LOW-COST, LIGHT WEIGHT, THIN FILM SOLAR CONCENTRATOR

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1. Background

This research addresses a cost barrier towards achieving a solar thermal collector system with an installed cost of $75/m^2 and meet the Department of Energy's (DOE's) performance targets for optical errors, operations during windy conditions and lifetime. Current concentrators can cost as much as 40-50% of the total installed costs for a CSP plant. In order to reduce the costs from current $200-$250/m^2, it is important to focus on the overall system. The reflector surface is a key cost driver, and our film-based polymer reflector will help significantly in achieving DOE's cost target of $75/m^2. The ease of manufacturability, installation and replacement make this technology a compelling one to develop. This technology can be easily modified for a variety of CSP options including heliostats, parabolic dishes and parabolic troughs.

2. Project Objectives

The specific project objectives are: 1) design and development of a mirror module using an inexpensive reflective metalized polymer film bonded onto a light-weight structural polyurethane rigid foam support, 2) design and development of a low cost non-traditional mirror module support structure, 3) selection of low cost drive components and associated control system, 4) design, integration and testing of a low cost concentrator, and 5) cost analysis of the proposed system to demonstrate $75/m^2 collector system DOE target. The project will be accomplished in a partnership between JPL and L'Garde over a period of three years.

3. Key Findings

The project start was delayed from Oct '12 to Jan '13 due to interagency agreement issues. Weekly meetings between JPL and L'Garde have been on-going and significant progress towards some of the key elements of Phase 1 identified earlier – facet design optimization, foam material selection, metallized film selection, concentrator performance optimization

3.1.Facet Design Optimization

Being in the early design phase, several large and small heliostat design options are being considered independently by JPL and L'Garde keeping the core requirements for performance under winds and cost. The down selection of the final designs will be done in the next quarter. One proposed large heliostat concept is shown in Figure 1 which meets several of the requirements. Only the heliostat design is shown below.

Figure 1. Heliostat (JPL-L1) with magnetically latched spring loaded hinged facets.

The heliostat (100 m^2) shown in Fig 1 consists of 36 sub-facets (1.67mx1.67m) which can be bowed in two directions like a kite using guy wires. This allows for control of the heliostat focal point by appropriate tensioning of the guy wires. In addition, the facet mass and costs can be significantly lowered by allowing the sub-facets which are attached along one edge to the horizontal support tubes to "give" in windy conditions with magnet latching and springs to detach and snap back.

3.2 Structural Foam Selection

Structural foam selection has been initiated and over six potential candidates have been identified. In particular, the 3M™'s Reinforced Polyurethane Foam and Dow's BETAFOAM™ used as structural foam for automotive applications look promising and discussions with the vendors have been initiated. A simple model has been developed to determine required foam thickness to withstand operating winds of 35 mph and meet 1 mrad pointing error due to the between 27 mph and winds [value derived from DOE FOA]. Based on discussions with JPL material experts, ASTM standards D3574, D638 and D790 have been identified as potentially being required ones for foam testing and procurements.

3.3. Silverized Film Selection

In the proposal, ReflecTec silverized film was identified for the project. Since then, materials like 3M™'s 1100 film were identified as alternatives. Both film samples were procured and will be tested for optical performance. The standard ASTM E903 has been obtained.

3.4. Concentrator performance optimization

Prior studies have indicated LCOE is best optimized when larger heliostats (~ 100 m^2) are chosen. However, new designs such as eSolar seem to indicate that with rapid drops in prices in actuators, etc., it might be feasible to reduce LCOE with smaller heliostats. Our project approach is to design heliostat sub-facets that can be used for both large as well as small heliostats. In order to meet this ambitious but reasonable goal, the team is looking to optimize the sub-facet dimensions. One major driver is the error budget flow down to the sub-facet level where a smaller size heliostat may be beneficial. The error allocation for surface irregularities and stiffness of the foam itself will drive the foam thickness requirements which will impact the total cost. The team is in the process of formulating the problem and using tools like SolTrace and DELSOL 3 for heliostat level and field level studies to identify the best selection of sub-facet parameters, heliostat design and field layout.