Reflector Augmented Solar Water Heater

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Reflector Solutions

Mission

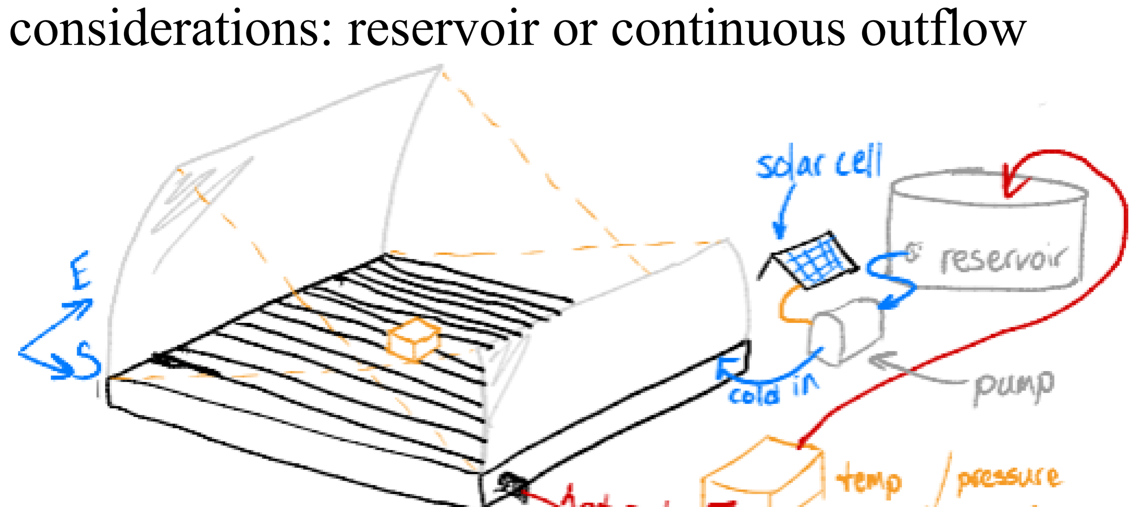
- The goal of this project is to design, conduct, and report the results of an experiment that involved the augmentation of a solar hot water heater with reflectors
- A theoretical thermal model of the collector/reflector system was developed based on the geometry of the system and position of the sun
- Measurements taken of the inlet and outlet temperatures were used alongside the thermal model to calculate the increase in efficiency
- Results were analyzed and a research paper prepared, ready for conference submission

Research

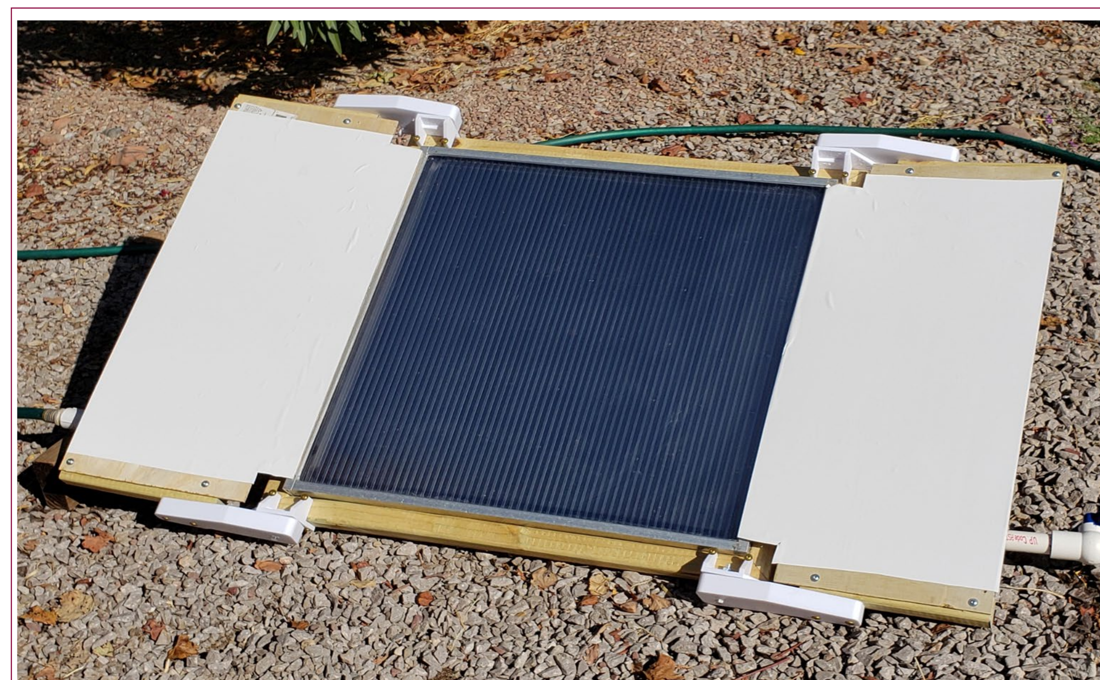
- Solar water heaters have become common technology applied in thousands of homes across America[1]
- The elected solar water heater is an active system
- Department of Energy reports solar water heating systems can reduce energy costs by 50% to 80%[2]
- Increasing the solar radiation incident on the collector panel predicted to increase efficiency and lengthen the effective heating period duration[3]
  - Using reflectors cheaper than increasing panel size
- Previous reflector research utilized fixed parabolic panels similar to large scale power plants[4,5]

