FAE: A CPV-CHP SYSTEM AT CONCENTRATION 2000 TO PRODUCE ELECTRIC POWER AND HEAT

Filippo Paredes[1], Fabio Montagnino[1], Ignazio Dentici[1], Sergio Milone[1], Alessandro Buscemi[1], Luca Venezia[1], Marco Barbera[2,3], Franco Gelardi[2], Marco Cannas[2], Simonpietro Agnello[2], Ugo Lo Cicero[3], Alfonso Collura[3]

[1] IDEA s.r.l., Termini Imerese (PA), Italy

[2] Dipartimento di Fisica e Chimica, Università di Palermo, Via Archirafi 36 ,90123, gaetano.bonsignore@unipa.it, Palermo, Italy

[3] Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

Abstract

FAE "Fotovoltaico ad Alta Efficienza" ("high efficiency photovoltaic") is a project proposed to the Sicilian Regional Government (which founded it) by a consortium of public research institutes (University of Palermo, National Institute of Astrophysics) and of private companies in 2011. The prime goal of FAE is to achieve a nearly complete exploitation of the concentrated solar power by collecting, in addition to the electric output of the multi-junction cells, also the heat produced in the cells at temperatures suitable for domestic and industrial uses. The recovery of the heat requires a forced cooling of the cells which can therefore work at an extremely high solar concentration, exceeding 2000. This in turn reduces the number of cells and associated subsystems, with a reduction of the system cost.

A full prototype of the FAE unit is currently under test in Palermo, the production of a test field (150 kWe) is foreseen in 2014. The main features of the FAE system are the following:

- Optics: each cell (1 cm^2) is illuminated by a rectangular off-axis parabolic mirror (slumped extra-clear glass, silvered on the second surface, of aperture 46x46=2116 cm^2 in a projection normal to the sun, therefore providing a nominal concentration of 2116). The secondary optics is a frustum (made of BK7 glass) in optical contact with the cell front. The total optical transmission in the relevant spectral range (320-1800 nm) is about 90% and field of view on sky of the cell is a square with a FWHM side of 2.6 degrees.

- Cooling system: different types of heat exchangers are currently under test, all based on forced flow of water (plus antifreeze, if necessary). All of them, according to the numerical simulations, can provide a very efficient cooling of the cell at maximum sun power with a limited temperature difference (10 to 30 °C, depending mainly on thermal resistance of the cell mount) between the cell and the cooling fluid. By simply changing the flow speed the cooling system can respond to different conditions and requirements and can provide a coolant fluid temperature up to approximately 90°C. It is therefore possible to satisfy a variety of requirements for warm or hot water, from sanitary water and building heating-cooling to low temperature industrial uses.

- Mount and tracking: The mount is specifically designed for an easy installation on roof tops (both, horizontal and inclined) but is also suitable for larger CHP fields. It is of Alt-Alt type, composed by a long "primary" axis (which can be mounted horizontal or inclined, typically but not necessarily in N-S direction) supporting a number of short (about 1 m) "secondary" rotation axes (each one moving two optical concentrators and cells) orthogonal to the main axis. All the secondary axes are moved by a single actuator via a parallelogram transmission. The tracking system consists in a double control loop: an "open loop" algorithm (providing an accuracy of a fraction of a degree, limited by installation inaccuracies) and in a "closed loop" system (based on a four quadrant sun sensor) providing a high tracking accuracy.