Clean Energy For Sustainable Economy & Environment

Innovative Non-Mechanical Tracking Solar Concentrator for Multipurpose Sunlight Harvesting

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Abstract

Broad spectrum of sunlight contains larger portion of infrared radiations which can be utilized for various thermal applications. Here, we report harvesting of sunlight in terms of water heating and electricity generation. Most of the solar concentrators required continuous tracking system to remain in direct sunlight radiations. We have designed and developed large Fresnel lens and segmented mirror-based system for multiple applications without tracking the sun. Fresnel lens focusses sunlight and six segmented mirrors mounted at different angles redirects sunlight radiations in a particular area without tracking during daytime. The entire system is mounted in a single mechanical mount with no moving parts. We have demonstrated simultaneous solar water heating and electricity generation through thermoelectric generator modules (TEG) using developed system. This type of system having multiple applications is compact, efficient and cost effective.

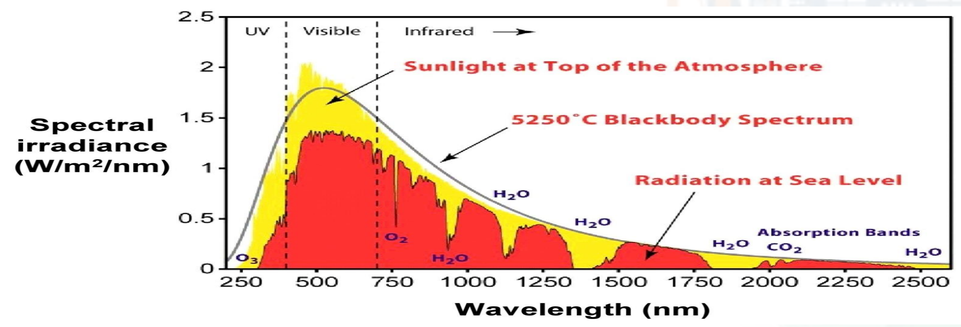
Introduction

Sunlight

1)Totally Free and Abundantly Available

2) Green Energy : Zero Environmental Pollution

3)Broad Spectrum: Sunlight Radiations reaches on earth surface contains 50 to 55 % Infrared,40-45 % Visible and 3-5 % U.V



Source:https://www.researchgate.net/publication/271891094_Design_and_Fabrication_of_an_Albedo_Insensitive_Analog_Sun_Sensor

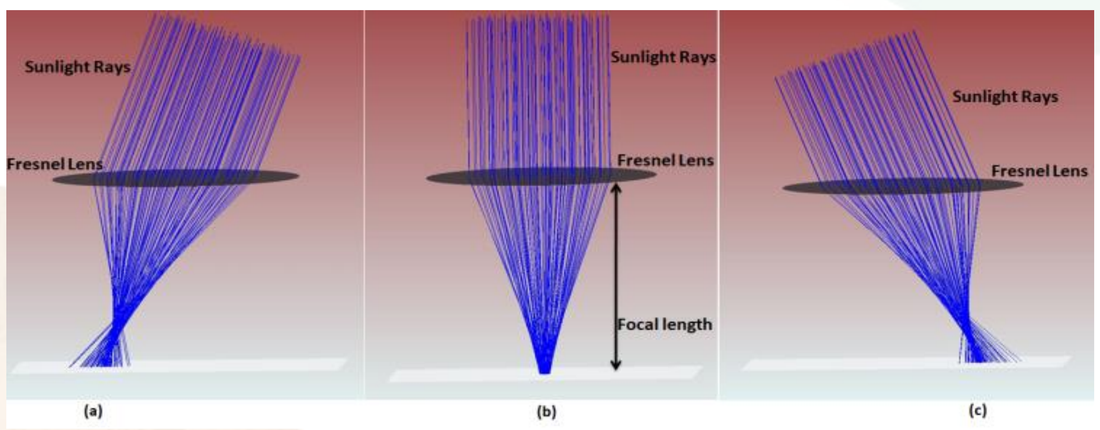


Figure: Schematic diagram of Ray Tracing in ZEMAX for sunlight rays at different angles with fixed Fresnel lens (a) Morning hours (b) at Noon (c) Evening hours

Materials and Methods

Fresnel Lens : To Focus Sunlight rays

Segmented Mirror Systems : To Redirect the Sunlight rays

Copper Box : Persistent heat storage in water for long time.