Concept Development

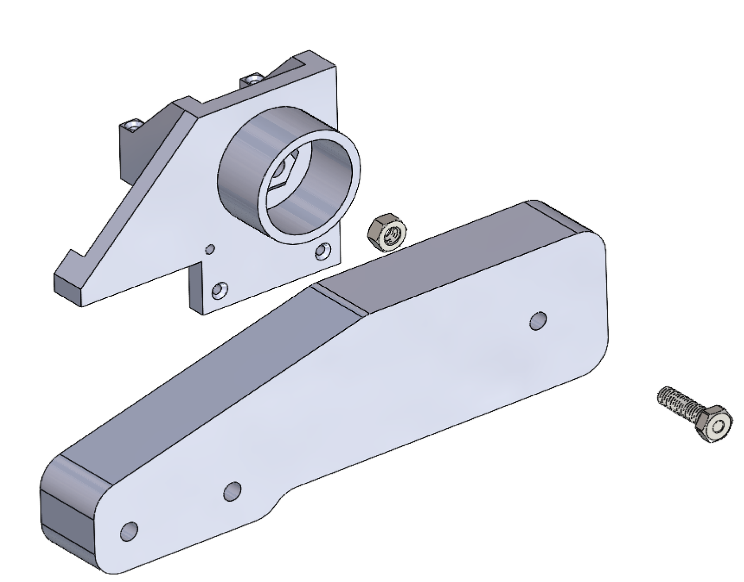
- Augment a solar water heater system designed for RVs with variable angle flat reflectors
- Design needed to have optimal reflector angles at various times of day; entire system at optimal tilt
- Reflectors need to be easily adjustable
- Automated temperature data collection with type K thermocouples for inlet and outlet flow
- Closed loop vs open loop water usage considerations: reservoir or continuous outflow



