4. Dish-Stirling solar collector design

A Dish-Stirling collector system consists of a paraboloidal mirror (dish) which concentrates the solar insolation to a receiver placed at the focal point. This receiver converts the solar energy into heat creating a continuous high-temperature heat source for the Stirling engine.

Dish-Stirling systems have provided one of the highest solar-electricity efficiencies with demonstrated conversion around 30%. However, a significant drop in the overall price has to be achieved to become cost-competitive within the energy market. A key point to reduce costs is to increase the efficiency of the solar conversion process at the same time as the components lifetime is increased.

This design enhancement is developed through modelling, simulation and testing (lab and full scale) of the mirror and the receiver both individually and collectively.

Modelling and simulation

An accurate modelling and simulation of a real system always implies coping with miscellaneous physically correlated processes. For the dish-Stirling system, it involves ray-tracing, FEM, aerodynamics and heat transfer. Roughly speaking, ray-tracing provides the solar power input; FEM obtains solid temperatures and structure displacements for mechanical integrity; the aerodynamic study calculates dish wind loads and convection coefficients; and internal heat transfer analyses provide heat fluxes and temperature changes. Thus, different models have to be coupled coherently to obtain a reliable outcome, which is verified with measurements and testing.

Measurements and testing

Measurements and component functional testing are essential to validate the designs and the model accuracy. Therefore, required experiments for solar receiver component testing and validation are performed in lab-scale at KTH in

the high light flux solar laboratory and in the real environment in the Cleanergy dish configuration.