EML 4501 | Summer 2021 | Group 1
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Solar Pack

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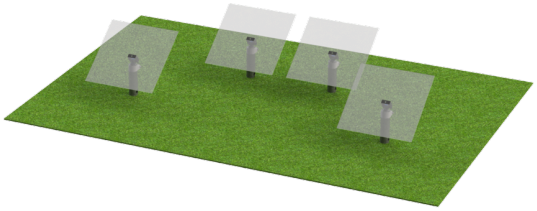
Abstract

The Solar Pack is a module consisting of four heliostats with a 1 m² reflective area. It aims to tackle the high costs associated with classical heliostat designs, which employ large steel structures and multiple drive systems. To achieve this, our hedgehog concept is a modular, industrial solar processing unit designed for linear expansion. Each heliostat in the module features a support structure, two positional rotation servo motors, and a 90° bracket for mounting the mirror to the support pedestal. The two servo motors utilized within the controls system provide 180° of movement in two axes, ensuring a focal point to the receiver tower in a CSP plant is maintained. The novelty in our design lies in the ease of assembly, due to a high ratio of Off-The-Shelf (OTS) parts . Moreover, the modules have necessary azimuthal spacing between them in the field to prevent interference while also minimizing land use. A field of 350 heliostat modules is projected to generate 1.73 MW of focal thermal input power and have an average yearly optical efficiency of 0.71.

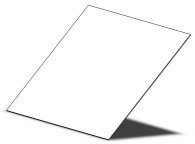
Full Assembly



- Note the trapezoidal pattern to eliminate shading losses
- Pipes will be placed directly into the ground
- Mirrors can enter “stow mode” by tilting the mirrors perpendicular to the ground to combat high winds and protect the controls system.

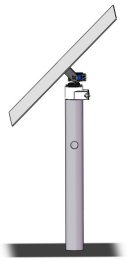
Mirrors Subsystem

- The heliostats utilize standard, flat glass mirrors as their reflective surface
- The total reflective area per module is 1 m²
- Comprised of 4 500 mm x 500 mm x 3 mm glass panels
- Each mirror is attached to the frame using epoxy adhesive for cost and assembly efficiency



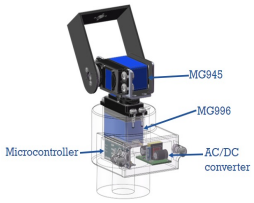
Frame Subsystem

- Consists of an 0.5 m long galvanized steel pipe
- Pipe will set into the ground with more of the shaft underground to enhance stability
- Adapter houses and protects the AC/DC converter and micro-controller
- Adapter and lid are the only manufactured parts present in our product



Controls Subsystem

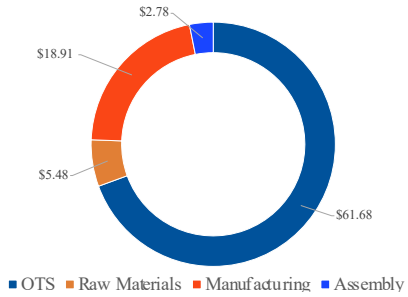
- Utilizes pan and tilt brackets and two motors for two-axis rotation
- Uses Servo motor model MG995 for altitude angle and MG995R for azimuth rotation
- Entire subsystem comprised of OTS parts
- Input for the controllers will be sent from a central hub at the central receiving tower



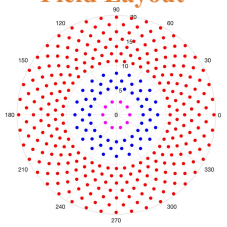
Product Functionality

The Solar Pack will operate on two axes of rotation by utilizing two servo motors. The motors provide over 180° of azimuth rotation and 90° of altitude angle. Each individual heliostat can track the sun throughout the day via microcontrollers included in each assembly. Wi-fi connectivity will connected to a central computer hub that will monitor the positions of the heliostats in the field. Each individual module has a total of 1 m² of collection area divided among four glass mirrors, resulting in four individually-controlled heliostats per module.

Cost Overview



Field Layout



- Projected field layout simulated via *MATLAB*
- Note the radial staggered pattern
- The color code corresponds to the different power zones where modules in the same zone are expected to have the same azimuthal spacing

Customer Needs

1. Total collection area ≤ 1 meter squared
2. Each module must be composed of 2-16 heliostats.
3. Optical losses due to tracking errors not to exceed 40%
4. Each module must be capable of tracking the sun throughout the day.
5. Individual heliostats within module units cannot shade other heliostats in that unit.
6. Modules must redirect sunlight to receiver target
7. Cost must be below $100 per meter squared
8. Automated onboard tracking
9. The total module area relative to the reflecting area should be small
10. Individual parts must be equal in price or less expensive than the closest available OTS part.
11. Reflecting surface must be washable
12. Focal thermal input power ≥ 1 MW
13. Solar concentration ratio ≥ 1000 suns
14. Farthest heliostats must account for dispersion.
15. Operational lifetime of the installation must exceed 20 years.
16. The system operates under ambient and solar conditions in Las Vegas
17. Spacing for cleaning vehicle to pass
18. The topography of the overall installation may be assumed to be completely flat.

Mirror

1. Total collection area is 1 meter squared
3. Optical losses are rated at 29%
5. Mirrors are placed in a trapezoidal configuration
7. Total mirror subsystem cost per module is $3.00
10. Completely made of OTS parts
11. Mirror strength is rated at psi to be able to be cleaned
12. Total power generation of the field rates at 1.73 MW
13. Provides a solar concentration ratio greater than 1000 suns

Frame

2. Each module consists of 4 heliostats
7. Total frame cost per module is $10
9. The module area to reflecting area ratio is 112%
10. Only 2 OTS parts
15. Lifetime exceeds 20 years including maintenance
17. 8 feet of space between modules
18. Galvanized steel pipes can be installed into flat surface

Controls

4. Modules are capable of tracking sun via micro-controller
6. Mirrors can be angled to direct sunlight to receiver
7. Total controls subsystem cost per module is $57
8. Micro-controller is connected to central hub via Wi-Fi
10. Completely made of OTS Parts
14. Position relative to receiver will be accounted for by the input to the controller
16. All parts operate under ambient temperatures in Las Vegas