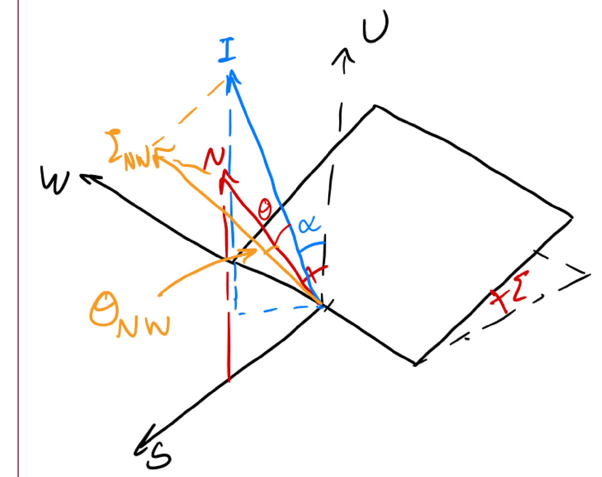
Final Design



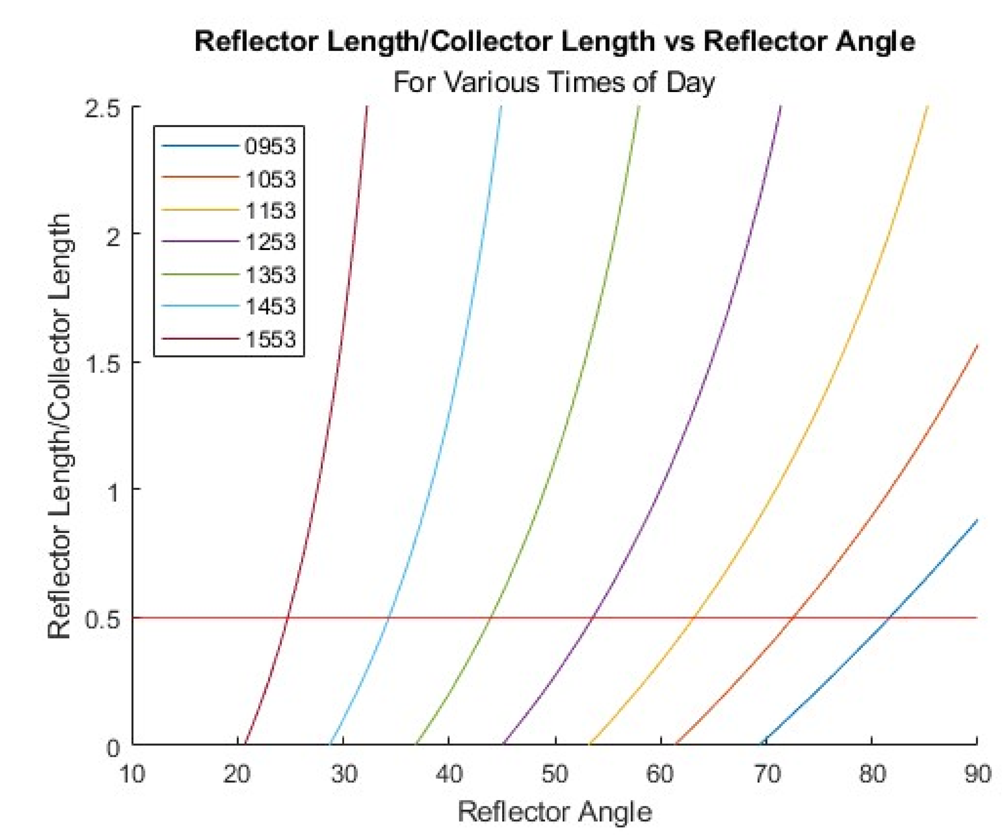
- The base of the solar water heater frame was constructed from 2”x2” wood pieces
- Angled at approximately 32°, maximizing the effectiveness of the heater
- Hinges were designed to utilize captured nuts to tighten the reflectors once set at the desired angle
- The hinges were printed in PET-G due to the desirable properties and ease of manufacturing
- An M6 nut was embedded in the base of the hinges, and bolts secured them in place
- Custom hinges were chosen to leave as little gap as possible between the reflectors and the base
- An open loop system was chosen in order to simplify the design as well as keep the inlet temperature as consistent as possible
- An aluminum base was initially considered, however this added to the complexity of the manufacturing, so a wooden base was selected
- Many materials were considered for the reflector surfaces, such as polished aluminum, gold reflective material, and white reflective material
- White reflective material was ultimately chosen due to the reflective properties, maximizing the amount of infrared rays reflected
- Infrared rays were of priority due to the heater panel converting these wavelengths into heat



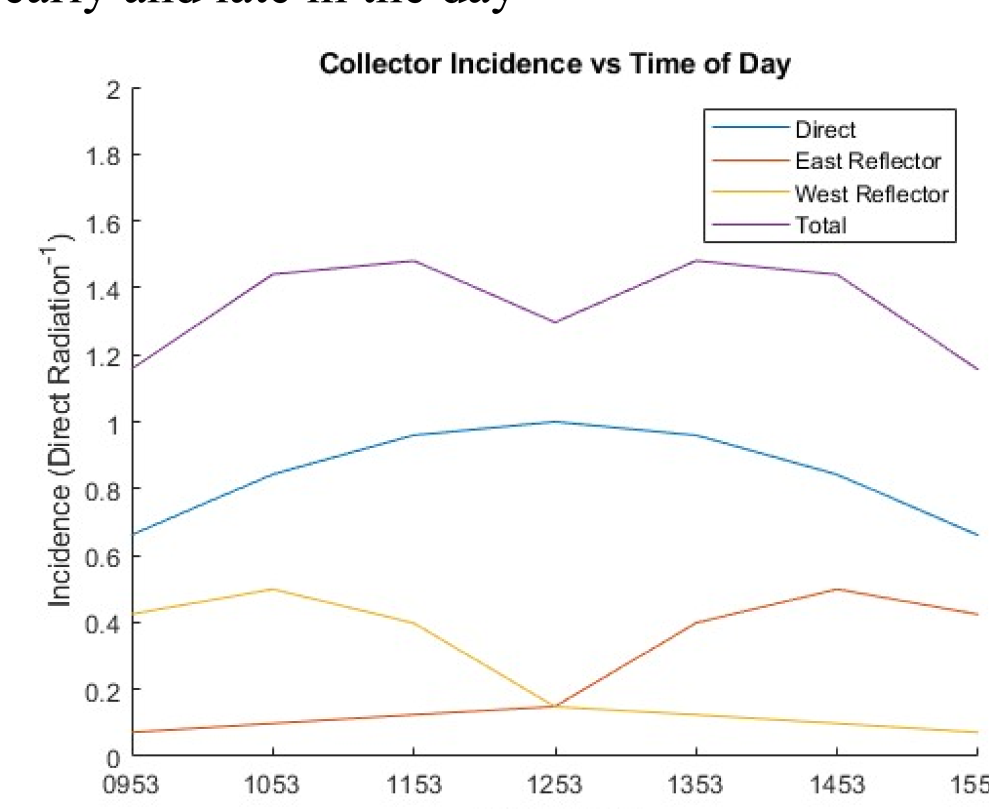
Thermal Model



- The optimal reflector angles were calculated using the left diagram given the solar elevation and azimuth angles and the tilt angle of the collector
- Optimal collector tilt angle is equal to latitude angle: 32° for Las Cruces at equinox
- Optimal reflector angle varied with time of day and aspect ratio of the reflector panels



