

# Dual-Wing Heliostat

## Abstract

The dual-wing heliostat team believes in the beauty of simplicity. With fewer parts that can be easily assembled and readily sourced, this team aims to make solar thermal power generation more accessible. This design was built upon the vision of a full, sparkling solar field. Each module is controlled with its own microprocessor board which takes in local data from each heliostat and reports this information back to the central tower, allowing the central tower controller to optimize the entire solar field for maximum efficiency.

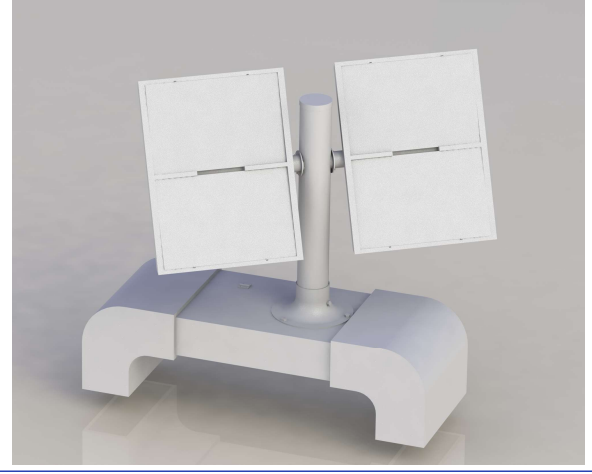
The module's reflectors are mounted in a "window-pane" arrangement, with their corners tilted in towards a central vertex, giving useful light focusing ability to flat mirrors. The mounts which support these reflectors can be injection-molded as one piece, lending them to large-scale manufacturing. These mounts are slid onto either end of a cross-bar, and bolted on. The structural core of the dual-wing heliostat module consists of two PVC pipes, one acting as a central pillar and axis for azimuthal rotation, and the other as a cross-bar which rotates the reflectors altitudinally to reflect sunlight. The motor which controls altitudinal motion sits within the central pillar to protect it from the harsh desert. The base is made of square PVC tubing to offer a cost-effective but stable support for the design. The dual-wing heliostat may be small in scale, but the realm of possibility is as large as a desert solar energy field.

## Functionality

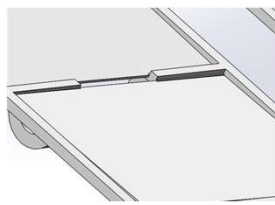
A heliostat is a device which directs sunlight toward a specific point, regardless of the sun's position overhead, which is typically done by moving a reflective surface. Using many heliostats, a receiver they are collectively aimed at can reach temperatures exceeding 1000 °C, allowing this thermal energy to be harvested.

Control of the heliostats is provided externally and sent wirelessly to a receiver housed in the base of the heliostat: additionally, a controller within the heliostat confirms the heliostat position and provides feedback to the central tower for error-tracking, allowing for further optimization of heliostat aiming no matter where a given heliostat is installed. The four silver-backed mirrors of the reflector are angled to be slightly concave, reducing dispersion of light for heliostats that are within 50m of the receiver tower.

## Full Assembly



## Angled Reflectors



Early concepts for the reflector had concavity to reduce dispersion of light. This is done with flat mirrors by mounting them at an inwards angle, enhancing focusing at distances up to 50 m.

## Reflector Mount Snap-fits



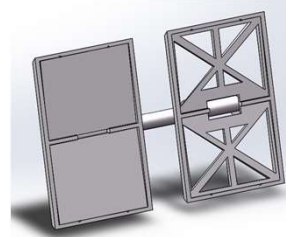
The mirrors are held against the angled reflector mount surface using snaps-fits, which are molded as part of the mount. Snap-fits reduce assembly time and ensure that mirrors can be removed easily.

## Cost Overview

Category	Cost
OTS Parts	\$ 29.89
Modified OTS Parts	\$ 19.48
Raw Materials	\$ 53.07
Manufacturing Labor	\$ 4.32
Assembly Labor	\$ 8.46
Energy Consumption	\$ 0.45
<b>Total:</b>	<b>\$ 115.62</b>

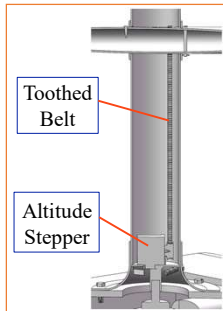
## Sub-Assemblies

### Reflector



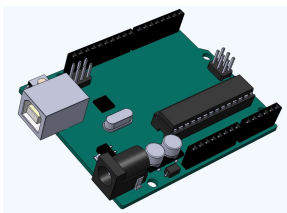
The reflector is composed of four silver-backed mirrors mounted with a slight inwards tilt. The frame holding them is injection-molded PEI plastic, which has rings that are bolted to the actuation cross-arms.

