CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S1105

Project Title

Development of a Household Direct-Steam-Generation Solar-Powered Water Recovery System, Year II

Abstract

Objectives/Goals

Access to clean water is a pressing issue worldwide. Large-scale, solar-powered desalination systems are viable but the investment is too costly for developing countries or small cities. In Year I, an initial prototype of a novel multi-stage, solar-powered water recovery system for household use was designed, built, and tested. It used parabolic trough collector technology and evaporation, air flow, recirculation, and condensation stages. The objective this year was to make significant design changes to increase performance, efficiency, and operability, including full sun-tracking automation.

Methods/Materials

Improved insulation and heat concentration were incorporated. Two optimization studies were conducted to increase freshwater output. The first hypothesis was that increasing surface area within the condensation stage would provide greater output. The second hypothesis was that lowering the flow rate of the water, by changing pipe aperture, in the recirculation stage would create more vapor due to longer contact time and thus greater output. The sun-tracking system was automated to allow full range of movement, including return to the origin after sunset. Water quality tests were conducted.

Results

System temperatures were higher by at least 10°-13°C. Increasing surface area in the condensation stage yielded lower output, while reducing recirculation flow yielded greater output. Automation resulted in full-sun tracking to maximize sun exposure and improved operability. Freshwater output increased 60%, and prototype efficiency from 15% to 20%. Differences in output between years and within Year II were statistically significant. Through microbial and dissolved solid tests, water was proven safe for human consumption.

Conclusions/Discussion

Improved insulation and heat concentration yielded better system performance. The hypothesis of the surface area study was disproved, validating the prior design. The flow study hypothesis was supported; lowering the recirculation flow produced more vapor available for condensation. Full automation of the sun-tracking rotation mechanism improved performance and operability. The prototype currently produces 1.7 liters of fresh water per day. Further refinements and scale-up will provide enough drinking water for household use while minimizing climate change by using solar energy. Mass production could enable this system to be in households in many parts of the world.

Summary Statement

This Year II project is the modification and optimization testing to increase performance, efficiency, and operability of a novel, low-cost, multi-stage, solar-powered water recovery system for household use.

Help Received

Father provided support in system construction. My research advisor, Mr. Peter Starodub, provided guidance throughout the process.