Renewable and Sustainable Energy Reviews 91 (2018) 754–782

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Solar tracking systems: Technologies and trackers drive types – A review

A.Z. Hafez[a,b,*], A.M. Yousef[a,c], N.M. Harag[a]

[a] Renewable Energy Engineering Program, University of Science and Technology, Zewail City of Science and Technology, Giza, Egypt
[b] Nottingham Transportation Engineering Centre, Faculty of Engineering, University of Nottingham, Nottingham, United Kingdom
[c] Mechanical Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt

ARTICLE INFO

Keywords:
Solar
Tracking
Azimuth
Elevation
Tilt
Polar
Active
Passive
Collector
PV

ABSTRACT

This paper presents a comprehensive review on solar tracking systems and their potentials in solar energy applications. The paper overviews the design parameters, construction, types and drive system techniques covering different usage application. There are two main solar tracking systems types that depending on their movement degrees of freedoms are single axis solar tracking system and dual axis solar tracking system, which are addressed in the recent studies. The solar tracker drive systems encompassed five categories based on the tracking technologies, namely, active tracking, passive tracking, semi-passive tracking, manual tracking, and chronological tracking. The paper described the various designs and components of the tracking systems. There are 42.57% of the studies discussed and presented single axis tracking systems while 41.58% of these studies to the dual axes tracking systems. In the recent research studies, the most common solar tracker drive type was active tracker by 76.42% usage in applications while in the second most impact type is the chronological solar tracker by 7.55%. Furthermore, in the solar tracking techniques, Azimuth and altitude tracking achieved 16.67% in usage, Horizontal tracking by 16.67%, Azimuth tracking by 10%, and polar tracking by 4.44%.

1. Introduction

The solar tracking system plays an important role in different solar energy applications where its benefits not only exist in the power and efficiency gains and increase compared to the fixed systems, but also in the economic analyses of the large-scale solar energy applications. The systems are oriented with optimal tilt angles towards the equator from the horizon to maximize the solar radiation affects on the solar collectors and panels. The tracking angles depend on the site latitude and climatic conditions. There are two main solar tracking systems types that depend on the movement degree of freedom are single axis solar tracking system and dual axis solar tracking system. Several sun tracking systems are evaluated and showed to keep the solar panels, solar concentrators, or other solar applications as the recent studies of single axis tracking [1–43], dual axis tracking [44–85], single and dual axis tracking [86–107] with respect to the tracking systems types. A single axis solar tracking system is a technique to track the sun from one side to another using a single pivot point to rotate. This system has main three types: horizontal, vertical, and tilted single axis tracking system. The main CSP applications of the single axis tracker are parabolic trough and linear Fresnel solar systems. The main disadvantage of the single axis tracking system is that it can only track the sun during the daily movement and not the yearly movement, and during the cloudy days, the efficiency of the tracking system is reduced by a large amount due to the rotation around only one-axis. A dual axis solar tracking system is a technique that tracks the sun in two different axes using two pivot points to rotate. Solar tracker system in this type usually has both horizontal and vertical axes. One of the most important applications to dual axis tracker are CSP applications and especially solar dish and solar tower systems where the long distance between the heliostat reflectors and the receiver point concentration lead to angle errors in the results.

The solar tracker drive systems are classified into five types based on their tracking technologies, namely, active tracking, passive tracking, semi-passive tracking, manual tracking, and chronological tracking [1–90,92–96,98–100,108–112]. Active solar tracking system is the system that determines the position of the sun path in the sky during the day with the sensors. These sensors trigger the motor or actuator to move the drive system to the system towards the sun throughout the day. If the solar radiation beams are not perpendicular on the solar tracking system, then this will made a difference in light intensity on one sensor as compared to another leading to act the tracking system to be perpendicular on the sunlight beams. Active tracking system sorted with different control types as microprocessor-based, electric-optical sensor-based, date and time methods, and auxiliary PV cells [64,113]. Active tracking systems using microprocessor and electric-optical

* Corresponding author at: Nottingham Transportation Engineering Centre, Faculty of Engineering, University of Nottingham, Nottingham, United Kingdom.
E-mail addresses: ahafez@zewailcity.edu.eg, ahmed.mohamed2@nottingham.ac.uk, ahmed.mohamed@nottingham.ac.uk, ahmedzakaria5@gmail.com (A.Z. Hafez).

https://doi.org/10.1016/j.rser.2018.03.094
Received 15 June 2017; Received in revised form 25 November 2017; Accepted 31 March 2018
1364-0321/ © 2018 Elsevier Ltd. All rights reserved.

