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Simulation and evaluation of small scale solar power tower performance under Malaysia weather conditions

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Abstract. Solar energy is the most available, clean, and inexpensive source of energy among the other renewable sources of energy. Malaysia is an encouraging location for the development of solar energy systems due to abundant sunshine (10 hours daily with average solar energy received between 1400 and 1900 kWh/m^2). In this paper the design of heliostat field of 3 dual-axis heliostat units located in Ipoh, Malaysia is introduced. A mathematical model was developed to estimate the sun position and calculate the cosine losses in the field. The study includes calculating the incident solar power to a fixed target on the tower by analysing the tower height and ground distance between the heliostat and the tower base. The cosine efficiency was found for each heliostat according to the sun movement. TRNSYS software was used to simulate the cosine efficiencies and field hourly incident solar power input to the fixed target. The results show the heliostat field parameters and the total incident solar input to the receiver.

1. Introduction

All Solar Power Tower (SPT) systems are just commercially employed in certain regions in the world especially in arid areas of mid-latitude zones, such as Spain, Russia, Italy, Germany, Australia, and US [1]. It is usually believed that SPT systems cannot be used in the tropics with relatively high diffuse fraction of global radiation. However, there is no systematic study on this issue [2].

Malaysia is rapidly developing and the growing energy demand requires alternative energy sources to fulfil the demands [3]. Currently most of the solar power used in Malaysia is Photovoltaic (PV) systems on a domestic level only and large scale commercial use is not significant yet [4].

In this paper the solar power tower technology is examined for collecting and redirecting solar power in order to produce thermal energy for latitude 4.34° in Malaysia by designing a small-scale heliostat field then calculating the cosine efficiency for each heliostat and finally simulating the incident solar input to a fixed target mounted on the top of a tower.

2. Model description

2.1. Sun position definition

In order to calculate the hourly heliostat field efficiency, a model for solar position has been utilized. The solar position equations are obtained from Duffie and Beckman [5].

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