CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S1125

Project Title

Development of a Non-Tracking Solar Thermal Concentrator Using the Simultaneous Multi-Surface Design Method

Abstract

Objectives/Goals

The main issue associated with solar power is its high costs, caused by the expensive tracking systems required for solar energy systems to remain efficient. Furthermore, current solar concentrators have been shown to be intrinsically flawed, resulting in huge opportunities to improve on current technology by developing an intelligent non-tracking concentrator that can accept indirect sunlight while offering higher levels of energy efficiency.

Methods/Materials

An efficient, novel, non-tracking design is created using principles of optics and the Simultaneous Multi-Surface (SMS) Design Method. The design method is applied to create a point-by-point calculation of two surfaces that redirect light from varying angles to an absorber. Information gained from the design of one surface facilitates the design of the other until the entire concentrator is established. From there, the concentrator's unique shape is derived using ray tracing, the edge-ray theorem, and the law of reflection. To test the design, a prototype was built using aluminum sheet metal and reflective film, along with a parabolic trough as a control. Due to adverse weather, experiments were conducted with a heat lamp to mimic the sun. The incoming angle of light to the concentrators was varied and the temperatures of the absorbers were recorded.

Results

The parabolic trough outperformed the designed concentrator slightly at direct sunlight (0° deviation), but the designed concentrator vastly outperformed the parabolic trough in angular deviations from -13° to 13°. This data suggests that the designed concentrator will be able to concentrate light from varying angles while remaining stationary and reach similar efficiencies to a tracking parabolic concentrator. Calculations based on experimental data revealed a theoretical conversion efficiency of 20.9% from incoming solar energy to electricity.

Conclusions/Discussion

Cost analysis based on experimental data suggests that using this non-tracking system will allow for a significantly lower cost per watt than traditional solar power systems. The non-tracking concentrator efficiently redirected light from various incoming angles and offers an exciting alternative that outpaces current solar energy systems.

Summary Statement

A novel non-tracking solar concentrator is designed, built, and tested, offering a significantly improved cost and efficiency than current systems.

Help Received

None. I designed, built, and tested the non-tracking concentrator myself.