OPTIMIZED HYBRID STANDALONE MICROGRID USING METAHEURISTIC ALGORITHMS

By

Yasmin El-sayed Kotb Abd Allah

A thesis submitted to the

Faculty of Engineering, Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Electrical Power and Machines Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

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Under supervision of

Assoc. Prof. Dr. Ahmed M. Ibrahim

Electrical Power and Machines Department

Faculty of Engineering, Cairo University

Dr. Mahmoud Mohamed Sayed

Electrical Power and Machine Department

Faculty of Engineering, Cairo University

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Approved by the Examining Committee:

Assoc. Prof. Dr. Ahmed M. Ibrahim — **Main Supervisor**

Signature: ……

Prof. Dr. Essam Eldein Abu Elzahab — **Internal Examiner**

Signature: …….

Prof. Dr. Fahmy metwally Ahmed Bandary — **External Examiner**

Signature: …….

(Professor of control of power system at Faculty of engineering at Shobra – Banha University)

FACULTY OF ENGINEERING, CAIRO UNIVERSITY,

GIZA, EGYPT

2017

Engineer: Yasmin El-sayed Kotb Abd Allah
Date of Birth: 01 / 10 / 1990
Nationality: Egyptian
E-mail: Yasmin.elsyed@gmail.com
Address: 6 October – Egypt

Registration Date: 01 / 10 / 2012
Awarding Date: / / 2017
Degree: Master of Science
Department: Electrical Power and Machines Engineering

Supervisors: Assoc. Prof. Dr. Ahmed Mohamed Ibrahim
Dr. Mahmoud Mohamed Sayed

Examiners: Assoc. Prof. Dr. Ahmed Ibrahim (Main Supervisor)
Prof. Dr. Essam Eldein Abu Elzahab (Internal examiner)
Prof. Dr. Fahmy Metwally Ahmed Bendary (External examiner)
(Professor of control of power system at Faculty of engineering at Shobra – Banha University)

Title of Thesis: OPTIMIZED HYBRID STANDALONE MICROGRID USING METAHEURISTIC ALGORITHMS

Key Words: Energy in Egypt, Hybrid renewable energy system (HRES), Particle Swarm Optimization (PSO), Genetic Algorism (GA), Stand alone PV.

Summary

Energy is the backbone for almost human services, wherefore Egypt seeks to diversify its sources of energy owing to suffering from severe power shortages over the past years, while a lot of areas derives from electricity such as the three cases studied in this thesis which located in the western desert. Two villages (Abu minqar and Darb Al Arbaein) were a part of the UAE solar energy project grant but the capacity of the installed PV system has excessive energy than their load demand. This thesis provides their optimum size with the lowest COE and LPSP.

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I would like to begin this thesis by first thanking God for his greatest gifts: for having the greatest parents, family and my husband who are always supporting me and giving me the strength and courage to achieve my dreams.

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I hope this work could be a start for me to some development and great achievements in this field for Egypt.

DEDICATION

I dedicate this master to my greatest parents, specially my father who is the best father in whole world; he dedicated all his life for me and my brothers.

I also dedicate my thesis for my great husband who supports me all time to complete this thesis and he is the Unknown Soldier behind all my success.

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- **Symbols**

h	:	Planck's constant (6.6×10^{-34} joule.sec).
c	:	Light speed (3×10^{8} m/s).
λ	:	The photon wave length (m)
eV	:	Electron Volt (1 eV= 1.6×10^{-19} joule)
A	:	Area swept by the rotor blades (m^2).
AP	:	Awareness probability.
C^{CC}	:	The capital cost ($).
$C^{G}(P_i)$	:	Fuel consumption rate per unit of power [MMBTU/KWh].
C^{MO}	:	Maintenance and Operating cost ($).
C_d^{fuel}	:	Fuel Cost ($).
P_w	:	Rating power of wind farm (W).
G	:	Irradiation (w/m^2)
T	:	Temperature (C^o)

- **Abbreviations**

HPPEA	:	The Hydro Power Plants Execution Authority
EEHC	:	Egyptian Electricity Holding Company
NREA	:	New and Renewable Energy Authority
PV	:	Photo-Voltaic
PVRES	:	Photo Voltaic Renewable Energy System
COE	:	Cost Of Energy
GA	:	Genetic Algorithm
PSO	:	Particle Swarm Optimization
HRES	:	Hybrid Renewable Energy System
SEPG	:	Solar Energy Project Grant
RES	:	Renewable Energy System
HPWS	:	Hybrid PV/ Wind renewable energy System
DG	:	Diesel Generator
OPEC	:	Organization of the Petroleum Exporting Countries
HAWT	:	Horizontal Axis Wind Turbine
VAWT	:	Vertical Axis Wind Turbine
CMA-ES	:	Covariance Matrix Adaptation- Evolution Strategy
UAE	:	United Arab Emirates.
MPP	:	Maximum Power Point
MPPT	:	Maximum Power Point Tracker
WF	:	Wind Farm
NPC	:	Net Present Cost
MC	:	Maintenance Cost
RC	:	Replacement Cost
INSGA	:	Improved non-dominated Sorting genetic algorithm
LCE	:	Lowest levelized Cost of Energy
IC	:	Initial Cost
MOPSO	:	Multi-Objective Particle Swarm Optimization
CRF	:	Capital Recovery Factor
TCE	:	Total Cost of Energy
SFF	:	Sinking Fund Factor

ABSTRACT

Energy is the backbone of the modernistic industrial economy, it provides a fundamental constituent for almost many human services, wherefore Egypt seeks to diversify its sources of energy owing to suffering from severe power shortages over the past years, while a lot of areas derives from electricity because most of these areas may be mountainous area, remote area or desert as the three cases studied in this thesis which located in the western desert.

Two villages (Abu minqar village and Darb Al Arbaein village) were a part of the UAE solar energy project grant (SEPG) for lighting Egypt's villages, but the capacity of the installed PV system has excessive energy than their load demand. So, this thesis aims to satisfy their actual load demand from the PV system.

In the third case study Al Tamanin village, different scenarios have been tested to exploit all renewable sources in this location because the Egypt wind atlas mentioned the western desert as having one of the highest wind speed areas in Egypt. For more reliability the hybrid renewable energy system studied also for Al Tamanin village.

In this thesis the hybrid renewable energy system consists of a PV model, wind power model (to utilize its perfect wind speed), battery model and also a diesel generator as an alternative source of electricity. This system is developed for Al Tamanin village case. This thesis studies the actual load of the three villages.

A simulation code and GA have been developed to analyze the system and getting the optimal sizing purpose for the installed PVRES or for the HRES. These results are compared with other optimization technique (PSO).