OPTIMIZATION OF PV SIZE FOR OFF-GRID CONNECTED PV SYSTEM CONSIDERING UNCERTAINTIES USING DIFFERENTIAL EVOLUTION ALGORITHM

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DEDICATION

This project report is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

Increase in global energy demand has made renewable energy systems more attractive. In the past decade the utilization of PV systems has tremendously increased due to global warming phenomena and the rapid depletion of fossil fuel reserve. However, the intermittency and inconsistency of energy supply are some of the main drawback associated associate with the PV technologies. The hybridization of PV system with battery storage system improves the reliability and efficiency of the PV supply. In the past decade, standalone PV system become one of the systems that has been widely used. In this dissertation, the optimization of the PV system with battery storage is performed. The objective is to optimize PV system with battery, considering temperature and solar irradiance in order to maximize the output. The proposed system is designed to supply the energy demand of Al-Mamoon University College. This project considers yearly temperature and solar irradiance. The sizing optimization is performed using differential evolution (DE). Two key criteria are considered during the optimization process i.e., reliability and price of electricity. The proposed methodology is implemented using MATLAB software. The proposed approach based on (DE) is compared with particle swarm optimization technique in terms of fast convergence, accuracy.

ABSTRAK

Peningkatan dalam permintaan tenaga global telah menjadikan sistem tenaga boleh diperbaharui lebih menarik. Dalam dekad yang lalu, penggunaan sistem PV telah meningkat dengan pesat disebabkan fenomena pemanasan global dan kekurangan simpanan bahan api fosil yang cepat. Walau bagaimanapun, bekalan tenaga tidak berterusan dan tidak konsisten adalah beberapa kelemahan utama berkaitan dengan teknologi PV. Penghibridan sistem PV dengan sistem storan bateri memperbaiki jaminanan bekalan berterusan dan kecekapan bekalan PV. Pada dekad yang lalu, sistem PV individu menjadi salah satu sistem yang telah digunakan secara meluas. Dalam disertasi ini, pengoptimuman sistem PV dengan storan bateri dilaksanakan. Objektif adalah untuk mengoptimumkan sistem PV dengan bateri, mengambilkira suhu dan sinar suria untuk memaksimumkan keluaran. Sistem yang dicadangkan ini direka untuk membekalkan permintaan tenaga Kolej Universiti Al-Mamoon. Projek ini mengambilkira suhu dan sinar suria tahunan. Pengoptimuman saiz dilaksanakan dengan menggunakan evolusi pembezaan (DE). Dua kriteria utama yang dipertimbangkan semasa proses pengoptimuman iaitu jaminan bekalan berterusan dan harga elektrik. Metodologi yang dicadangkan dilaksanakan menggunakan perisian MATLAB. Pendekatan yang dicadangkan berdasarkan (DE) dibandingkan dengan teknik pengoptimuman koloni zarah dari segi penumpuan cepat, ketepatan.

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LIST OF ABBREVIATIONS

DEA	-	Differential Evolution Algorithm
PSO	-	Particle Swarm Optimization
SAPV	-	Stand Alone Photovoltaic
CSP	-	Concentrated Solar Plants
LLP	-	Loss of Load Probability
LPSP	-	Loss of Power Supply Probability
LOPP	-	Loss of Power Probability
TFSC	-	Thin Film Solar Cell
CIG	-	Copper Indium Gallium
CIGS	-	Copper Indium Gallium Selenide
OPC	-	Organic Photovoltaic Cell
GCPVS	-	Grid Connected Photovoltaic System
BIPV	-	Building Integrated Photovoltaic
TPV	-	Terrestrial Photovoltaic
T&D	-	Transmission and Distribution
DESS	-	Battery Energy Storage System

LIST OF SYMBOLS

P	-	Power
G	-	Solar irradiance
T	-	Temperature
η	-	Efficiency
σ	-	Rate of self-discharge/hour
SOC	-	State of charge
C_B	-	Battery capacity
AD	-	number of autonomy days
DOD	-	Depth of discharge
C	-	Cost
i	-	Actual interest rate
n	-	Service life of the system
t	-	Time
E	-	Energy
^{o}C	-	Celsius
F	-	Future cost
α	-	Cost of PV array
%	-	Percentages

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CHAPTER 1

INTRODUCTION

1.1 Background of study

The solar photovoltaic renewable energy (RE) development had expanded greatly because of continuous decrease in the rate of solar photovoltaic prices. The change in global energy structure towards a sustainable structure is because of technical innovations and use of renewable energy sources. The present-day power system structure has two main challenges - supplying a continuous secure power and reduction of environmental issues from power production [1]. In recent times, electric energy is the fastest growing form of energy in the world; the reason for this fast growth is the increased industrialization and extensive technical development.

