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

Benedict, Anna (School: The Middle School Attached to USTC)

Access to clean water is a pressing issue worldwide. Large-scale, solar-powered water recovery systems, for desalination of ocean or brackish water, minimize climate change but are prohibitively expensive for developing locations. In Year I, an initial prototype of a novel multi-stage, sun-tracking, solar-powered water recovery system for household use was designed, built, and tested. It utilized parabolic trough collector technology and evaporation, air flow, recirculation, and condensation stages. In Year II, significant prototype modifications were made to increase efficiency, performance, and operability. Full automation of the sun-tracking rotation mechanism, including return to origin after sunset, plus improvements in heat retention, vapor capture, and water flow provided a marked difference. Improved insulation and heat concentration yielded a temperature increase of 10°-13°C, essential for the next level of system output. Through microbial and dissolved solid tests, water was proven safe for human consumption. Two in-depth optimization studies were conducted. Additional surface area employed within the condensation stage yielded a decrease in output, validating the prior design. The second study optimized heated water flow within the recirculation stage, controlled by changing pipe aperture, enabling more vapor to be produced and greater freshwater output. Lower brine flow rates yielded greater freshwater output. Differences in freshwater output between years and optimization study results within Year II were statistically significant. Freshwater output increased 60%, and prototype efficiency from 15% to 20%. The prototype will produce 1.7 liters of fresh water per day. Further refinements and scale-up will provide enough drinking water for household use.