solar cells used to capture the energy from the sunlight and directly convert them into electricity. The PV array is connected to power conditioning unit, known as inverter and other system components to yield the desired output. The output from the system is eventually channeled to a local utility grid. The system can be installed either as distributed system or as centralized system [3]. Distributed systems are commonly installed at point of loads in smaller capacities when compared to centralized systems. In contrast, centralized systems are usually installed in large-scale capacities and frequently have megawatt capacities.