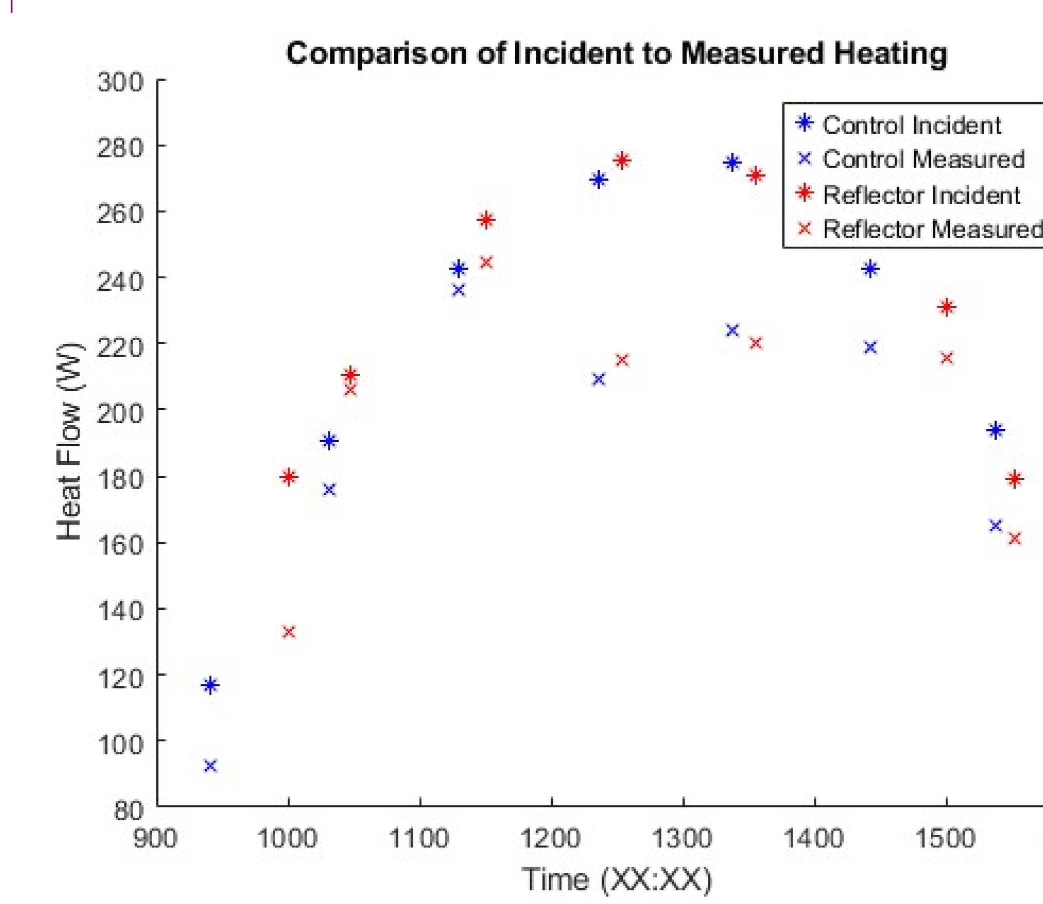
- Using optimal reflector angles, the predicted increase in solar radiation incident on the collector was calculated
- Reflector panels predicted to be more effective early and late in the day



- Expected heating formula: $Q'_{predicted} = I \times A$
- Actual heating: $Q'_{measured} = m'_{water} \times C_p \times (T_{inlet} - T_{outlet})$

Testing and Results

- The testing procedure consisted of a series of data collection test runs
- The data collected consisted of water inlet and outlet, and ambient temperature, and solar irradiance on the collector
- Testing was comprised of two main runs, the control (no reflectors), and reflector run (reflectors up)
- Acquiring these measurements provided the team with data to determine the efficiency increase in the system, and solar irradiance differences, with and without reflectors
- The reflector system yielded an overall increase in efficiency of 0.92 percentage points over the control system
- The reflectors provided a consistent increase in heating efficiency and incident solar radiation, though not very large. A flow rate of 0.4179 gpm was used to reach the maximum heating potential of the system



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