TEG Module : To convert heat into voltage generation

Water Tank : To hold hot water for commercial/ household purpose.

Result: Optical Ray Design using ZEMAX Software

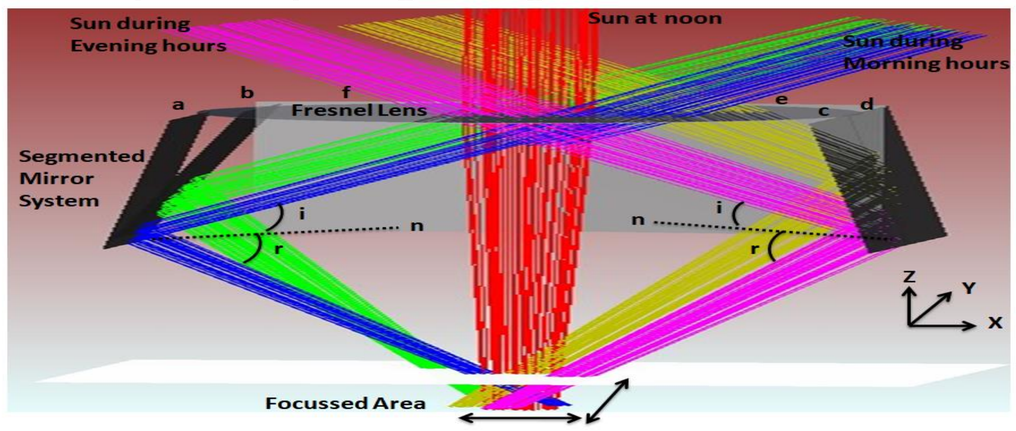


Figure: Schematic diagram of non-tracking solar concentrator using ZEMAX

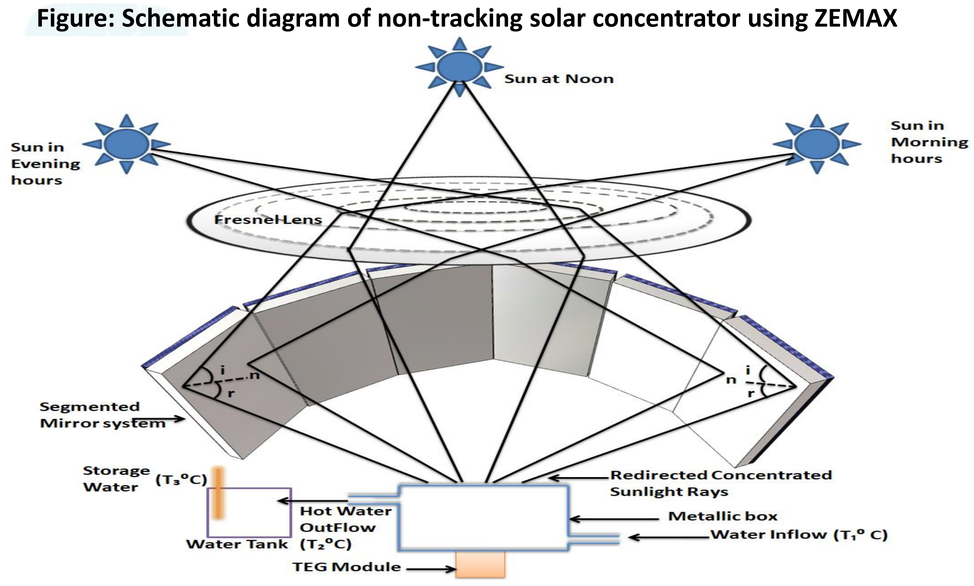


Figure: Schematic Diagram of Experimental Setup

Heat gained by the water is given by:

$$Q = m \times C_p \times (T_2 - T_1) \quad \textbf{(1)}$$

Efficiency of the system is evaluated using an equation 2 shown below:

