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The effect of spatial orientation of solar energy receiver on the energetic gain

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Abstract. The angle of incidence of solar radiation on the PV panel is a function of many factors: the angle of solar declination, the angle of latitude, the hour angle, the azimuth angle and the angle of receiver inclination to the ground. Optimization of the positioning of a solar energy receiver, considering the possible energetic gain, with the Liu-Jordan isothropic mathematical model has been made. The influence reflectivity coefficient of the ground and transparency coefficient of the atmosphere on the investigated angle has been taken into account. The computer simulation results have been presented and compared with those obtained by other authors.

Key words

solar energy, optimal setting of the receiver, energetic gain, computer simulation.

1. Introduction

The Sun is composed of a mixture of gases with a predominance of hydrogen. Through most of the Sun"s life, energy is produced by nuclear fusion through a series of steps called the proton - proton chain.
These process are sourced with energy of solar radiation. This energy is radiated away from the Sun uniformly in all directions. Sources of solar energy are in practice unlimitted and at the same time, environment friendly. The total power sent by the Sun in cosmic space is equal 3,826 10^{26} W. Taking into account the conversion of solar energy into electric energy, the angle of incidence of solar radiation of the receiver plane is of considerable significance.
The European Union is preparing a new energy strategy for 2011-2020, 3 x 20 Report (20% reduction of emissions, 20% improvement of energy, and 20 % energy consumption from of renewable sources.

2. Density of solar power radiation

A. Basic relationships

The angle θ_{β}, is an angle of incidence of the radiation on a plane inclined at the angle β to the ground being the function of many variables. The variables and interrelations among them are shown in the figure 1 [9].
The angle θ_{β}, is described by the relationship [9, 20]:

$$\cos\Theta_\beta = \sin\delta\sin\varphi\cos\beta - \sin\delta\cos\varphi\sin\beta\cos\gamma + \cos\delta\cos\varphi\cos\beta\cos\omega + \cos\delta\sin\varphi\sin\beta\cos\gamma\cos\omega + \cos\delta\sin\beta\sin\gamma\sin\omega \quad (1)$$

The declination angle δ depends on the day n of the year. It is calculated according to the approximate Cooper rule [9, 20]:

$$\delta = 23{,}45\cdot\sin\left(360\cdot\tfrac{284+n}{365}\right) \quad (2)$$

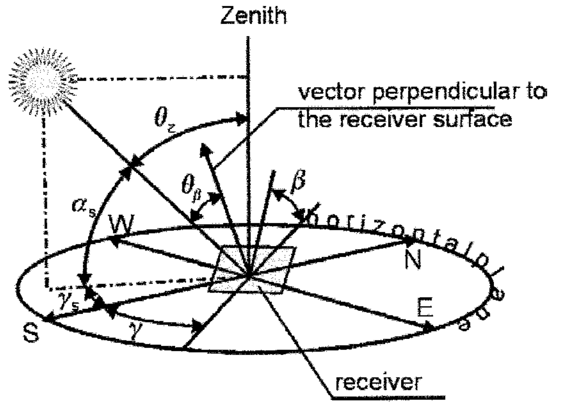

Fig.1. Sun and receiver in a horizontal coordinate system. Explanations: α_s - the solar angle, β - angle of inclination of the receiver vs. of the ground, γ - receiver azimuth, ω - the hour angle, θ_β - the angle of incidence of the radiation on the surface of the receiver inclined at the angle β, to the ground, θ_Z - the zenith angle

ω - is the hour angle, taking the following value in accordance to the time of the day:

$$\omega = 15\left(\tau - 12^{00}\right) \quad (3)$$

where τ is the hour of the day.
The angle of latitude φ depends on the location. The next parameter , that is the azimuth angle of the receiver (Fig. 1), is the deflection accounted from the local meridan to the south direction (-15° - +15°). Taking into account that the surface of the receiver inclined at the angle β to the ground is oriented to the South, it takes a zero value [20]. Where β=0, $\theta_Z = \theta_\beta$, θ_Z - angle of incidence of the radiation on a horizontal surface (the zenith angle), Fig.1:

$$\cos\Theta_Z = \cos\delta\cos\varphi\cos\omega + \sin\varphi\sin\delta \quad (4)$$

The density of solar power radiation flux is a sum of radiation energies in the whole spectrum of wave lengths reaching a surface unit [W/m^2]. Solar radiation is characterized by components:direct component G_{dr}, diffused component G_{df} and secondary reflected radiation G_r [9]. The G_{dr} and G_{di} values are assessed on the grounds of many years data obtained from weather stations [1], G_r is considered as a secondary radiation