Pre-Design of a Mini CSP plant

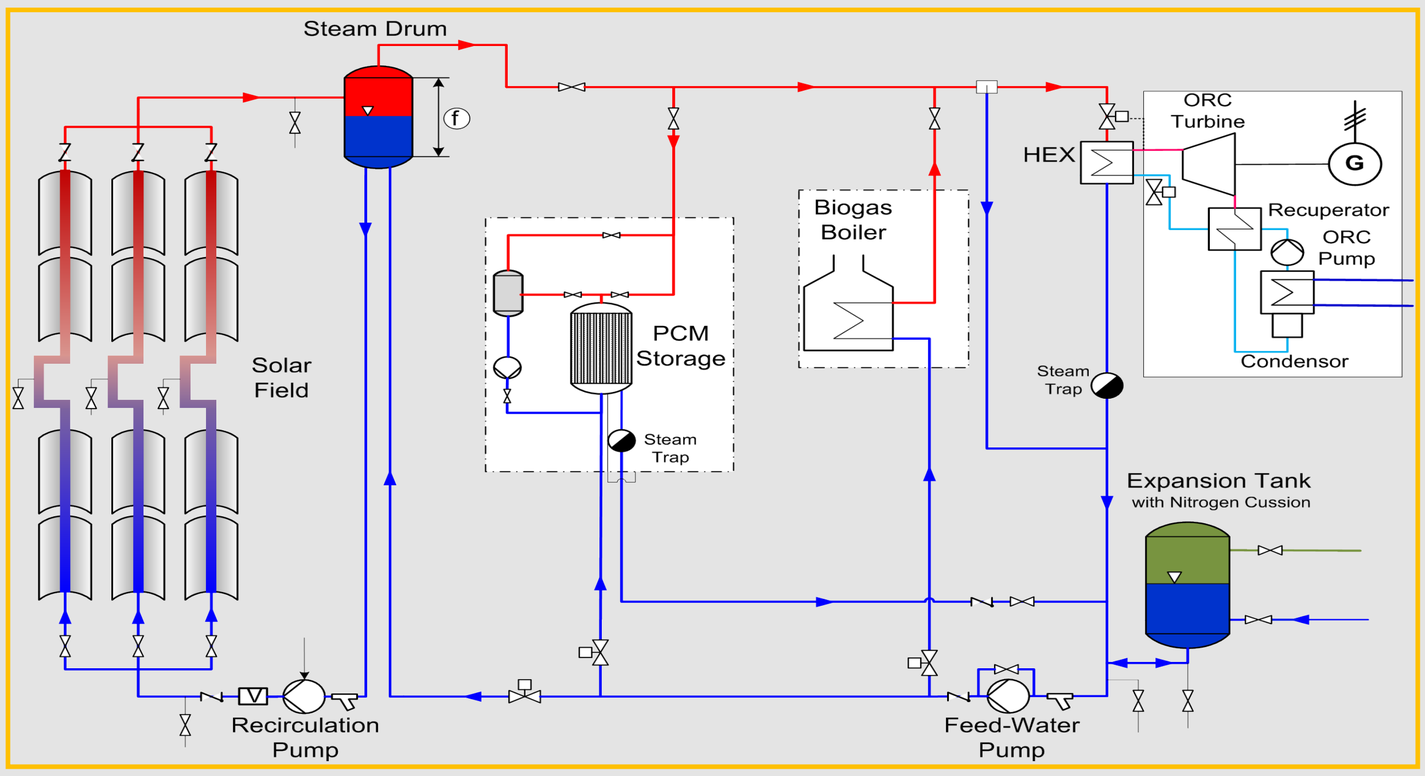

Fig. 1. Plant layout with steam lines in red, condensate and feed water lines in blue

Introduction

Small scale solar electricity generation is a technology which is of interest for many communities in the sun belt area. The REELCOOP project funded by the European Union aims at developing and demonstrating three such systems with two of them using thermal power cycles and one using PV. The system described here includes parabolic trough collectors and an organic Rankine cycle (ORC), enhanced by a biogas boiler and a thermal storage. It will be installed at the École Nationale d'Ingénieurs de Tunis (ENIT), in Tunisia. This installation will then be used, not only for demonstration, but also for training students on the involved renewable techniques.

The design (Figure 1) is ongoing and will be followed by installation and commissioning planned for March 2015.

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General layout

Solar power generation is typically accomplished in large plants in the range of several dozens of MW, to reduce electricity costs by economies of scale. The scope of the REELCOOP project is to develop a solar thermal electricity generating system of about 60kW for small scale power generation. As no appropriate steam turbine or engine could be found, an ORC had been chosen, operating at an inlet temperature of about 170°C. This is more adapted to the temperature range of concentrating process heat collectors mostly not equipped with vacuum receivers.
The nominal gross efficiency of an ORC of the company Zuccato reaches 13 to 15%. The solar field size has been adapted to the thermal power demand and designed for a net collector surface of 979 m².
Due to original planning and because the development of a Phase Change Material (PCM) storage is foreseen in the project, the heat will be transferred via saturated steam. Accordingly, the solar field is designed for direct steam generation (DSG) mode with the recirculation concept. At nominal operation sub-cooled water at about 140°C enters the collectors, where it is heated to 170°C and partially evaporated. The water content is then separated in a steam drum and recirculated. The saturated steam leaves the steam drum, and is then condensated and sub-cooled to 80°C in two plate heat exchangers, in order to drive the ORC cycle. To demonstrate how electricity can be provided in times of low radiation, a biogas boiler and a thermal storage are integrated. The storage module is designed with an innovative spiral concept. The remainings of the canteen at ENIT are foreseen to be treated in a anaerobic digester. The gas will be stored and burned in a biogas boiler to supply steam at the pressure desired for the turbine.
At ENIT the system will especially demonstrate the technology options and how they can be operated in combination to optimise the electrical output.

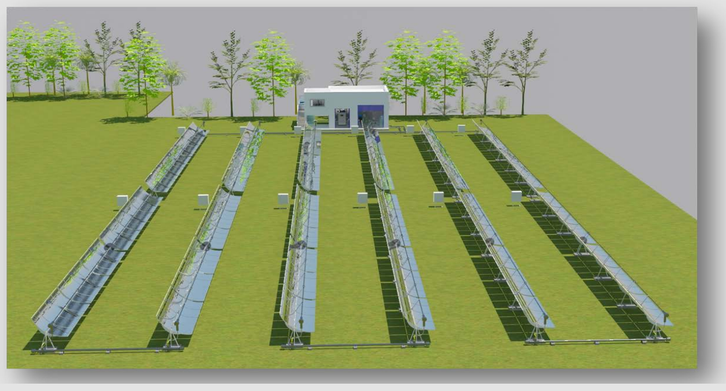

Fig. 2 Draft of solar field and building for other equipment

The authors would like to acknowledge the REELCOOP project (www.reelcoop.com), that receives funding from the European Union Seventh Framework Programme (FP7/2007-2013), under grant agreement n° 608466.