$$\eta_{Th} = \frac{Q}{A_p I_b \Delta t} \quad \textbf{(2)}$$

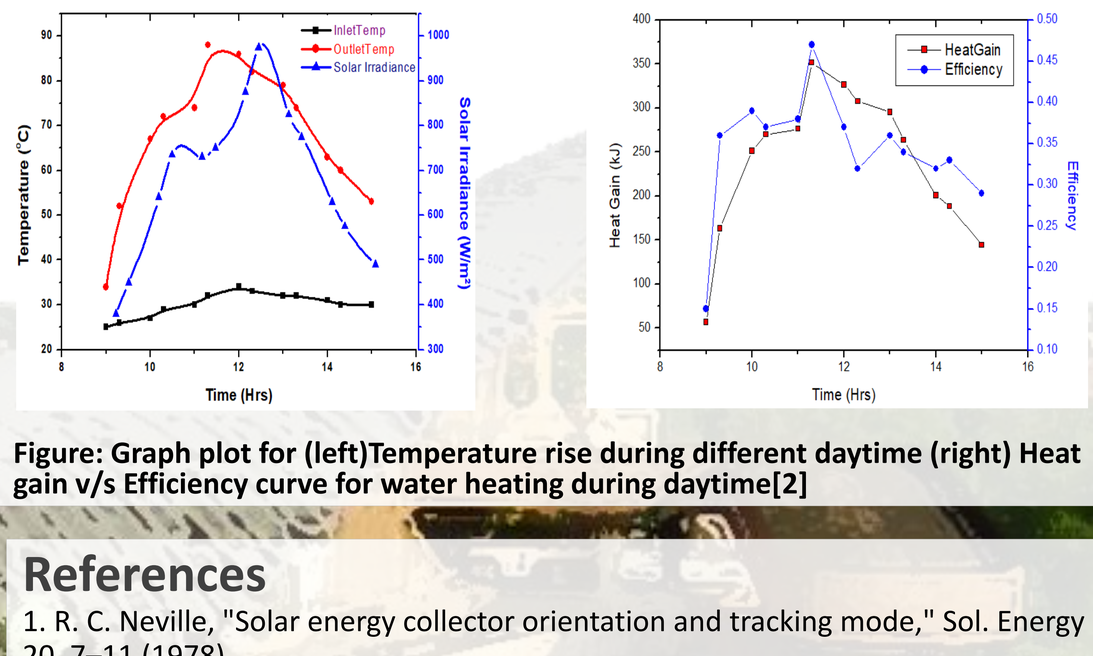


Figure: Graph plot for (left)Temperature rise during different daytime (right) Heat gain v/s Efficiency curve for water heating during daytime[2]

Conclusions

1) Successfully developed a non-tracking solar concentrator system based on a combination of large Fresnel lens and segmented mirrors.
2) Demonstrated simultaneous solar water heating and electricity generation using the developed system.
3) Fabricated system is useful for many solar thermal and electrical applications.

Industrial Significance

Completely Green Energy Harvesting without mechanical tracking system. Low cost and Sustainable system.

Technology Readiness Level

Prototype of the system developed for Instant Water Heating and Power Generation.

References

1. R. C. Neville, "Solar energy collector orientation and tracking mode," Sol. Energy 20, 7–11 (1978).
2. Mayank Gupta, Atul Kumar Dubey, Virendra Kumar, and Dalip Singh Mehta, "Solar concentrator based multipurpose sunlight harvesting system without tracking," OSA Continuum **2**, 667-676 (2019).
3. Mayank Gupta, Atul Kumar Dubey, Virendra Kumar, and Dalip Singh Mehta,"Sunlight Harvesting System for Simultaneous use of Room Indoor Lighting and Water Heating," in *Light, Energy and the Environment 2018 (E2, FTS, HISE, SOLAR, SSL)*, OSA Technical Digest (Optical Society of America, 2018), p. JT2A.5.
4. P. J. Hession and W. J. Bonwick, "Experience with a sun tracker system," Sol. Energy **32**, 3–11 (1984).
5. M. J. Clifford and D. Eastwood, "Design of a novel solar tracker, " Sol. Energy **77**,269-280 (2004).

Acknowledgement

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