Cairo University

OPTIMUM TILT ANGLE FOR SOLAR COLLECTORS USED IN NEW CAIRO

By

Mohamed Ahmed Sarwat Hafez

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

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Title of Thesis: OPTIMUM TILT ANGLE FOR SOLAR COLLECTORS USED IN NEW CAIRO

Key Words: Fuel Consumption, Solar Energy, Optimum Tilt Angle, Mathematical Models.

Summary:

As shown Nowadays all the world suffers from the fuel problem, accordingly, most of the countries try to depend on generating the electricity from a renewable source of energy, on the presented thesis it is will be discussed how to reduce the fuel consumption on electricity generation by using solar energy. One of the most important parameters that affect Photovoltaic (PV) panel Performance of both grid-connected system and the off-grid system is solar radiation received. The position and angle of a PV panel are two very important factors in PV system design. This Thesis investigates the optimal tilt angle of PV panels using the mathematical method. Mathematical models are used to estimate the total (global) solar radiation on a tilted surface and to calculate the output energy of PV panels. An experimental setup installed in (Schneider Electric Egypt Roof – New Cairo) is utilized to provide the real data.

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LIST OF SYMBOLS AND ABBREVIATIONS

• Symbols

d	The difference in distance between the sun and the earth
Io	The extra-terrestrial solar radiation (kWh/m^2/day)
G	Monthly average global solar radiation on a horizontal surface (kWh/m^2/day)
G_b	Monthly average direct beam solar radiation on a horizontal surface (kWh/m^2/day)
G_{BT}	The direct beam solar radiation on an inclined surface (kWh/m^2/day)
G_d	Monthly average diffuse solar radiation on a horizontal surface (kWh/m^2/day)
G_{DT}	The diffused solar radiation on an inclined surface (kWh/m^2/day)
G_{RT}	The ground-reflected solar radiation on an inclined surface (kWh/m^2/day)
G_T	The total solar radiation on an inclined surface (kWh/m^2/day)
I_{MPP}	PV module maximum power point current (A)
I_{pv}	PV array output current (A)
I_{sc}	Short-circuit current of module (A)
K_t	Monthly-average clearness index
n	Number of the day in the year
P_{max}	Maximum PV array power (W)
P_{pv}	PV array output power (W)
R_b	The geometric factor
S_{STC}	The solar irradiance at Standard Test Condition (1000 W/m^2)
T	The cell temperature (ºC)
T_a	The absolute of the body temperature (ºk)
T_{max}	The maximum air temperature (ºC)
T_{min}	The minimum air temperature (ºC)
V_{MPP}	PV module voltage atmaximum power point (V)
V_{oc}	PV module open circuit voltage (V)
Ws	Wind speed in (knots).
ϕs	The surface azimuth angle
θ	the incidence angle (º)
θ_z	The zenith angle of the sun (º)
ρ	The albedo ground reflection
σ	Stefan-Boltzmann's constant (5.67 × 10^{-8} W/m^2/º k^4)
L	The latitude of the site (º)
δ	Declination angle (º)
Σ	The tilt angle of the module measured from the horizontal (º)
Σ_{Opt}	The optimum tilt angle of the module measured from the horizontal (º)
H_{SR}	Sunset hour angle (º)
H_{SRc}	Sunset hour angle for the tilted surface (º)