HELIOS- High Efficiency Light Intensifying Optical System

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Abstract

Group 2's design of the heliostat excels in minimizing production cost per module to create a field for concentrating solar-thermal power. The concept generated is the high efficiency light intensifying optical system, also called HELIOS. The hedgehog concept centers around utilizing off-the-shelf parts to assemble a heliostat module with minimal moving components to reduce the cost of production and increase accessibility.

The heliostat module was designed around a simplistic modular design and PVC framework to achieve a lightweight structure with a high range of motion and small footprint capable of withstanding extreme wind conditions, constant UV exposure, and severe temperatures. The design concept is composed of five subassemblies: the base, support framework, reflector panels, rotation mechanism, and solar tracking. The base is made of 6061-aluminum angle stock and concrete to maintain a low center of mass and provide strong resistance to wind forces. The support framework is composed of PVC to minimize cost while also being durable against natural elements. The reflector panels are made from 1 cm thick float glass to make replacement low cost and infrequent.

The rotation mechanism utilizes four stepper motors for reflector panel elevation and one stepper motor for support frame rotation. The controller is mounted to the base of the heliostat module and is primarily tasked with tracking the sun. Additionally, the controller tracks the angular position of each reflector panel and can reset itself daily. The overall concept is designed for longevity, low-cost manufacturability, and enduring the extreme weather of the American southwest.

Product Functionality

The HELIOS module consists of four glass mirrors mounted on a PVC frame that redirects sunlight to a central tower receiver to heat an enclosed fluid, turning a turbine to generate electricity. A stepper motor located at the base drives a gear in the planetary gear system which rotates the entire support frame azimuthally. The heliostat base is comprised of angle stock set in a concrete foundation. A threaded rod is welded to the angle stock and supports the weight of the frame for stability. Each reflector is adhered to a PVC rod rotated by a stepper motor enclosed in the frame. The module's two degrees of freedom allow it to track the sun's movement throughout the day to accurately reflect the sunlight with an ESP32 controller. The unique design uses off-the-shelf parts and light-weight materials for low-cost applications.

Hedgehog Concept

What we are passionate about?

Creating an energy system that is more sustainable and self-reliant for the years to come - solar energy reduces waste and emissions.

What we are best at in the world?

Varied personal interests within our group such as design, machining, controls, mechanical system failure, and renewable energy allow us to combine our strengths to solve problems collaboratively.

What drives our economic engine?

Lowering the cost per m^2 of reflective area to <$100 (ideally 60 by government call to action) to be a viable energy collection method that is more affordable and accessible while remaining profitable.

Full System Render

Key Subsystems

Rotation Mechanism: The rotation mechanism rotates the reflectors in increments of 0.45 degrees. Each of the NEMA 17 stepper motors has 400 steps per rotation and the stepper drivers allow for half stepping. The support frame is attached to the base subsystem through a planetary gear system which is powered using another NEMA 17 stepper motor. In this configuration one of the planet gears is rotated which in turn rotates the ring gear turning the frame azimuthally. Each motor interfaces with a limit switch to calibrate the stepper position and enhance performance.

Controls System: The ESP32 controller is mounted on the angle stock and is protected by a 3-D printed plastic enclosure. The pre-determined code drives the heliostat's motion. The controller can receive its signal via Wi-Fi.

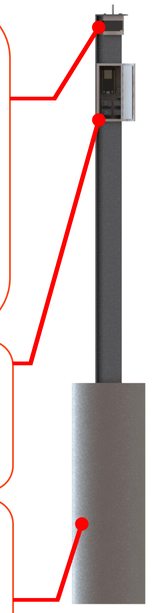
Base: The base is constructed from aluminum angle stock which is partially encased in a cylinder of concrete. This design minimizes material costs and module weight by only using one angle stock to support the frame.

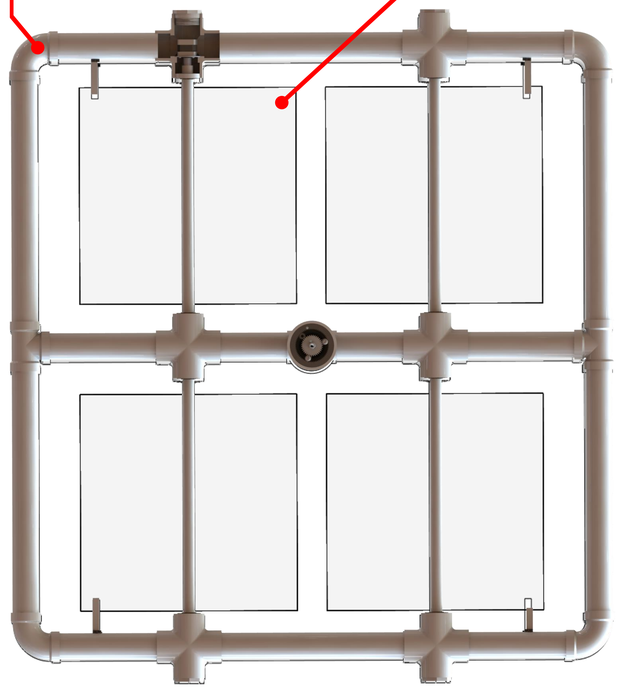
Cost Analysis

OTS Parts	$358.75
Modified OTS Parts	$26.61
Raw Material	$207.81
Manufacturing Labor	$26.47
Assembly Labor	$69.02
Energy Consumption	$1.52
Total:	**$690.18**

Support Frame: The support frame is constructed from 2" schedule 40 PVC and supports 4 reflectors using ¾" schedule 40 PVC pipes. The frame has 3 tee connectors to support the central crossbar and 6 cross connectors to house the stepper motors and bearings responsible for turning the reflectors.

Reflection Surface: The square reflective mirrors are made from silica (float) glass, which has a low thermal expansion coefficient to minimize deformation in drastic temperature changes. The glass material was chosen as opposed to a reflective film to increase durability during the 20-year lifespan.





HELIOS- Customer Needs

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