



Cairo University

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

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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 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.

TABLE OF CONTENTS

ACKNOWLEDGMENTS.....	i
DEDICATION	ii
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF SYMBOLS AND ABBREVIATIONS	ix
ABSTRACT.....	xi
CHAPTER (1): INTRODUCTION.....	1
1.1.Energy in Egypt	1
1.2.Thesis Motivation	6
1.3.Background and Literature Review	7
1.4.Thesis Main Objectives	9
1.5.Thesis Outline.....	9
CHAPTER (2): Renewable Energy System	11
2.1.Solar Photovoltaic Energy	11
2.1.1 Principle of Photovoltaic system	12
2.1.2.1 PV arrays	12
2.1.2 Storage mechanism	14
2.1.3 Electronic Components	15
2.1.3.1 Charge Controller	15
2.1.3.2 Inverters	16
2.1.4 PV System Configurations	17
2.1.4.1 Standalone PV system	17
2.1.4.2 Grid connected PV system	17
2.1.5 Solar System application in Egypt	18
2.2 Diesel Generators (DG)	19
2.2.1 Diesel Generator performance	20
2.3 Wind Energy	21
2.3.1 Relations of speed and power	23
2.3.2 The actual power produced by wind turbine	23
2.4 Hybrid Renewable Energy System	24
2.4.1 Classification of hybrid configuration	26
2.4.1.1 AC-Coupled configuration system	26

2.4.1.2 DC-Coupled configuration system	27
2.4.1.3 Series/Parallel Hybrid power system	28
2.5 Summary	31
CHAPTER (3): MODELING OF THE RENEWABLE ENERGY SYSTEM AND METAHEURISTIC ALGORITHMS	32
3.1. Modeling of the Renewable Energy System.....	32
3.1.1 Modeling of PV system	33
3.1.2 Modeling of Wind system	34
3.1.3 Modeling of Diesel Generator	35
3.1.4 Modeling of Inverter (DC/AC converter)	36
3.1.5 Modeling of battery system	37
3.1.5.1 Battery Constraints	37
3.2. METAHEURISTIC ALGORITHMS	37
3.2.2 Principle of METAHEURISTIC ALGORITHMS	38
3.2.3 Types of METAHEURISTIC ALGORITHMS	39
3.2.3.1 Genetic Algorithms (GA)	39
3.2.3.3 Particle Swarm Optimization	45
3.3 Summary	47
CHAPTER (4): CASE STUDY OF EGYPT	48
4.1. The Installed PVRES	48
4.1.1. The First Case Study (Abu minqar village).....	48
4.1.2. The Second Case Study (Darb Al Arbaein Village).....	51
4.2. The Third case study (Al Tamanin Village)	52
4.3 Summary	54
CHAPTER (5): Problem Formulation and Simulated Results	55
5.1. Problem Formulation	55
5.1.1. Power reliability analysis	55
5.1.2. The Economic Analysis.....	57
5.2. Simulated Results	60
5.2.1. The Installed PVRES Results	62
5.2.1.1 The First Case (Abu Minqar Village)	62
5.2.1.2 The Second Case (Darb Al Arbaein Village)	65
5.2.2 The Third Case (Al Tamanin Village).....	68
5.2.2.1 PV/DG scenario	68

5.2.2.2 Wind/DG scenario	70
5.2.2.3 Hybrid PV/ Wind/ DG system Scenario	71
5.2.2.4 DG Scenario	74
CHAPTER (6): CONCLUSIONS AND FUTURE WORK.....	76
6.1. Conclusions.....	76
6.2. Suggested Future Work	77
REFERENCES	78
APPENDIX (A): Areas that installed with PVRES with the UAE solar energy project grant (SEPG) for lighting Egypt's villages.....	85
APPENDIX (B): PSO Algorithm M-FILE	86

