OPTIMIZATION OF SURFACE ORIENTATION ANGLES TO RECEIVE MAXIMUM SOLAR RADIATION AT SABHA CITY IN LIBYA

Thesis

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NOMENCLATURE

δ is solar declination angle

n is the day of the year [a number 1 through 365]

ω is Solar Hour Angle (hr)

t_s is the solar time (hr)

t_c is the civil time in hours corresponding to the midpoint of the time step [hr]

λ is the longitude [°]

Z_c is the time zone in hours east of GMT [hr]

E is the equation of time [hr]

n is the day of the year, starting with 1 for January 1st.

θ is the angle of incidence [°]

β is the slope of the surface [°]

γ is the azimuth of the surface [°]

$\emptyset$ is the latitude [°]

θ_z is the zenith angle [°]

G_{on} is the extraterrestrial normal radiation [kW/m^2]

G_{sc} is the solar constant [1.367 kW/m^2]

G_o is the extraterrestrial horizontal radiation [kW/m^2]

$\bar{G}_o$ is the extraterrestrial horizontal radiation averaged over the time step [kW/m^2]

ω_1 is the hour angle at the beginning of the time step [°]

ω_2 is the hour angle at the end of the time step [°]

H_{ave} is the monthly average daily of global horizontal solar radiation (KWh/m^2/day)

$H_{o,\ ave}$ is the average extraterrestrial horizontal radiation for the month [kWh/m^2/day]

N is the number of days in the month

$\bar{G}$ is the global horizontal radiation on the earth's surface averaged over the time step [kW/m^2]

$\bar{G}_b$ is the beam radiation [kW/m^2]

$\bar{G}_d$ is the diffuse radiation [kW/m^2]

$\bar{G}_T$ is hourly total radiation on a tilted surface (KW/ m^2).

G_{bT} is hourly beam radiation on a tilted surface (KW/ m^2).

G_{gr} is hourly ground-reflected solar radiation (KW/ m^2).

ρ_g is the ground reflectance, which is also called the albedo [%]

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ABSTRACT

In this paper, the Genetic Algorithm (GA) is implemented to calculate the optimum tilt and surface azimuth angle for solar system surfaces to receive maximum solar radiation. Sabha city in Libya is selected to verify the results of GA. The optimum surface orientation angles and the flat surface input solar energies for these angles are calculated in monthly and yearly bases. Then, The comparison of different optimizations of GA and South-Facing for an inclined surface was compared with the horizontal surface in a year and the energy gained was investigated. The total extra solar energy gained in one year for the yearly optimized surface angles of GA and South-Facing compared to the horizontal surface are 10.8% and 10.3%, respectively. The total extra solar energy gained in one year for the monthly optimized surface angles of GA and South-Facing compared to the horizontal surface are 18.72% and 18.03%, respectively. The yearly optimum tilt angle of the generic algorithm was 30.4° where the azimuth was at -19°. In another result, the yearly optimum tilt angle of south-facing was 29°. It has been figured out that the yearly optimum tilt angle of both was closed to the latitude of the location. Furthermore, the results indicate that the monthly based optimization improved the energy gain higher than the yearly based optimization. The genetic algorithm optimization performed better results than the conventional south facing optimization although the difference of the results was not significant for both yearly and monthly total incident solar radiation.

Keywords: Solar energy, Solar radiation, Orientation angles, Optimization