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## First year of operational experience with a solar process steam system for a pharmaceutical company in Jordan

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### Abstract

Industrial energy consumption represents one third of the total energy used worldwide, significant amount of which is thermal energy. This paper presents details of the recent installation of a linear Fresnel collector to provide saturated steam at 6 bar gauge (166 °C) through Direct Steam Generation (DSG) on the supply level for process heat usage in the Jordanian pharmaceutical manufacturing company RAM Pharma, where first solar steam has been provided in March 2015. This commercial DSG project also represents the first solar DSG plant in MENA.

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## 1. Technical description

### 1.1. Location and application

RAM Pharmaceutical Industries Co. Ltd is a pharmaceutical manufacturing company with a large variety of pharmaceutical products in Sahab, an industrial area in Amman (Jordan). RAM Pharma decided to install a solar process heat system, with the goal to reduce the fuel consumption of their diesel fired steam boiler by more than 30.000 l diesel annually.

### 1.2. The solar collector field

In late 2014 Industrial Solar installed 18 LF-11 Fresnel modules [6] for direct steam generation. Industrial Solar's first commercial direct steam generating system was installed on the roof of the factory in two strings with a total aperture area of 396 m<sup>2</sup> and a peak capacity of 222 kW<sub>th</sub> and had been directly connected to the steam supply of the factory. The collector modules have been arranged in two parallel strings of 9 modules each, connected with a cross-over pipe on one side, and thus forming a loop with inlet and outlet on the other side. Each module contains one 4 m long absorber pipe, and 11 primary mirror segments underneath. To form a string out of several modules, the absorber pipes are being welded together, while the primary mirrors are connected by couplings (see Fig. 1).

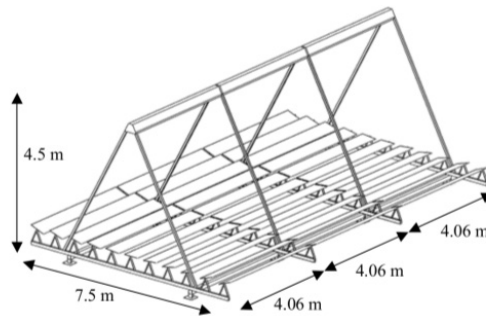


Fig. 1. Schematic drawing of 3 connected modules of the Industrial Solar's Linear Fresnel Collector LF-11.

### 1.3. Hydraulic concept

The solar collectors provide saturated steam on the supply level at 6 bar gauge (166 °C) directly to the steam network of RAM, which is mainly used for pill drying in the factory. The direct steam generation has been realized applying the so-called recirculation concept, where the solar field is supplied with a surplus of feed water, so that only a part of the water is evaporated in the absorbers, while the remaining liquid is being recirculated back to the collector inlet [1-4]. This secures enough cooling of the absorbers to avoid overheating, which would occur at a dry-out of the absorbers. Coming from the collector field the water/steam mixture enters a steam drum. In the steam drum the two-phase flow is being separated. Steam leaving at the upper side of the drum is supplied to the RAM factory's steam network, while the liquid water content is being recirculated into the solar field. The supplied steam is being replaced in the solar collector circuit by feeding in treated water from the RAM makeup water system.

### 1.4. The steam drum

Apart from its function as a separator the steam drum buffers changes in water content in the piping due to variation of the solar thermal power input. Furthermore the drum with a fill volume of 2000 l has been designed large enough to work as a steam accumulator with a gliding operation pressure range currently between 7 bar<sub>g</sub> and 13.5 bar<sub>g</sub>. With this size and gliding pressure range, the steam accumulator can provide enough storage capacity to

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