Conventional energy sources such as petroleum, natural gas and coal are used as a major source to produce this enormous energy to meet power demand. About 67% [2] of current total electricity is produced by using fossil fuel sources, and their use leads to increased greenhouse gas emission and other types of environmental changes. This condition enforces energy sector to make a good effort to ensure environmental safety and continuous energy production. Therefore, the main task of power sector is to produce appropriate technical solutions and business models to maintain the energy sector stability.

The RE sources are considered as suitable alternative solutions for future electricity generation. RE Sources are environment friendly resources which gives clean energy and naturally replenished sources of power generation which are quickly getting to be viewed as best alternatives as compared to conventional resources such as fossil fuel power generation plants. In addition Renewable energy sources, mainly solar, wind, hydro and geothermal are the fastest-growing energy sources for electricity generation. The solar energy mainly is considered as a future of energy

sector and is the fastest growing of all renewable energy sources. Solar energy is the most abundant resource of power in form of heat and light from the sun. It can produce concrete module output efficiency that can help in making precise estimation of power generation. However, solar irradiation is dependent on weather conditions and have some flexibility to be designed for distributed generation or as grid connected large scale production.

Stand-alone PV system (SAPVS) is considered the future of the energy sector and will play very important role in the future of electricity production. Stand-alone PV system usually includes an energy storage system with it; the idea of SAPVS is well established for both distributed and centralized systems [3]. Malaysian conditions are considered very suitable for the stand-alone PV system as they produce electricity throughout the year. The solar irradiation data of Malaysia shows that its very suitable for solar PV system with high irradiation throughout the year. However, there are technical issues with the SAPV systems because of the size optimization of the system. The optimization of the system is not possible by directly experimenting the installation because of different load and irradiance data. For this purpose, differential evolution algorithm is used in this project in the MATLAB platform to optimize the suitable size of SAPV for a rural area [4].

The following are the advantages of PV systems [5]:

i. They are stable electricity generators as they can directly generate electricity from sunlight. They normally come pre-packaged, wired and ready for mounting. There are no moving components in the modules, hence, there is no need for services and maintenance.

ii. The sizes and outputs of PV systems vary depending on their applications. Their lightweight allows for safe and easy transportation of the components.

iii. PV systems can be expanded easily by introducing more modules either in series to increase the voltage capacity of the system or in parallel to increase the current generation.

iv. PV systems are configured to withstand harsh conditions. Modules can withstand high temperatures and can operate at any elevation or wind condition. PV systems can be fabricated with storage capabilities that ensures stable quality power generation even when the weather is dull.

v. PV systems are not associated with any form of noise pollution or carbon emissions.

1.2 Problem Statement

The uncertainty associated with solar irradiance and temperature affects the power output of stand-alone PV system. Similarly, the inconsistency of load demand over a period of time is also a challenge. On the other hand, the high cost associated with renewable system components is a major challenge and limits their broad usage in the off-grid application and for the individual homeowner. To overcome the aforementioned problems, the system must be properly size via sizing optimization techniques to fully harness the benefit of the renewable energy resources based energy system.

1.3 Objectives

The specific objectives of the study are as follows:

a) To mathematically model PV and battery system.

b) To optimize the PV system using Differential Evolution algorithm (DEA) considering PV, solar irradiance and temperature uncertainties and load variation in order to minimize the cost of energy (COE) at minimum loss of load probability (LLP).

1.4 Scope of Study

In this study, the temperature and solar irradiance data was taken from rural areas of Iraq and the case of the study Al-Mamoon University college located in an Off-grid community is considered. This project focuses on the use of differential evolution theorem to optimize the SAPV system for optimal electricity generation in the rural areas. This project involves the designing of the MATLAB programming of the differential evolution theorem and recording of the solar irradiance data and temperature of the rural area to simulate and analyze the SAPV system.

1.5 Significance of Study

This study helps in choosing the appropriate PV system size under changing irradiance and temperature. The use of differential evolution algorithm (DEA) helps in appropriate sizing of the PV system and in reducing the computational time, making it easy to implement. This project will help in choosing the optimized PV system size which will be helpful economically and technically for the PV system installer.

1.6 Thesis Organization

This project report is organized in the following manner:

Chapter 1 describes the SAPV system and provides general information about the study objectives, the problem statement, as well as the scope of the research.

Chapter 2 reviewed the past works done on the optimization of the PV system using different optimization techniques. This chapter includes the literature review about different optimization techniques, as well as the modeling of different components of the PV system in MATLAB software.

Chapter 3 discusses the methods used in this project for PV system optimization using MATLAB; it also explains the optimization process.

Chapter 4 analysed the result obtained from MATLAB software. The analysis of loss of load probability (LLP) and the cost of energy (COE) will be discussed in this chapter.

Chapter 5 concludes the results and the SAPV system also the suggestion for the future works.

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