# Hybrid Stirling Systems: Development of a Solar/Combustion Thermosyphon Receiver

**Johan Lindh[1], Marcia Mantelli[2], Tiago Uhlmann[3], Per Eskilson[4], Martin Nilsson[5], Miriam Manzoni[6], Marco Marengo[7]**

[1] R&D Project Leader. [2] Associate Professor, Ph.D. [3] Master Student. [4] CTO, M.Sc. [5] Chief Engineer Thermodynamics, M.Sc. [6] Ph.D. in Technologies for Energy and Environment. [7] Professor of Thermal Engineering.

[1, 4, 5] Cleanergy AB, Regnbågsgatan 6, SE-417 55 Gothenburg, Sweden

[2, 3] Federal University of Santa Catarina, Mechanical Engineering Department, Bairro Trindade, 88040-970, Florianópolis, SC, Brazil

[6, 7] School of Computing, Engineering and Mathematics, University of Brighton, BN2 4GJ Brighton, United Kingdom

[1] Phone: +46(0)704042417, E-mail: johan.lindh@cleanergy.com

## Abstract

One of the largest global science projects for the next two decades, SKA [1], implies a demand of up to 100 MW of continuous renewable zero-carbon footprint off-grid energy [2]. The EU funded project BioStirling-4SKA [3] aims to fulfill this demand utilizing a seamless hybrid solar/combustion-Dish Stirling system. This paper outlines the development of a hybrid energy receiver as a part of this project.

Numerous attempts to develop hybrid receivers have been performed in the past, where nearly all research has been based on concepts with either heat pipe or pool boiler technology [4]. These solutions have always suffered from high cost, short life time or high risks due to large quantities of liquid-metal. Heat pipes need a complex wick structure, which is costly and often suffers from limited lifetime [5], hence a new approach was necessary to meet the project goals and deliver a commercial solar dish/Stirling technology.

The final design consists of 48 wickless thermosyphons oriented in two concentric circles, enabling both a tubular sun receiver and a radial gas flow through the pipes (Fig. 1).

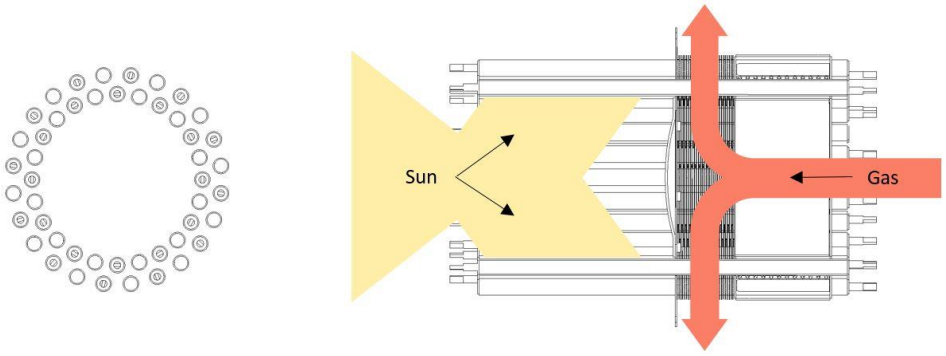


Fig 1. Left: 48 pipes oriented in two concentric circles. Right: Solar irradiation hits the pipes on the inside of the circles. Combustion gases flow radially through a fin package connected to the pipes.

The proposed design included the development of a high temperature thermosyphon capable of using two different heat sources [6]. The geometrical and thermal challenges are mainly linked to the small heat transfer contact area between the thermosyphons condenser and the attached working gas channels. These challenges were solved by filling the empty areas between the channels and thermosyphons condenser with stainless steel spheres and molten glass. This technique improves the conductivity of these areas, resulting in a homogeneous temperature distribution. The thermosyphons have been designed specifically for this purpose using a lumped parameter model [6] and further built and tested in order to meet requested performance [7].

The first hybrid receiver prototype (Fig. 2) was tested successfully on Cleanergy's SunBox engine in combustion only mode, generating a maximum electrical power output of 7.7kW with an electrical efficiency of 17%.

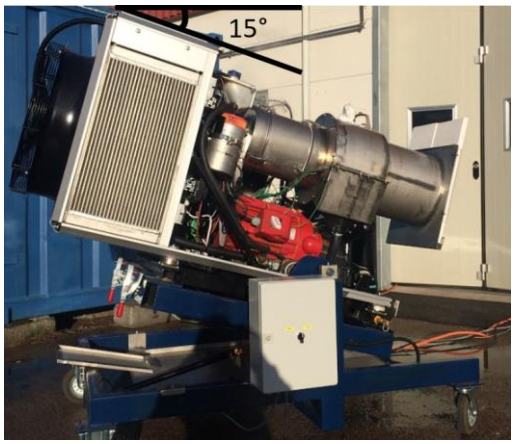


Fig 2. The hybrid receiver mounted on a SunBox engine and inclined 15°

Different heating powers were evaluated at an inclination of 15° and all results indicates that the developed receiver will also perform well when heated only from the sun or from both sun and gas simultaneously.

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