ASTRI Drop-in Heliostat Concept

Philip Fairman[1], Manuel Blanco[2], Phil Connor[3], David Farrant[1], Nawshad Haque[3], Jerry Huang[3] ,Scott Martin[1], Karl Wilson[1]
(1) CSIRO Manufacturing, (2) CSIRO Energy, (3) CSIRO Mineral Resources

ASTRI
AUSTRALIAN SOLAR THERMAL RESEARCH INITIATIVE

One of the heliostat concepts for the Australian Solar Thermal Research Initiative (ASTRI) low cost ($AU90 /m²) heliostat project is the Drop-in Heliostat. We explain the Drop-in Heliostat and how it can save costs.

Solar power tower plant

The 25 MW_e reference plant requires approximately 250,000m² of heliostat mirror surface. Typically the heliostat field is around 30-50%[1] of the capital cost of a plant. As of 2013[2], the cost of a heliostat is estimated to be in the range of $US150-200/m² ($AU200-270/m²) By reducing the cost down to $AU90/m² the cost of a 25 MW_e plant can be reduced by as much as $AU45million.

Figure 1: Comparable-sized 20 MW power plant near Seville, Spain. 2650 heliostats spread across 185 hectares (Gemasolar)

The component cost breakdown for a 64m² heliostat[3] is shown below. The component cost was €110.70/m². ($AU165/m²). Installation and checkout costs were €17.5/m² ($AU26/m²).

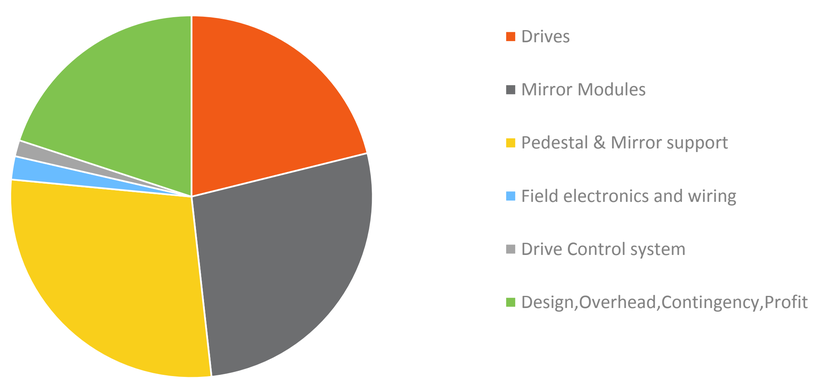

Figure 2: Component cost breakdown for a 64m² heliostat.

The ASTRI Drop-in heliostat aims to reduce costs by:

- Eliminating field electronics and wiring
- Reducing the pedestal and mirror truss costs
- Simplifying the transportation and installation process.

To achieve these ends we are using:

- FEM to optimise the mechanical design
- Optical modelling to predict optical performance
- Techno-economic modelling for accurate costing
- Field prototype to validate design.

Figure 3: Illustration of heliostat concept.

Traditional Heliostat

A traditional heliostat requires surveying, ground levelling and a concrete footing. Additionally, field wiring needs to be connected and laid in conduit within trenches. Once the heliostat is installed, it needs to be aligned and calibrated so it images into the solar receiver. Typically calibration is required repeatedly over the lifetime of the heliostat. The mirror truss is usually quite rigid so the mirror can be considered as an absolute frame of reference, simplifying the heliostat control to open loop.

Drop-in Heliostat

Our Drop-in heliostat is an autonomous unit with its own power supply consisting of a small PV panel and lithium battery. It is small and light enough to be able to be installed by 2 people with a portable crane. It requires minimal ground preparation for installation: a concrete footing is not required, using instead a commercial non-displacement pile driven system.

Differential GPS allows the heliostat to determine is position relative to the tower to <10cm in the horizontal and vertical directions, avoiding the requirement of accurate surveying of the heliostat field. The heliostats communicate with each other and the tower using a Wi-Fi mesh network.

Installation

The footing is first driven into the ground. The pedestal is then bolted to the footing and finally the mirror, truss and motors (all one assembly) is lowered onto the pedestal. The electronics is then turned on. The heliostat communicates to the tower via the mesh network and using a GPS unit temporarily located in the heliostat, it's position relative to the tower's receiver is determined and logged without the need for surveying.

Pointing

A 9-axis absolute orientation sensor (similar to that used in mobile phones) attached to the mirror monitors the mirror's tilt relative to the Earth's magnetic and gravitational fields and the accelerometer and gyroscope of that sensor monitors the forces and vibration of the mirror. The information is fed back into the drives allowing the heliostat to image the sun on to the solar receiver with great accuracy and repeatability. Using absolute orientation sensors also means a lighter and cheaper mirror truss can be used, reducing its cost.

ASTRI Drop-in Heliostat Features

- 12-16 m² with four facets with the shape to minimise blocking and deformation due to wind.
- Fully pre-fabricated, drop in place with autonomous power, control and initial set-up. Installation time expected to be less than 30 minutes per heliostat including alignment.
- Footings: concrete-free non-displacement pile system.
- Optional optical closed-loop control.
- Prototype under construction for field evaluation.
- Cost modelling tool for this heliostat is under development.

CSIRO

AUTHOR CONTACT
Philip Fairman
e Philip.Fairman@csiro.au
w www.csiro.au

REFERENCES
1. IRENA Report, "Concentrating Solar Power", Renewable energy technologies: Cost analysis series, Volume 1: Power Sector Issue 2/5, June 2012, p. 18
2. SolarPaces 2013, "Heliostat cost reduction – where to now?", J. Coventry, J. Pyke. Energy Procedia Vol. 49, 2014, pages 60-70
3. SolarPaces 2013, "Life Cycle cost optimized heliostat size for power towers", K. R. Bhargav, F. Gross, P. Schramek, Energy Procedia Vol. 49, 2014, pages 40-49

ACKNOWLEDGEMENTS
The Australian Solar Thermal Research Initiative (ASTRI) program is supported by the Australian Government, through the Australian Renewable Energy Agency (ARENA).

ARENA
Australian Government
Australian Renewable Energy Agency