Nomenclature

b	The axis that parallel to the earth surface
$B-1$	First mirror of the solar box cooker
$B-2$	Second mirror of the solar box cooker
$CTES, ba$	Thermal energy storage cost at the balance point, $
Csf	Cost of solar field, $/m^2
H	Height of the shading plate, m
i	The cosine of incidence angle
L	Dual booster mirror solar cooker length, m
$L1$	Distance of the photosensing element from the plate, m
r	The tracking axis
S	Sun ray vector
u	The third orthogonal axis
W	Dual booster mirror solar cooker width, m
Wa	Solar hour angle, °
Y	Azimuth, °

Greek Symbols

α	Altitude angle, °
α_w	Azimuth angle, °
δ	Declination, °
$\theta 1$	Incidence angle of solar rays on the tracked panel, °
θi	Incidence angle, °
βin	Inclination of booster mirror B-1, °
θin	Inclination of booster mirror B-2, °
ϕ	Latitude angle, °
θL	Longitudinal incidence angle, °
$\Delta\eta track$	Loss of optical efficiency, %
γ	Orientation of the still, °
βp	Pyramidal sensors angle, °
ψrim	Rim angle, °
θs	Solar incident angle with respect to PV normal vector, °
θz	Solar incident zenith angle, °
βs	Stopping angle of tracker, °
θr	The amount of rotational angle about EE' axis measured from OV axis, °
βr	The amount of rotational angle about OV axis measured from OR axis, °
ρt	Thickness
β	Tilt angle, °
$\beta 1$	Tilt-angle of vertical-axis tracked solar panels with respect to the horizon, °
ΔJ	Tracking advantage, %
ρ	Tracking angle, °
θT	Transverse incidence angle, °

Acronyms

AADAT	Azimuth - Altitude Dual Axis Tracker
ASGHT	Asymmetric Greenhouse Type Still
CPV/T	Concentrated Photovoltaic Thermal
CSP	Concentrating Solar Power
DOF	Degree of Freedom
FKE	Faculty of Electrical Engineering
FLC	Fuzzy Logic Controller
FPC	Flat Plate Collector
FPGA	Field-Programmable Gate Array
ISNA	Inclined South-North Axis
ISNA-3P	Inclined South-North Axis - Three Positions
ISN-axis	Inclined South-North Single-Axis
LDR	Light Dependent Resistor
LFMSC	Linear Fresnel mirror solar concentrator
MED	Multi Effect Distillation
NISE	National Institute of Solar Energy
PID	Proportional Integral Derivative
PLA	Programmable Logic Array
PLC	Programmable Logic Control
PMDC	Permanent Magnet Direct Current
PMMA	Poly Methyl Methacrylate
PTC	Parabolic Trough Concentrator
PV	Photovoltaic
PVGCP	Photovoltaic Grid-Connected Plants
RSM	Reluctance Stepper Motor
RTC	Real Time Clock
SC	Spherical collector
SIST	Sensor Independent Solar Tracking
SMA	Shape Memory Alloy
SOG	Silicon of Glass
SOP	Slope of Panel
SPSTC	Semi-Passive Solar Tracking Concentrator
UTeM	Universiti Teknikal Malaysia
VSAT	Vertical Single Axis Tracker

sensors are used at least two photoresistors or PV cells. A comparison between the output signals of the two variables parameters is conducted, and, subsequently, send signal of the difference between them to the drive motor. In solar tracking systems with auxiliary bifacial solar cells, the cells trigger the drive system to move to the desired position. At cloudy days, this system is not accurate where the sensors cannot made a decision due to the low solar irradiance intensity difference between the sensors [64]. Solar power arrays play an important role in the design of the solar tracking systems with high precision designed systems. In addition, due to the large scale and widely use of PV systems for different applications, this type of solar tracking systems are widely used [114]. Passive tracking system is one of the solar tracking systems which depend on the thermal expansion in materials or an imbalance in pressure between two points at both ends of the tracker, where usually these materials as a fluid (liquid or gas). The passive solar tracking system relies on a low boiling point compressed gas fluid, which cause the structure of the tracker to move to an imbalance. A semi-passive tracking system is a technique where the solar tracking concentrator can track the sun and keep the sun's rays perpendicular to the absorber's cross-sectional area with a minimal mechanical effort and reduced movement for sun tracking. The system is consisted of a micro-heliostat array, a Fresnel lens and a receiver. Manual solar tracker is a method where the system can track the sun angle from season to season with manual tilt angle changing per seasons using a manual gear for ease of the system construction and maintenance. One of the significant advantages of the manual tilt angle axis as the secondary axis in the dual-axis tracking systems is cheaper than used in the previous types by implementing a second motor. A chronological solar tracking system is a time-based tracking system where the system collector or module moves with a fixed rate and a fixed angle throughout the day as well for different months. The motor or actuator is controlled to rotate at the low rate (15° per hour approx.). One of the main advantages of this system, which is more energy efficient because no energy losses at this tracking calibration due to low tracking error [88].

The main aim of this study is to review the solar tracking systems methods to decide which the optimum type, application, and the design for the solar systems. In Section 2, the historic overview of the solar tracking systems are described. The new techniques of the solar tracking systems are discussed in Section 3. In Section 4, the solar tracking systems types are described, as well as introduced the solar

Download English Version:

https://daneshyari.com/en/article/8111184

Download Persian Version:

https://daneshyari.com/article/8111184

Daneshyari.com