### Actuation



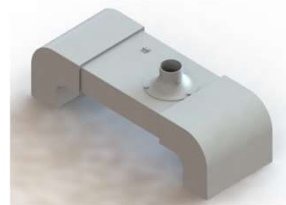
The actuation subsystem consists of two PVC pipes mounted vertically and horizontally, the latter being the cross-arms to hold the reflectors. The vertical pipe rotates via a geared motor at its base, whereas the horizontal pipe rotates using a pulley and motor mounted inside the vertical pipe.

### Controls



The controls system has a microprocessor which is used to translate positioning signals received from the central tower into inputs to the actuation motors through a motor control relay. It also sends position data back to the central tower to allow positioning error to be assessed.

### Base



The base of the heliostat is molded PVC. It houses the controller and azimuthal-rotation motor. It features two feet which are buried during installation (pipes not pictured for size), ensuring the heliostat will not be blown out of place or tip over due to wind forces on the reflector.

- C1: Uses 4-16 heliostats
- C2: Installation costs to not exceed \$100/m<sup>2</sup>
- C3: Individual parts must be ≤ in cost to closest OTS part
- C4: Reflecting surface must be conventionally washable
- C5: Operates under ambient weather conditions in Las Vegas
- C6: 20-year operational lifetime
- C7: Capitalizes on innovations enabled by small size
- C8: Delivers 1 MW power to central tower after losses
- C9: Collection Area < 1 m<sup>2</sup>
- C10: Concentration ratio > 1000 suns
- C11: Mitigate optical losses
- C12: Capable of tracking sun throughout day
- C13: Factor of safety in mechanical design > 2
- C14: Sun tracking automated and computer-controlled
- C15: Furthest heliostats must account for light dispersion
- C16: Redirects light to tower 100 m tall
- C17: Heliostats must not shade eachother
- C18: Module area to reflective area must be minimized

- M1: 4-16 heliostats per module
- M2: Costs must be minimized
- M3: Washable to maintain 97% reflectivity
- M4: Operates at temperatures between 35°F - 125°F
- M5: Operational Lifetime ≥ 20 years
- M6: Reliability, minimize number of joints
- M8: Delivered thermal input > 1 MW
- M9: Over 1 m<sup>2</sup> reflector surface area
- M10: Minimal number of parts
- M12: Optical losses < 40%
- M13: Azimuth angle range :180° bidirectionally
- M14: Altitude angle range : 90° bidirectionally
- M15: Mechanical factor of safety N >2
- M16: Minimize overall tracking error
- M17: Minimize loop time (local tracking error)
- M18: Reflected light accuracy
- M11: Minimal weight
- M7: Size, Minimal structural surface area

## Reflector Subsystem

## Actuation Subsystem

## Controls Subsystem

## Base Subsystem

- F1: (C1) Uses 4 heliostats
- F2: (C2) Installation cost will not exceed \$100/m<sup>2</sup>
- F3: (C3) OTS parts used wherever possible, source as many different parts from same supplier
- F4: (C4) Snap fits on reflector mount for easy removal
- F5: (C5) Operates under ambient weather conditions in Las Vegas
- F6: (C6) 20-year operational lifetime
- F7: (C7) Uses less than 20 unique parts
- F8: (C8) Reflectors angled inward for focusing effects
- F9: (C9) Reflector surface area 1.26 m<sup>2</sup>
- F10: (C10) Reflectors of silver-backed glass
- F11: (C11) Controls communicates with central tower
- F12: (C12) Actuates 360° altitudinally and azimuthally.
- F13: (C13) Factors of safety on any parts experiencing bending moment exceed 2
- F14: (C14) Microchip processor uses local data to optimize entire field
- F15: (C15) Microchip offers very quick loop time
- F16: (C16) Controller has lag time on order of milliseconds
- F17: (C17) Highest weight contribution is from the base
- F18: (C18) Non-reflective area remains beneath reflectors