Cairo University

DESIGN OF PHOTOVOLTAIC SYSTEMS FOR REMOTE VILLAGE IN YEMEN

By

Ibrahim Saleh Mohammed Almaghrebi

A Thesis Submitted to the
Faculty of Engineering at 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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Under supervision of

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Electrical Power and Machines Department	Electrical Power and Machines Department
Faculty of Engineering,	Faculty of Engineering,
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Title of Thesis:

DESIGN OF PHOTOVOLTAIC SYSTEMS FOR REMOTE VILLAGE IN YEMEN

Key Words:
Photovoltaic, Hybrid system, Life Cycle Cost, LBBO, LVRT

Summary:

In this thesis, the design of photovoltaic systems for a remote village in Yemen is presented. The design includes stand-alone PV system and hybrid system with diesel generator, also the possibility of connecting PV system to the national network is also studied. In order to provide practical design for this village, the data was collected through the Ministry of Electricity in Yemen. It includes solar radiation and temperature, in addition to a field investigation is conducted to estimate the electrical loads.

To choose the optimal design for feeding the village, a comparison was done through two methods: the first by using heuristic approach and the second through the use of HOMER program. The first method depends on calculating the sizes of the various components of the system, such as the number of PV panels, number of batteries and diesel generator capacity, according to the lowest cost on the lifetime of the system and the most reliable system. While the second method is based on HOMER optimization program, the program is also used to study the effect of the variation in solar radiation and interest rate factor on the cost of energy for systems.

A MATLAB / SIMULINK model for a PV grid connected system is also implemented. A maximum power point tracking algorithm is applied to extract as much energy as possible during solar radiation change. PI controller is also applied in the structure of the inverter. Its parameters are optimized using Linearized Biogeography Based Optimization technique (LBBO). Also, the low voltage ride through (LVRT) control was carried out to keep the PV array connected to the grid during voltage sags.

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DEDICATION

This thesis is dedicated to my dead **father** who has been a great source of motivation, love, and inspiration.

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1-Symbols

A	:	The annual payment ($).
C_D	:	The diesel generator cost ($) per kW.
C_t	:	The total capital cost ($).
$C_{o\&m}$	:	The total operation and maintenance cost ($).
$C_{REP-bat}$	:	The total present replacement cost of batteries ($).
$C_{REP-inv}$	:	The total present replacement cost of inverter ($).
C_{sa}	:	The total salvage cost ($).
D	:	Duty cycle.
E_g	:	Band gap for silicon (1.11 e.v).
E_L	:	The daily load energy demand (kWh).
F	:	The single payment ($).
F_{pr}	:	Fuel price per liter ($).
H_D	:	The amount of oil required in liter per day (liter/day).
I_d	:	The normal diode current (A).
I_{mpp}	:	Maximum power point current of PV module (A).
I_n	:	The normal current of inverter (A).
I_o	:	The cell reverse saturation current (A).
I_{pv}	:	The PV current (A).
$I_{pv\ cell}$	:	The cell photo current (A).
I_{sc}	:	The short circuit current (A).
i	:	Interest rate (%).
K	:	Boltzmann's constant (1.38×10^{-23} joule/ºk).
K_D	:	The percentage of the initial generator cost (%).
K_i	:	Integral gain.
K_p	:	Proportional gain.
K_t	:	The temperature coefficient at short circuit current (Amp/°C).
K_v	:	The temperature coefficient at open circuit voltage (V/°C).
N	:	No. of replacements.
n	:	The lifetime of the project (years).
N_C	:	The number of cloudy days.