LIST OF TABLES

Table 2.1: Projects installed in different places of Egypt	18
TABLE 3.1. THE DETAILED PARAMETERS FOR MODELING THE PV	33
Table 3.2. The detailed parameters for modeling the wind turbines.....	35
Table 3.3. The detailed parameters for modeling the DG.....	36
Table 3.4. The detailed parameters for modeling the Inverter.....	36
Table 3.5. The detailed parameters for modeling the Battery.....	37
Table 5.1: The input parameter for the economic analysis	59
Table 5.2: The optimum results for Abu Minqar village of both GA and PSO.	63
Table 5.3: The optimum results for Darb Al Arbaein village of both GA and PSO.....	65
Table 5.4. The optimum result of GA for Al Tamanin village (PV / DG scenario).....	68
Table 5.5. The optimum results of GA for Al Tamanin village (Wind/DG scenario).....	70
Table 5.6. The optimum results obtaining from GA for DG scenario.....	72
Table 5.7. The optimum results for all scenarios with economic results.....	74

LIST OF FIGURES

Figure 0.1:	Peak load curve 2013/2014 – 2014/2015	2
Figure 0.2:	The installed capacity versus the peak load	2
Figure 1.3:	Peak load curve 2015/2015 – 2015/2016	3
Figure 1.4:	The installed capacity versus the peak load for 2015/2016	3
Figure 0.5:	Evolution of Electric Generation from 2010 till 2022	4
Figure 0.6:	The installed capacity of the renewable energy	6
Figure 2.1:	V-I characteristic of PV cell	13
Figure 2.2:	Series charge controller	15
Figure 2.3:	Shunt charge controller	15
Figure 2.4:	Full bridge single phase Inverter with filters	17
Figure 2.5:	Different types of wind turbines	21
Figure 2.6:	Power curve for variable speed wind turbines	23
Figure 2.7:	Centralized AC- coupled Hybrid system	26
Figure: 2.8:	Decentralized AC-coupled Hybrid systems	27
Figure 2.9:	DC- coupled Hybrid System	28
Figure 2.10:	Series hybrid system	29
Figure 2.11(a)	DC- coupling configurations	30
Figure 2.11(b)	AC- coupling configurations	30
Figure 3.1.	Renewable system with PV/DG/Battery	32
Figure 3.2.	Renewable system with PV/DG/Battery/Wind	32
Figure3.3:	GA flow chart	41
Figure3.4:	PSO flow chart	46
Figure 4.1:	Map of Egypt and location of the three villages	48
Figure.4.2:	Global solar irradiation in Egypt	49
Figure.4.3:	The actual average monthly solar irradiation	50
Figure.4.4:	The actual hourly load demand for Abu minqar village	50
Figure.4.5:	The average actual load of the three villages	51
Figure.4.7.	The Actual average solar irradiation of Darb Al Arbaein village	52

Figure.4.6.	The average monthly temperature of Abu minqar village	51
Figure.4.8.	The actual average temperature of Darb Al Arbaein village	53
Figure. 4.9.	The average solar irradiation of Al Tamanin village	53
Figure. 4.10.	The average monthly temperature of Al Tamanin village	53
Figure. 4.11(a).	The average monthly wind speed of Al Tamanin village	54
Figure. 4.11(b).	The hourly wind speed of Al Tamanin village	54
Figure. 5.1.	The Flow Chart for the RES	56
Figure. 5.2	Convergence characteristics of the GA and PSO algorithm for case (1).	63
Figure.5.3	Monthly generated energy from PV, battery and DG for Abu Minqar village	64
Figure. 5.4	The Dump Power of Abu Minqar village	64
Figure 5.5	Convergence characteristics of the GA and PSO algorithm for case (2).	66
Figure 5.6	The Dump Power of Darb Al Arbaein village	67
Figure 5.7:	Monthly generated energy from PV, battery and DG for Darb Al Arbaein village	67
Figure 5.8:	Monthly generated energy from PV, battery and DG for Al Tamanin village	69
Figure 5.9	Convergence characteristics of the GA for PV/DG scenario.	69
Figure 5.10:	Monthly generated energy from Wind turbines and DG for Al Tamanin village	70
Figure 5.11.	Convergence characteristics of the GA of Wind/DG scenario.	71
Figure 5.12:	Monthly generated energy from PV, battery, wind and DG for Al Tamanin village	73
Figure 5.13	Convergence characteristics of the GA for HPWDS scenario	73
Figure 5.14	Convergence characteristics of the GA for DG scenario.	74

LIST OF SYMBOLS AND ABBREVIATIONS

• 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°)

• 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).